Stakeholder-Centered Sustainability Assessment of Airport Fueling Projects

By

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DECLARATION

I, Azzam Qari, declare this document to be my own unaided work, and where published sources are used, they are acknowledged.

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Abstract

Airport planning is a complex process due to the number of standards and regulations that must be met, as well as the involvement of different stakeholders in the planning process. Airport construction and operation is on the rise, and consequently, the sustainable development of airports has become a concern in the development of civil aviation. However, there is limited academic research on developing a systematic framework for airport sustainability assessment.

To address these research gaps, this thesis aimed to develop a mathematical sustainability assessment model for supporting sustainable development of airport fueling projects from multi-dimensional assessments that incorporates systematic methods for identifying and aggregating sustainability criteria. The research also presents two models that focus on analyzing the sustainability of these airports from emissions and energy consumption perspectives. Using a "Top-Down-Bottom-Up" methodology, the model identifies and assesses relevant sets of sustainability assessment criteria through quantitative and qualitative indicators that are compared against standard of measures. The proposed mathematical model uses Multi-Criteria Analysis to evaluate project alternatives based on a set of economic, environmental, and social sustainability criteria and indicators, as well as an overall sustainability index. The Multi-Attribute Utility Theory is used to aggregate the different indicators and calculate the sustainability index of each project alternative. The other two models present the first detailed initiative of emissions and energy analyses for aircraft fueling project. The models present the emission and energy impacts of each project alternative numerically and graphically with respect to the sustainability measures (economic, environmental and social).

The models were evaluated on their merit by a focus group composed of different stakeholders of airport operations. Two case studies incorporated different designs alternatives and operational conditions for two international Gulf Cooperation Council airport fueling projects to illustrate the models and their practical applications. The case studies used the models to analyze the sustainability of the two aircraft fueling projects. Analysis of the results supported that the suggested models were appropriate to assess the sustainability of airport fueling projects. The data indicates that the implementation of the proposed models would aid in collecting information that would assist in the evaluation of airport sustainability, and would provide a comprehensive analysis that would allow airport fueling projects to operate more efficiently.

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List of Abbreviations

ACRP	Airport Cooperative Research Program
ANOVA	Analysis of Variance
ASAT	Airport Sustainability Assessment Tool
ATAG	Air Transport Action Group
BSSE	Behavioral and Social Sciences and Education
CDA	Chicago Department of Aviation
CEC	Carbon Emission Calculator
CH_4	Methane
CORSIA	Carbon Offsetting & Reduction Scheme for International Aviation
CST	Center for Sustainable Transportation, Canada
DOE	Debt to Equity
DSD	Department of Sustainable Development
EC	Environment Canada
EEA	European Environment Agency
EIA	Environmental Impact Assessment
ELS	Earth and Life Studies
EPS	Engineering and Physical Sciences
FEC	Fuel Estimation Calculator
FS	Fuel System
GCC	Gulf Cooperation Council
GHGs	Greenhouse gases, CO_2, CH_4, N_2O, fluorinated gases
GMC	Green Meeting Calculator
GRI	Global Reporting Initiatives
GRP	Gulf Research Program
GSSB	Global Sustainability Standards Board
HDDV	Heavy-Duty Diesel Vehicle
HDGV	Heavy-Duty Gasoline Vehicle
HMCRP	Hazardous Material Cooperative Research Program
HMD	Health and Medicine Division
HSSE	Health, Safety, Security and Environment

HVAC	Heating, Ventilating and Air Conditioning
ICAO	International Civil Aviation Organization
ICAO - CEC	Carbon Emission Calculator
ICAO - FEC	Fuel Estimation Calculator
ICAO - GMC	Green Meeting Calculator
IISD	International Institute for Sustainable Development
ITP	Into-Plane
LDDV	Low-Duty Diesel Vehicle
LDGV	Low-Duty Gasoline Vehicle
MAUT	Multi-Attribute Utility Theory
MCA	Multi-Criteria Analysis
MCDM	Multiple Criteria Decision-Making
N_2O	Nitrous Oxide
NAE	National Academy of Engineering
NAM	National Academy of Medicine
NAS	National Academy of Sciences
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NCRRP	National Cooperative Rail Research Program
NMS	Noise-Monitoring System
NPV	Net Present Value
NRTEE	National Round Table on Environment and Economy
NZME	New Zealand Ministry of the Environment
OECD	Organization for Economic Cooperation and Development
ORTEE	Ontario Round Table on Environment and Economy
OSHA	Occupational Safety and Health Administration (US)
PC&I	Potential Criteria and Indicators
PGAD	Policy and Global Affairs Division
PM_{10}	Particulate matter under 10 microns diameter; a regulated pollutant
PPE	Personal Protective Equipment
PROSPECTS	Procedures for Recommending Optimal Sustainable Planning of European City Transport System
ROA	Return on Assets

SAM	Sustainable Airport Manual
SAMA	Saudi Arabian Monetary Agency
SDG	Sustainable Development Goals
TAC	Transportation Association of Canada
TC	Transport Canada
TDBU	Top-Down-Bottom-Up
THC	Total hydrocarbons including methane
TRB	Transportation Research Board
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
VTPI	Victoria Transport Policy Institute
WSM	Weighted Sum Model

CHAPTER 1 : Introduction

This chapter starts with overview information about sustainability development and its assessment for airport projects and proceeds to discuss the research problems investigated in this thesis. The research objectives, scope, significance, and a thesis outline are also presented in this chapter.

1.1 Overview

This research proposes the development of a stakeholder-centered sustainability assessment model for supporting the sustainable development of airport fueling projects, including two sub-models that focus on analyzing the sustainability of these airports from the emission and energy consumption perspectives.

Airport planning is a complex process due to the number of standards and regulations that must be met as well as the involvement of different stakeholders in the planning sub-processes (Niekerk and Voogd 1999). The demand for efficient airport facilities, capacity, services, safety, and security is growing due to the increase in the number of passengers, modern big aircraft, and the number of large busy airports. Therefore, the economic, environmental, and social impacts of airport construction and operation are increasing, and consequently the sustainable development of airports has become a concern in the development of civil aviation (Chen and Qian 2013). However, there is limited academic research on developing a systematic framework for airport sustainability assessment (Janic 2010).

Aviation is the fastest growing source of greenhouse gas emissions in the transport sector and the most climate-intensive form of transport. Most of these emissions result from the production of energy (BURN 2011). Aviation emissions have more than doubled in the last 20 years and the sector accounts for 5% of global warming. Over 700 million tons of carbon dioxide (CO_2) emitted by airlines in 2013 contributed to 2% of the 36 billion tons of global human emissions (Air Transport Action Group 2016). The aviation industry has committed to reduce the 2005 net carbon footprint by 50% by 2050. But considering the expected expansion in the aviation industry during the coming years, the total energy consumption is expected to continue increasing, and consequently achieving the targeted reduction in emissions will be a challenge. Meanwhile, current research on energy consumption assessment for airports is still in its initial stages (Chen and Qian 2013).

To address these research gaps, this research thesis aims to develop a mathematical sustainability assessment model for supporting sustainable development of airport fueling projects. The proposed mathematical model will use Multi-Criteria Analysis (MCA) to evaluate different project alternatives based on a set of economic, environmental, and social sustainability criteria and indicators, as well as an overall sustainability index (SI). The Multi-Attribute Utility Theory (MAUT) will be used to aggregate the different indicators and calculate the sustainability index of each project alternative. This index is an aggregated measure of the sustainability of a project alternative taking the three sustainability dimensions (i.e., economic, environmental, and social) into account (Ugwu et al. 2006a).

In addition, this research thesis aims to develop two sub-models that focus on analyzing the sustainability of airport fueling project alternatives from the emission and energy consumption perspectives. The sub-models will be presented as domain-specific measures of emissions and energy consumption, respectively that can be used when analyzing airport fueling project alternatives. The analysis of various project alternatives using the proposed sub-models will help identify the alternative with the lowest emissions and energy impacts to the economy, society, and the environment.

The models for this research will concentrate on aircraft fueling service project alternatives for a number of reasons. The aircraft fueling service is considered essential in every airport as it has complicated technical design and operations specifications and requirements compared to other ground services at airports (International Civil Aviation Organization 2011). A large volume of fuel is consumed every year throughout the world; 273 billion litres (72.2 billion gallons) of jet fuel was used by commercial aircraft in 2013 (IATA 2014). Moreover, the aircraft fueling service has the highest number of emission sources compared to other ground service activities at airports (Figure 1.1), such as infrastructure-related emissions (e.g., fuel tank farm and hydrant systems), operations emissions (e.g., fueling operations) and exhaust emissions (e.g., fueling mobile equipment exhaust) (ICAO 2011). Finally, many airport project initiatives target sustainability-related certification for terminal buildings; yet limited efforts have been conducted to cover fueling activities and facilities (ACRP 2008).

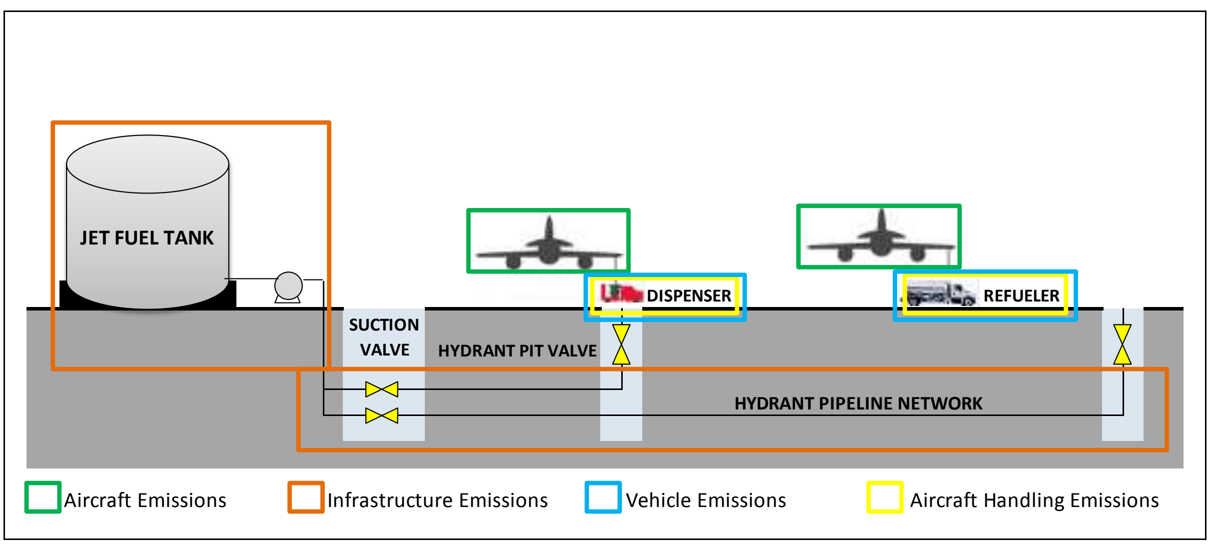


Figure 1.1: Airport-related emissions sources

1.2 Research Motivation

This research is motivated by four main drivers:

1. The growing consideration of sustainability by the global community to enhance quality of life and pursue prosperity in modern civilizations. Sustainability improvement can maximize economic impact along with minimizing environmental and social impacts (Koo et al. 2009).
2. The complexity of infrastructure planning, specifically airports, due to the involvement of different stakeholders and the variety of regulations and standards that must be met during airport planning (Niekerk and Voogd 1999).
3. The lack of systematic and context-specific models for assessing the sustainability of airport fueling project development. There is a need for such models to develop a means for pursuing sustainability and maximizing its potential benefits (Oltean-Dumbrava et al. 2013; Atkin and Skitmore 2008).
4. By 2050, the aviation industry has committed to reduce the 2005 net carbon footprint by 50% (Air Transport Action Group 2014). Therefore, energy and emissions-oriented sustainability analysis sub-models could help the aviation industry analyze airport project alternatives in order to achieve the planned target.

1.3 Problem Statement

Due to the enormous growth of the aviation industry, the complexity of airport planning processes that involve different stakeholders, and the variety of regulations and standards that must be met, there is a need for stakeholder-centred sustainability assessment models for airport fueling projects. However, there is a lack of systematic models for assessing the sustainability of airport fueling project development.

1.4 Research Objectives

The main goal of this research is to support sustainable airport development by developing a sustainability assessment model. As shown in Figure 1.2, its objectives are to:

1- Develop a mathematical sustainability assessment model for airport fueling projects by defining a set of sustainability criteria, indicators and related standard of measures to assess airport fueling projects;

2- Develop a mathematical model for analyzing the emissions of airport fueling projects;

3- Develop a mathematical model for analyzing the energy consumption of aircraft fueling projects; and

4- Validate all three research models using focus groups and case studies.

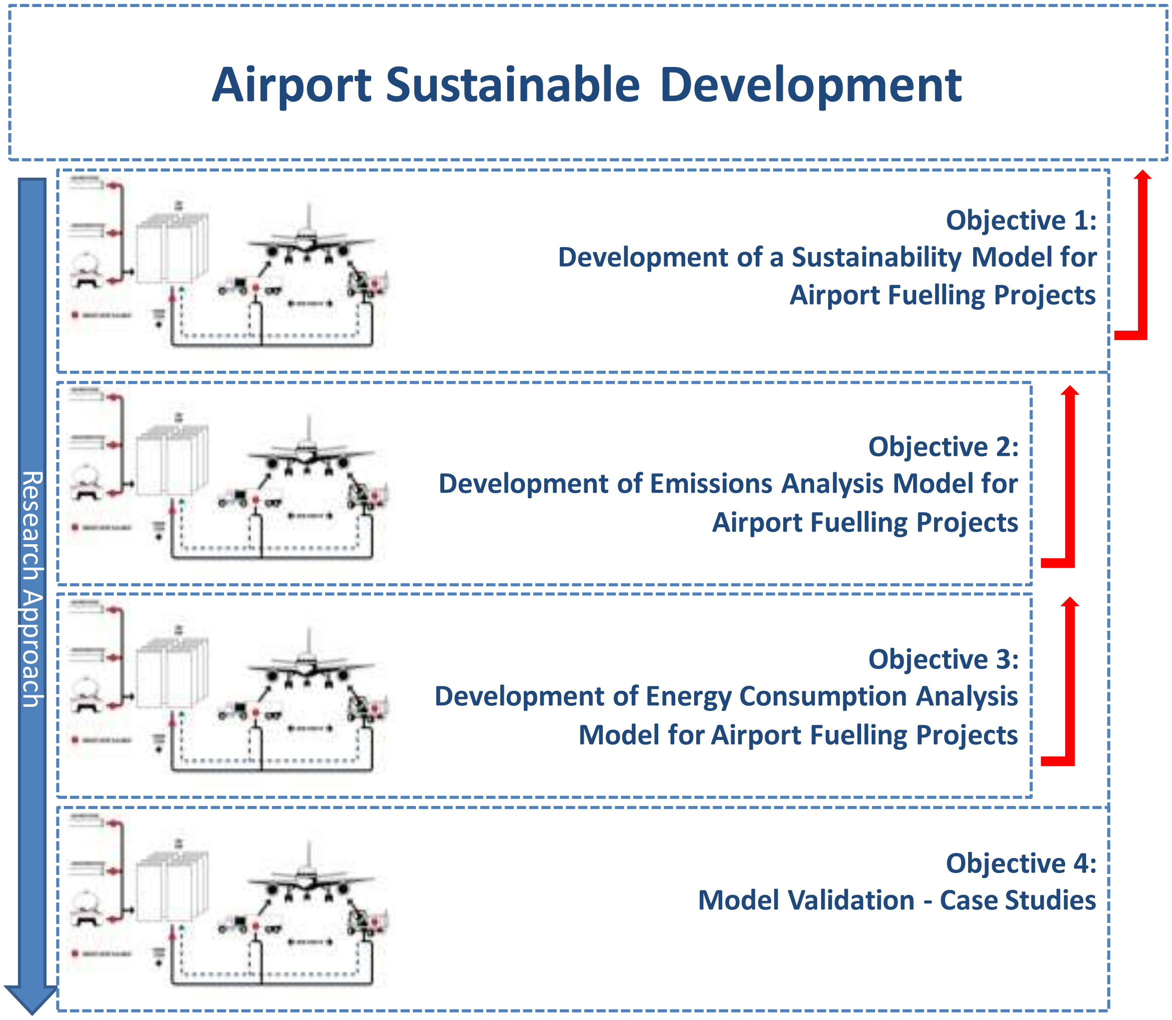


Figure 1.2: Research objectives

1.5 Research Scope

The research models will evaluate airport fueling projects through predefined equations and functions that will support systematic calculations and analyses of sustainability for airport fueling projects and will determine projects' emissions and energy consumption. Two case studies incorporated a variety of conditions and alternatives for international airport projects to illustrate the models and their practical applications. The case studies used the models to analyze the sustainability of different project alternatives for airport fueling projects (including elements such as tank farms, hydrant systems, into-plane mobile equipment and buildings).

The scope of this research covers airport fueling projects that consist of fuel system and into-plane (ITP) services and their elements (i.e., buildings, tank farm, hydrant system, mobile equipment, service vehicles, and manpower) as shown in Figure 1.3 and Table 1.1

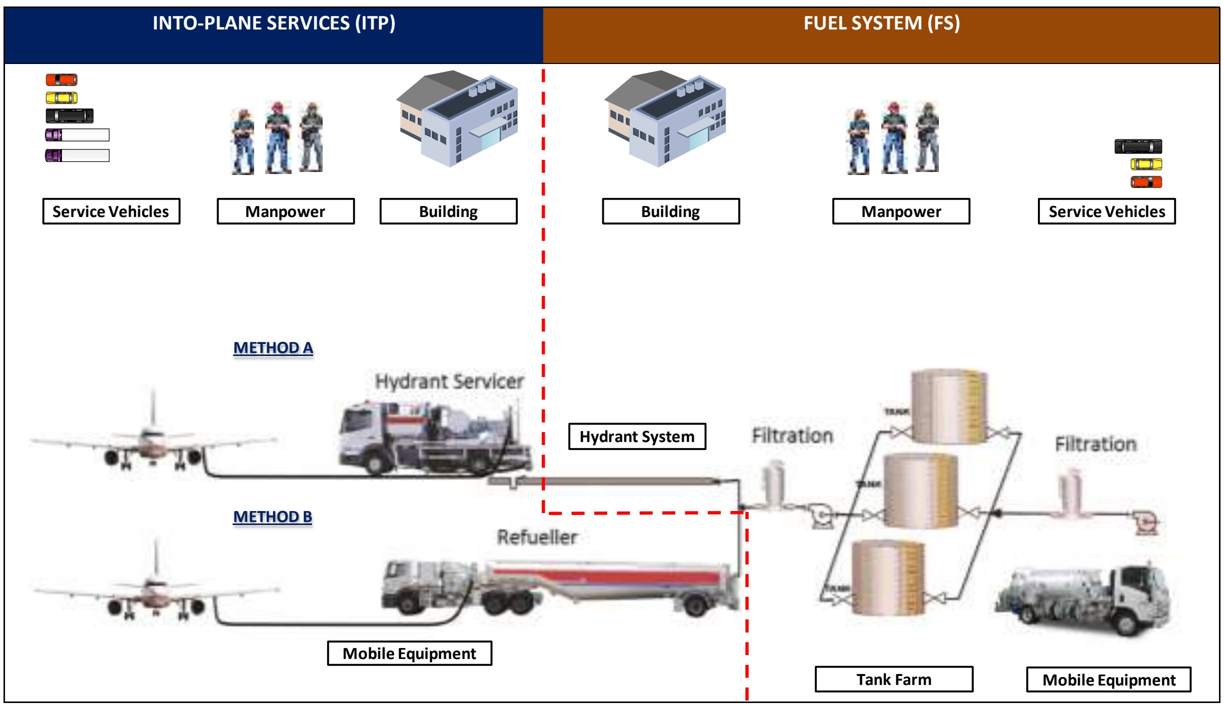


Figure 1.3: Overview of airport fueling system

Table 1.1: Research scope - airport fueling system elements

	Into Plane Services (ITP)	Fuel System (FS)
Building (B)	Buildings	Buildings
Tank Farm (TF)	N/A	Tank Farm
Hydrant System (HS)	N/A	Hydrant Systems
Mobile Equipment (ME)	Vehicles Fueling Components	Vehicles Fueling Components
Vehicles (V)	Service Vehicles	Service Vehicles
Operation & Procedures (O&P)	Manpower	Manpower

An airport fuel system consists of several elements such as:

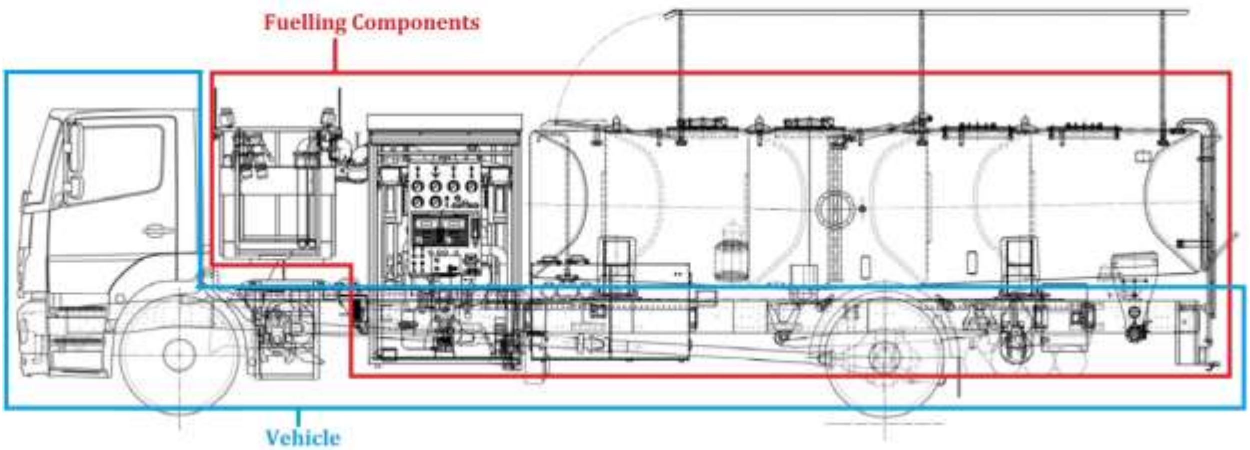
- Tank farm: Aircraft fuel might be received at a tank farm through pipelines or road tankers from refineries or bulk plants. On the other hand, the fuel could be delivered to the aircraft through a "refueler" in case of no underground jet fuel distribution pipelines network ("hydrant system") or by a "hydrant dispenser" via a hydrant system. A tank farm's fixed equipment and facilities are its major parts. They include fuel tanks (vertical or horizontal) to receive aircraft fuel by bridges or from bulk plant or refineries through pipelines. Other tank farm fixed equipment includes the off-loading rack (i.e., fuel receiving pumps, filters and meters), hydrant system pumps, filters and meters, the loading rack (i.e., fuel loading pumps, filters and meters), pipes, valves and gages, a firefighting system (i.e., water tank, foam tank, pumps), controls and instrumentations. Several safety measures are included in the design of the tank farm such as a blast resistant steel, high level shut off valve to prevent fuel spills, anti-corrosion painting, a tank banding area to control any fuel spill, tank earthing, adequate distance from building and aprons.
- Buildings: Fuel tank farm buildings include an administration building for staff, a maintenance workshop for mobile equipment and service vehicles and a warehouse for storing hydrant system and fuel tank farm spare parts. Building design and architecture can have considerable impact on staff productivity. Therefore, the building in which manpower operates should be a key interest in term of productivity. Nonetheless, factors such as good indoor air quality, thermal comfort, daylight, acoustics and amenities all play a crucial role in creating a healthy and productive workplace. Moreover, safety elements shall be factored in the design of the building to include measures such as an

effective firefighting system, practical emergency exits and the use of blast resistance steel in the event of an explosion caused by the fuel tank.

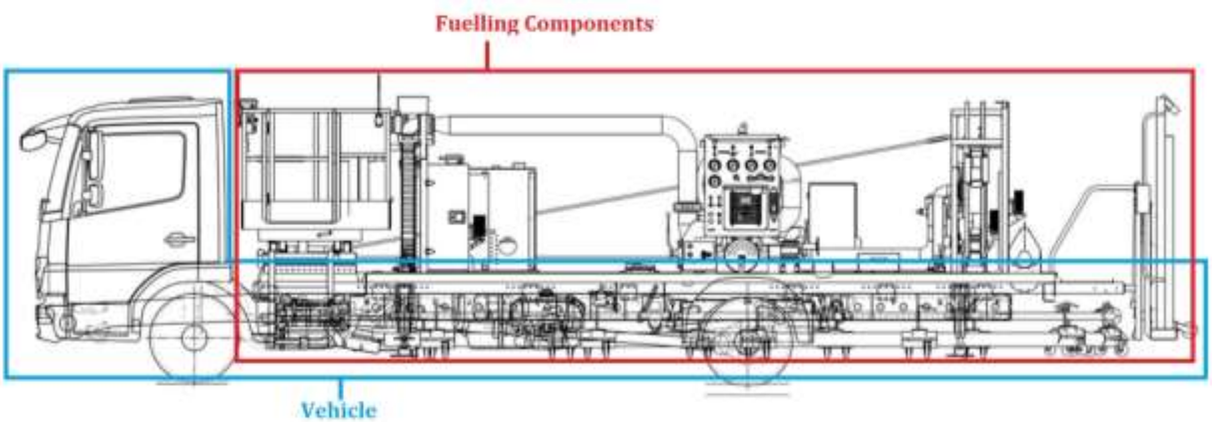
- Service vehicles: Service vehicles are used in the tank farm for staff transportation from landside to airside, within the airport aprons and facilities and for the operation and maintenance staff to ensure that the hydrant system and fuel loading bays are functioning effectively. Service vehicles include pickups, passenger cars and buses.
- Manpower: Manpower is considered the main pillar for effective operation of aircraft fueling. Staff requirements include competent expertise in the field of operation, health, safety, security and environment (HSSE), quality control, quality assurance, maintenance, procurement, training, and administration. Each of these functions is essential for the flawless operation of fueling activities. The main function of manpower is to manage, operate, and maintain the fuel depot to ensure the availability of quality aircraft fuel to be loaded to the hydrant system and fuel loading bays.
- Mobile equipment: Tank farm mobile equipment includes hydrant pit cleaners and flushing trucks. Mobile equipment is required to clean the fuel hydrant pits and flushing the hydrant system low points on a weekly basis. This consists of a vehicle truck and other fueling component or equipment such as pumps, vacuum system, tanks, pressure control valves, and sensors (Figure 1.4).
- Hydrant System: A hydrant system is an underground pressurized fuel pipeline network from the fuel tank farm to the aircraft parking (apron) area. The fuel could be delivered to the aircraft tanks through a "hydrant dispenser".

Into-Plane Service (ITP) is the operation to deliver aircraft fuel from the tank farm to aircraft tanks through a hydrant system (by dispensers) or loading rack (by refuelers). An ITP project includes several elements similar to the Tank Farm elements that have been mentioned above, such as buildings, service vehicles, and manpower. However, the ITP mobile equipment are different. There are two types of mobile equipment for the into-plane service: refueler and dispenser. They consist of vehicle trucks and other fueling component or equipment as follow (Figure 1.4). The refueler's main function is to deliver aircraft fuel from the airport tank farm to the aircraft tank. The refueler consists of many components mounted on the vehicle truck, such as a fuel tank (of various capacities ranging from 10,000 to 65,000 liters), pumps, a filtration system, meters, pressure control valves, sensors, hoses, couplers, safety and quality equipment and parts. Refuelers are used to perform two functions: refueling operation and defueling operations. Refueling operation by refuelers includes loading the fuel from the tank farm loading bays and transferring it to the aircraft wingtip. Then, the fuel is pumped from the refueler to the aircraft tanks. Conversely, defueling operation involves transferring the fuel from the aircraft tanks to the refueler tank due to the need to reduce the aircraft fuel for load balance or to conduct aircraft maintenance activities.

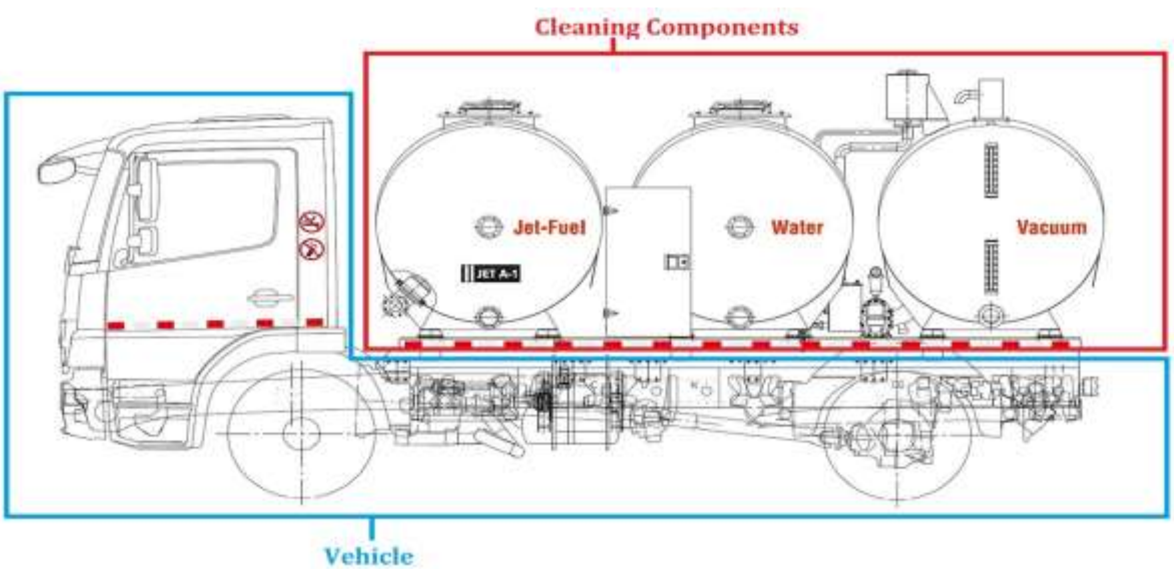
The dispenser's function is to deliver fuel from a hydrant pit (i.e., the hydrant system delivery point) to the aircraft tank. Similar to the refueler, the dispenser has many components mounted on vehicle trucks (e.g., filtration system, meters, pressure control valves, sensors, hoses, couplers, safety and quality equipment and parts). Yet, it has neither a fuel tank nor a pump since it delivers fuel from the hydrant system directly to the aircraft tank. Therefore, a hydrant dispenser can transfer more fuel quantities than a refueler. A hydrant dispenser is considered safer as it holds no tank and it is easier to drive and maneuver at the airport aprons.



REFUELER



DISPENSER



PIT CLEANER

Figure 1.4: Fueling mobile equipment

Operating mobile equipment with low emission is one of the sustainable measures implemented to minimize emissions. However, electric fueling equipment has not yet been deployed in the fueling industry. Such trucks can be utilized to enhance sustainable measures in the fueling industry in the near future.

1.6 Significance

There is a need to define a set of sustainability criteria, indicators and standard of measures for the sustainability of airport fueling projects considering the related quantitative and qualitative sustainability criteria. Currently, there is a lack of environmental, economic, and social criteria covering all airport fueling project elements (i.e., fuel system (tank farm and hydrant system) and into-plane refueling services) across the project's life cycle (i.e., planning and design, construction, operation and maintenance). Having one set of sustainability criteria to assess all types of engineering projects is not realistic (Oliterean-Dumbrava et al. 2013). Currently, there are several sustainability sets of criteria for different project types including airport terminal buildings, yet there is no domain-specific set of criteria for airport fueling projects (Koç and Durmaz 2015; Kılkış and Kılkış 2016). The existing sets of criteria cover buildings and vehicles only. They do not cover specific sustainability criteria related to tank farm, hydrant system, mobile equipment fueling components, and fueling operations. This makes this research the first to define a comprehensive set of sustainability criteria, indicators and standard of measures for the sustainability of airport fueling projects.

There is a need for domain-specific comprehensive assessment models that can help in assessing and managing the sustainability of airport fueling projects across their life cycles. This will help stakeholders select the best airport fueling project alternative during the planning and design phases. In addition, it will help assess airport fueling projects and manage their sustainability performance during other life cycle phases (i.e., construction and operation). Existing sustainability assessment models assess the key sustainability issues of airports using general sustainability criteria (Monsalud et al., 2014). These models cover buildings and vehicles only and do not cover other airport fueling projects' specific elements such as tank farm, hydrant system, mobile equipment fueling components and fueling operations. Sustainable development must be considered as a decision-making strategy in order to be a useful and implementable concept (Waas et al., 2014). There is a need to improve the coordination and decision-making process among airport operators and all other users including airport fueling operators for better sustainable development (Monsalud et al. 2014; Postorino and Mantecchini 2014; Ortega Alba and Manana, 2016). This research is the first to develop a domain-specific comprehensive assessment model for airport fueling projects that would support systematic calculations and analyses of sustainability. The model identifies the most sustainable project alternatives, facilitating thereby airport fueling projects' stakeholders' decision-making process.

Current airport air quality manuals and airport sustainability research initiatives do not consider all emissions related to airport fueling projects, nor the economic, environmental and social impacts of such emissions (ICAO 2011; Kılkış and Kılkış 2016). There are no initiatives of airport fueling projects that consider predefined equations and functions to determine all related emissions (i.e., tank farm emissions, hydrant system emissions, mobile equipment fueling component emissions, and aircraft fueling operation emissions) and to evaluate different design alternatives based on their economic, environmental and social impacts. This research develops the first model to support the systematic calculations and analyses of airport fueling projects' emissions. It provides predefined equations and functions to determine all related emissions and to assess the sustainability of different design alternatives.

Current research on energy consumption assessment for airports is still in its initial stages (Chen and Qian 2013). Nowadays, energy consumption reduction is a priority for airport managers who need to improve the energy efficiency at all airport facilities (Ortega Alba and Manana, 2016). Developing more accurate methods for modeling energy consumption of airport facilities are needed to lower consumption (Ortega Alba and Manana, 2016). This research is the first study to model the energy consumption of airport fueling projects through predefined equations and functions and to determine the energy consumption of all aircraft fueling related elements (tank farm equipment, hydrant system equipment, and fueling mobile equipment). This research model will be the first to evaluate different design alternatives based on their economic, environmental and social impacts.

1.7 Research Outline

Chapter 1 presents a background of the research topic on airport fueling sustainability development and assessment. The chapter highlights the problem investigated in this research, the research objectives, scope, and significance. Chapter 2 presents the literature review conducted for this research. Chapter 3 includes a detailed description of the research methodology for each research objective. The chapter describes the implemented methodology to develop a sustainability model for airport fueling projects (objective 1) in addition to the implemented methodologies to develop aircraft fueling emissions and energy analysis models for airport fueling projects (objectives 2 and 3). Chapter 3 also presents the methodology used to evaluate the models (objective 4). This chapter describes the evaluation process conducted through a focus group session and two case studies for all three research objectives. Chapter 4 presents the first research model, includes airport fueling project sustainability criteria and an assessment model (objective 1), and its validation through expert interview. The chapter presents the research contribution related to both research objectives 2 and 3 and their models. It describes the evaluation process conducted through a focus group session and two case studies of two airport fueling projects in the Gulf Cooperation Council (GCC) for all three research objectives. Chapter 5 ends with a conclusion of all four research objectives.

CHAPTER 2 : Literature Review

2.1 Introduction

This chapter presents a review of the literature in several main areas that are related to the proposed research (Figure 2.1). This literature review includes stakeholder management for construction project development, airport construction project management, sustainable development, sustainability assessment, airport emissions, airport energy and fuel consumption, airport and aircraft fueling, valuation, quantification, and aggregation methods, and model validation.

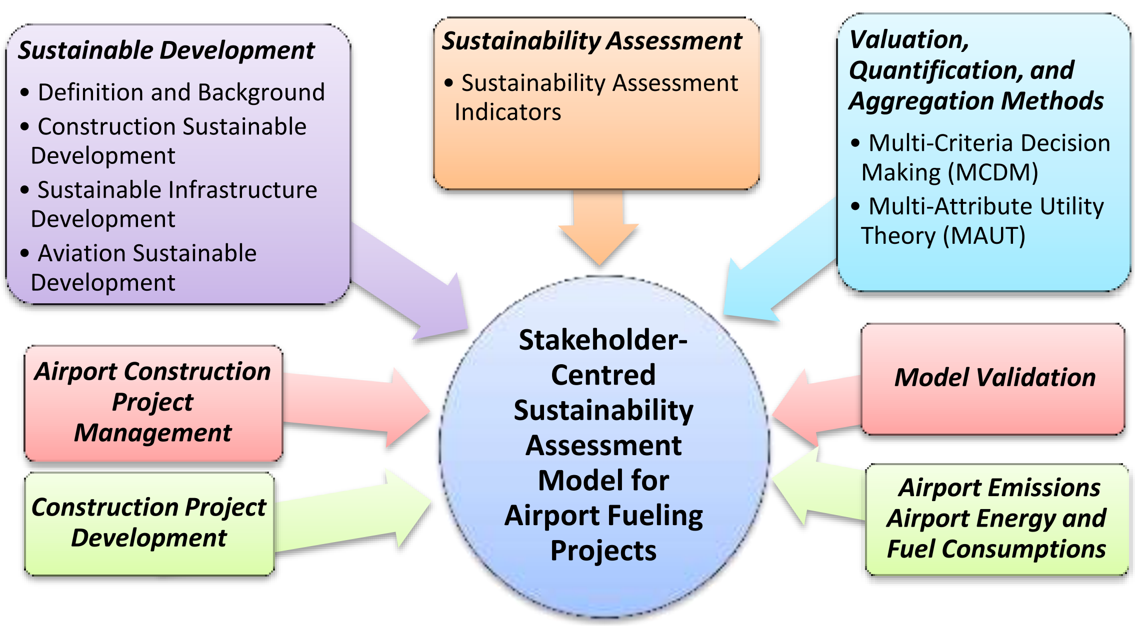


Figure 2.1: Literature review

2.2 Stakeholder Management for Construction Project Development

The origin of the stakeholder concept in strategic management began in 1984, and was defined as any group or individual who can affect, or is affected by the achievement of a corporation's purpose (Freeman 1984). El-Gohary et al. (2006) described stakeholders as "individuals or organizations that are either affected by or affect the deliverables or outputs of a specific organization", while Li et al. (2011) defined stakeholders as "those who can influence the project process or final results, whose living environments are positively or negatively affected by the project and who receive associated direct and indirect benefits or losses". Stakeholders can be categorized into two groups: internal stakeholders who are directly part of an organization's decision-making (e.g., owners, employees, contractors, suppliers), and external stakeholders (e.g., local community, interested groups, general public, authorities). The term is increasingly referred to in the media and has been applied to several domains, including construction project management (Atkin and Skitmore 2008).

Construction project management has focused on the methods of planning and managing the multifaceted activities required for completing construction projects (Morris 1994). Managing the stakeholders of construction projects is critical and needed to meet their expectations during the project's life cycle and consequently for completing the project successfully. Usually, these stakeholders have different interests and priorities that can place them in conflict or disagreements with the project (Karlsen 2008). However, enhancing stakeholder engagement improves their expectations, reduces unforeseen conflicts, and helps achieve a successful result for the project (Bourne and Walker 2006).

An increasing number of researchers (e.g., El-Gohary et al. 2006; Mostafa and El-Gohary 2014) have highlighted the significance of stakeholder management in construction projects, and numerous stakeholder management issues in construction projects have been identified. Olander (2007) stated that project management procedures are affected by project stakeholders.

Stakeholder satisfaction in construction has become important due to the increasing trend of stakeholders trying to influence the implementation of projects according to their individual concerns and needs (Li et al. 2013; Olander and Landin 2008). Yang et al. (2009) identified 15 critical success factors (CSFs) for stakeholder management through a literature review, which was consolidated by interviews and pilot studies with professionals in the construction industry. Their research findings indicated that stakeholders' social, economic and environmental responsibilities ranked first in the 15 CSFs, and consequently was considered to be the most important factor for the success of stakeholder management. The Illinois Department of Transportation (IDOT) highlighted the necessity of integrating stakeholder interaction into their project decision-making process to "add value to the communities it serves" (IDOT 2010), demonstrating the significance of stakeholders being involved in the sustainability development of construction projects.

A partial agreement by stakeholders on common processes and priorities is one of the main requirements of successful collaborative interaction (Afsarmanesh and Camarinha-Matos 2005). Research is also advocating for performance-driven, stakeholder-centric processes that provide full satisfaction to all stakeholders (Rezgui 2007) even when there are different priorities. Therefore, the stakeholder-centred approach is important for a successful construction project.

2.3 Airport Construction Project Management

Airport projects are huge strategic investments with a huge impact on a country's economic and social development. Yet, they have a unique and complex management and working environment due to several challenging factors (Adrem et. al. 2006; Khalafallah and El-Rayes 2008; Alnasseri et al. 2013). An airport is a complex system that consists of different buildings, facilities and areas (e.g., landside, airside, service area). The high density of people involved in running the airport while focusing on time restrictions to avoid flight delays is a real challenge (e.g., passenger, customs, police, fire department, airport operations, airline staff, fuel services, ground services). There is a high security level required for all airport areas and buildings (e.g., passenger terminals, landside, and airside). Airports have certain security checkpoints and procedures (e.g., licenses, badges, security requirements) for even permanent airport staff, vehicles, and equipment. Therefore, temporary contracting staff, equipment, and vehicles usually have more stringent security checks and procedures that might challenge them compared to other construction projects elsewhere.

Airport operations run 24 hours 365 days a year. Construction work sometimes has to follow certain operational needs and stop during certain seasons, days, or high traffic periods (i.e., specific hours). Special insurance policies are usually required for construction work in airports compared to other sites in order to cover a higher liability. Airport authorities require contractors to fulfill certain qualifications before they start any project. This is to make sure they conduct the required work as planned and avoid damaging any airport assets and facilities or impact the ongoing operations. Construction staff must understand and follow the unique and restricted safety rules and regulations of an airport facility. Alnasseri et al. (2013) illustrated the factors influencing airport construction, which is distinguished from other construction sectors due to airport projects' challenging and complex factors. The construction industry needs to adapt its traditional project strategies into new, integrated, and effective frameworks that require strategic management (Price et al. 2003; Yankov and Kleiner 2001).

However, there is a lack of literature on airport construction projects and their special characteristics and challenges (Alnasseri et al. 2013). While the literature covers “hard” project management skills (i.e., time, cost, quality control), there is a deficiency in “soft” project management skills (i.e., stakeholder management skills), especially for complicated projects such as airports. There is a need for a sustainability assessment framework that considers different stakeholders in order to develop a means for pursuing sustainability (Atkin and Skitmore 2008).

2.4 Sustainable Development

2.4.1 Definition and Background

While sustainable development has gained worldwide attention in the last 25 years, sustainability will be the greatest challenge of the 21st century (Sachs and Warner 1995). There are many definitions to describe sustainable development depending on an organization’s perspective. However, the most common definition is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations World Commission on Environment and Development 1987). Since then, various organizations, including government authorities, private consultants, non-profit agencies and interest groups, have developed different sustainability assessment tools to measure and monitor sustainable development. Sustainable development can be represented by three overlapping circles representing economic, environmental, and social sustainability (Figure 2.2).

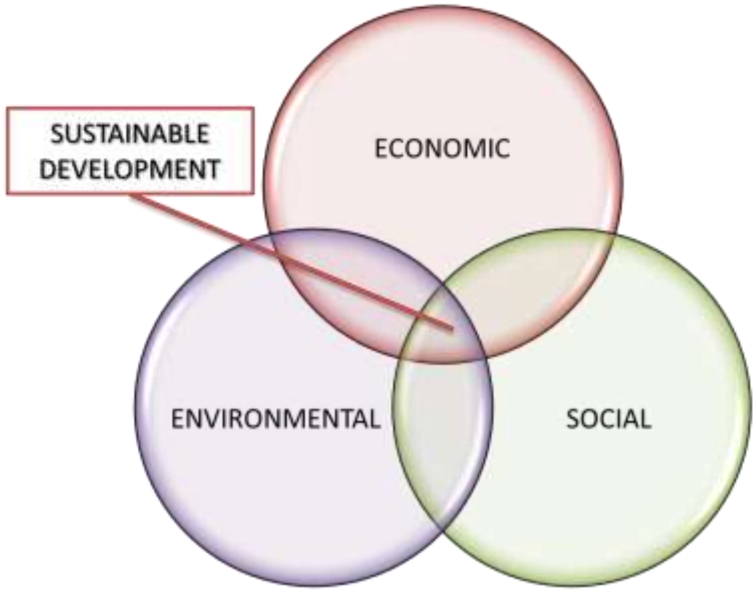


Figure 2.2: Three basic dimensions of sustainable development (Khalfan 2002)

While sustainable development has gained wide acceptance from stakeholders, the popularization of the sustainable development discourse has not yet reached satisfactory implementation (Waas et al. 2014). A huge effort is required to move sustainable development from discourse to actual implementation, which means translating discourse into real action (Lafferty and Meadowcroft 2000; Boehmer-Christiansen 2002). Therefore, sustainable development must be considered as a decision-making strategy in order to be a useful and implementable concept (Waas et al. 2014). Scholars have highlighted three challenges that have to be taken into account to consider sustainable development as a decision-making strategy (Hugé 2011; Waas et al. 2014): 1) Interpretation: sustainability should be interpreted with consideration to its organizing principles when applied in a given socio-environmental context; 2) Information-structuring: the inherent multi-dimensional complexity of sustainability should be structured into operational information (e.g., indicators) and properly communicated to feed the decision-making process; and 3) Influence: sustainability information should exert a real influence on decision-making and the actual implementation of sustainable development.

Therefore, this research's models support the implementation of sustainability development by assessing and analyzing different project alternatives and providing the tools for facilitating decision-making.

2.4.2 Construction Sustainable Development

Sustainable development has gained the attention of the construction industry which is a globally active and emerging sector (Ortiz et al. 2009). This industry is broadly recognized for its vital involvement in sustainable development due to its massive effect on the environment, economy, and society. The construction market accounts for 5.5% of the US$14.7 trillion gross domestic product (GDP) of the United States (Bureau of Economic Analysis 2011). In 2010, Canada's construction industries—residential, non-residential, and engineering, repair and other construction services—accounted for 6% of Canada's GDP, contributing $73.8 billion (Statistics Canada 2010). The European construction sector accounts for approximately 10% of the European GDP (European Construction Forum 2013). Environmentally, in the U.S. buildings account for 38% of all Carbon dioxide (CO_2) emissions and represent 73% of the U.S electricity consumption (Department of Energy 2011). The U.S. Environmental Protection Agency (EPA) estimates that 250 million tons of municipal solid waste was generated in the country in a single year (Environmental Protection Agency 2008a). Socially, in the U.S., the number of employees working in the construction sector was 7.3 million (U.S. Census Bureau 2011). In Canada, where construction is a major industry, more than 1.2 million persons are employed. In 2010, 7.1% of the employed Canadians age 15 and older worked in the industry (Statistics Canada 2010). In Europe, the construction industry accounts for about 7.1% of the total employment, representing approximately 30% of the industrial employment (European Construction Forum 2013). The origin of the sustainable construction concept (or "green construction" in some literature) was to show the construction industry's commitment to overall project sustainability (Hill and Bowen 1997). The most common definition of sustainable construction is "the application of sustainable development principles to the construction industry" (CIRIA 2001).

2.4.3 Sustainable Infrastructure Development

While the literature shows no standard definition for infrastructure sustainability, all related definitions must still include what the impact would be on the economy, environment, and social well-being (Jeon and Amekudzi 2005). Most infrastructure sustainability development definitions are consistent with the United Nations World Commission on Environment and Development (1987). For instance, stakeholders in transportation engineering define sustainability as the ability to meet the needs of the present generation in providing for the movement of people and goods from one location to another without compromising the ability of future generations to meet their own needs (Mills and Attoh-Okine 2014).

The infrastructure system has an important role to play in driving the sustainability agenda and it has been the aim of many countries to effectively implement sustainability practices in the entire construction industry. However, the involvement of stakeholders in infrastructure development projects is an essential factor in meeting their needs and accomplishing a successful project (El-Gohary et al. 2006). Economic, environmental and social equity issues of sustainability should be considered as part of the overall infrastructure development life cycle, including pre-project planning, in order to develop a sustainable infrastructure.

Figure 2.3: Sustainability metrics of the infrastructure project over its life cycle

Levitt (2007) has stressed the need for adopting the sustainability metrics - economic, environmental, and social concerns - for the construction and infrastructure domains, and are calling for maximizing these life cycle values as requirements for developing a sustainable infrastructure (Figure 2.3).

2.4.4 Aviation Sustainable Development

The aviation industry is responsible for connecting the global economy, providing millions of jobs and making our modern quality of life possible (Air Transport Action Group 2014). The importance of the aviation business originated from its vital economic and social contributions. According to the International Air Transport Association (IATA 2014), on an annual basis, the aviation industry incorporates 1,397 airlines, more than 25,000 commercial aircraft using over 273 billion litres of jet fuel, and over 36 million flights connecting to more than 3,864 airports. IATA (2014) highlighted aviation industry's economic, environmental, and social benefits and impacts. The aviation industry supports around 3.4% of global GDP and an economic impact of

$2.4 trillion. Environmentally, the aviation industry is the fastest growing source of greenhouse gas emissions in the transport sector and the most climate-intensive form of transport. Aviation emissions have more than doubled in the last 20 years. Its emissions account for 5% of the global warming and more than 700 million tonnes of carbon dioxide (CO_2) emitted by airlines in 2013 (2% of the global human emissions of 36 billion tons). Socially, the aviation industry transported over 3 billion passengers in 2014. Aviation improves living standards and alleviates poverty through tourism and serves as the only means of transportation to remote areas, promoting social inclusion and facilitates the delivery of emergency and humanitarian aid relief. Additionally, the aviation business industry is poised to have future healthy growth. Boeing (2014) forecasts that air flight traffic is expected to grow by 5% annually during the coming 20 years.

The aviation industry has a number of initiatives toward improving sustainability. The main initiatives are aimed at establishing an aviation management framework of sustainability. Table 2.1 summarizes part of the sustainability development practices highlighted in the literature that relate to general airport sustainability.

Table 2.1: Airport sustainability indicators

Economic	Environmental	Social
Welfare	Noise pollution	Delays and congestion
Economic growth	Air quality	Accidents
Capital	Land use	Sustainable means of transportation
Local purchasing	Water use	Employment
Local hiring	Waste	Employee well-being
Contribution to the community	Energy consumption	Passenger well-being
Contribution to research and development	Green building	Indoor environmental quality
Incentives for sustainable behaviour	Biodiversity	Local identity, culture and heritage
	Climate change	Stakeholder relationship

2.4.5 The Case of the Gulf Cooperation Council Countries

The GCC countries is a political and economic alliance of six Middle Eastern countries: Saudi Arabia, Kuwait, United Arab Emirates, Qatar, Bahrain, and Oman (Britannica, 2015). A high increase in air travel is driving airport expansion across the GCC. The Middle East reported the highest increase in international passenger growth during recent past years (Air Transport Action Group 2014). GCC airports are running an average of 92% passenger capacity utilization, whereas some countries like Saudi Arabia are operating at 130% capacity (Gulf Construction 2012). Saudi Arabia has an investment plan of US$53.33 billion in its aviation sector (out of US$90 billion for all the GCC) over the next four years to meet its increasing demands of air traffic due to a fast-growing population and to economic development (Gulf Construction 2012). While the GCC has unique motivations and challenges for sustainable development (economic, environmental and social) (Gulf Research Centre 2015), there is a lack of a systematic approach for airport project sustainability assessment that could take these context-specific challenges into account (Janic 2010).

In the GCC, an impressive increase in air travel is driving airport expansion. Currently, GCC airports are running an average of 92% passenger capacity utilization, where some countries like Saudi Arabia are operating at 130% capacity (Gulf Construction Worldwide 2012). In addition, the GCC area is expecting future key events and changes during the coming years. Saudi Arabia for example has started mega expansion projects of the two holy mosques in Makkah and Madina that will triple the current capacity of visitors at both locations. Consequently, three times the current amount of visitors are expected to arrive at Saudi Arabian airports by 2020. United Arab Emirates won the right to host the World Expo in Dubai in 2020. Expo 2020 Dubai is expected to attract 25 million visitors, 70% of which are from overseas. Qatar will host the

FIFA World Cup in 2022. The expected number of visitors for this event only is around 1 million. Saudi Arabia has an investment plan of US$53.33 billion for its aviation sector, out of US$90 billion for all of the GCC over the upcoming four years to meet its demands of increasing air traffic due to a fast-growing population and economic development (Gulf Construction 2012). Moreover, the GCC has many unique motivations and challenges for sustainable development implementation (economic, environmental, and social) (Gulf Research Centre 2015), and has started to give lots of attention to sustainable development. Yet, there is still a lack of a systematic approach for airport project sustainability assessments that would take the GCC's unique social and economic needs into account.

2.5 Sustainability Assessment

Sustainability assessment is a tool to support decision-making for sustainable development in various fields (Waas et al. 2014). Therefore, there are numerous definitions for sustainability assessment. Bond et al. (2012) defines it as “any process that directs decision-making towards sustainability”. Sustainability assessment is frequently considered to be a process that aims to assess the effects of decisions in advance, to predict future outcomes, or to support certain options or alternatives. Alternatively, the assessment of the effects triggered by past outcomes is always referred to as “evaluation”. However, the distinction between both terms (“assessment” and “evaluation”) is not always made (Ness et al. 2007; Pintér et al. 2012; Waas et al. 2014). Therefore, the proposed research models support both “assessment” and “evaluation”.

2.5.1 Sustainability Assessment Tools

Sustainability assessment tools are defined as the various analytical techniques that can be used to facilitate the comparison of different projects or policy alternatives (Bond et al. 2012). These tools can be divided into three categories: monetary, biophysical, and indicator-based (TEEB 2010; Gasparatos and Scolobig 2012). Monetary tools depend on modeling human behavior and the assumption that value arises from the subjective preference of individuals. These tools capture the individual's willingness to pay for services or products or the willingness to accept compensation for sacrificing this consumption. Consequently, monetary tools aim to maximize the utilities of individuals (e.g., happiness). Biophysical tools quantify the amount of natural resources that has been invested during the production of a good or service. These tools use the intrinsic properties of objects to assign value by determining the physical parameters and then translating them to units of measurement. Consequently, the lowest amount of natural resources (i.e., environmental impact) will be the preferable project alternative. Indicator-based tools include indicator selection, weighting, normalization, and aggregation. These tools depend on the indicators and their weighting. Gasparatos and Scolobig (2012) noted that out of the above-mentioned three categories of tools, indicator-based tools are the only sustainability assessment tools that fulfill all desirable features to be captured in sustainable development assessments.

Academics and practitioners highlight five main desirable features to be captured in sustainable development assessments (Gasparatos and Scolobig 2012): 1) relevant economic, environmental, and social issues, 2) the impact of projects into the future, 3) the needs and expectations of affected stakeholders, 4) the need to act on a precautionary basis, and 5) inter- and intra-generational equity.

As stakeholders' priorities vary from region to region, there are no identical sustainable criteria throughout the world. As the nature and size of civil engineering projects vary from one to another, there is a current lack of sustainability assessment tools in the industry that identify sustainability criteria for specific projects such as airport fueling projects to assess them systemically (Oltean-Dumbrava et al. 2013). There is also limited academic research in developing a systematic framework for airport sustainability assessment (Janic 2010). Therefore, the general sustainability assessment tools have been investigated in addition to the transportation sustainability assessment tools.

Appendices A, B, and C show a summary of general and transportation-specific sustainability assessment tools and related criteria. Where some of the developing organizations did not categorize the criteria under a certain sustainability category (i.e., economic, environmental or social), these criteria have been included under the most closely related category. The United Nations (UN) Indicators of Sustainable Development (2007) was developed to increase the international community's focus on sustainable development and assist in the adoption of a sustainable development national policy by decision-makers. In the same way, One Planet Living (OPL), developed in the United Kingdom by the non-profit organization BioRegional Development Group, created its own principles to act as a framework to enhance sustainability worldwide. The South East England Development Agency (SEEDA) in the United Kingdom was also developed to assess the sustainability of new development during the planning and design stages. Similarly, the Master Planned Community Assessment Tool (MPCAT) was created in Australia by the Victorian Government Sustainable Development Agency. The MPCAT's main aim is to provide the community stakeholders with a framework and common language to deliver sustainability to their communities. The Cascadia Scorecard was developed in the United States by the non-profit research and communication centre Sightline Institute to track and enhance the sustainability of the Pacific Northwest region.

Figure 2.4 shows a summary of organizations with airport sustainability efforts and initiatives by region or country. Several organizations have made different efforts in the aviation industry and airport domain, yet there are no existing initiatives for airport fueling projects specifically. Most initiatives and tools concentrate on aircraft and airport general facilities such as passenger terminals.

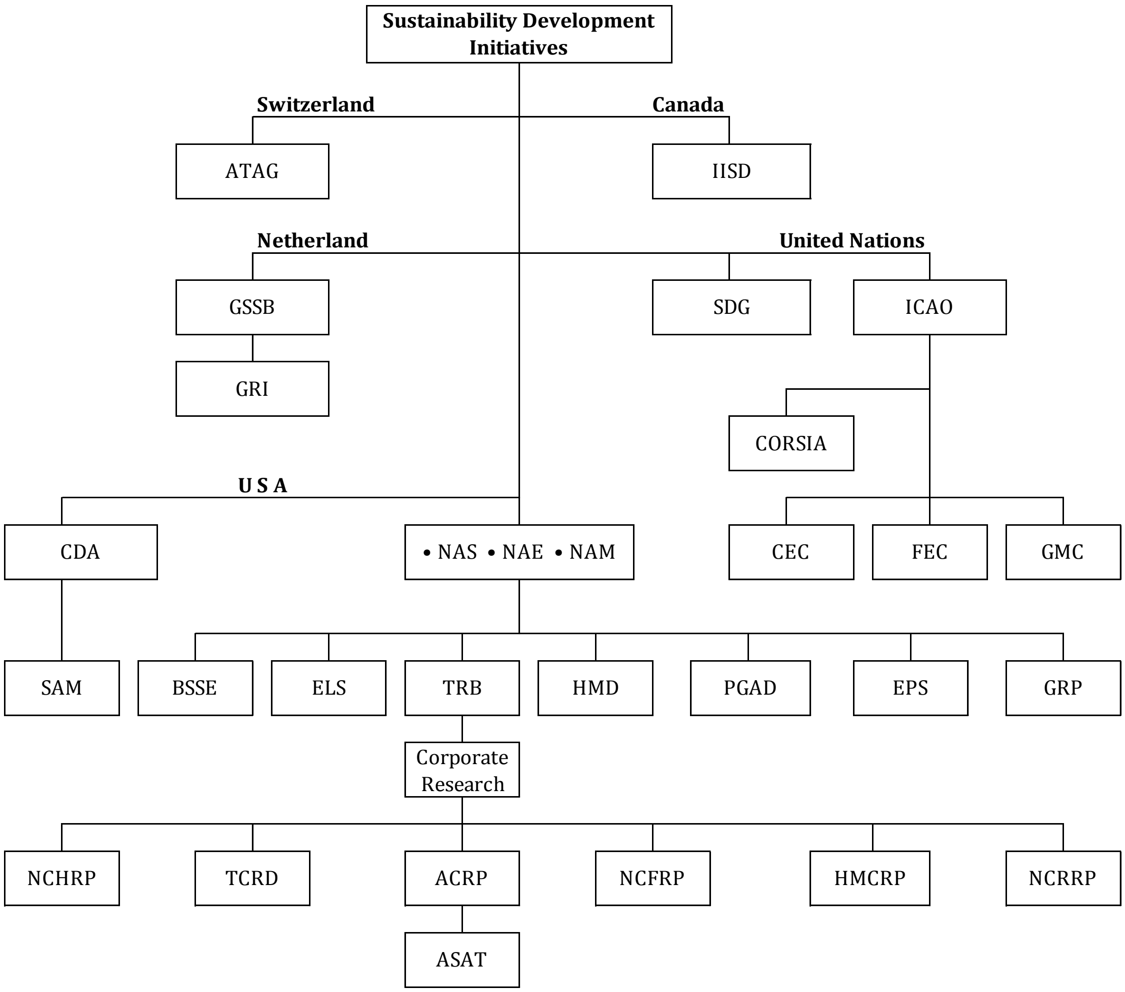


Figure 2.4: Airport sustainability development initiatives

The International Institute for Sustainable Development (IISD) is a leading international organization of innovation and research supported by the government of Canada. It has a number of practical solutions which integrate environmental and social priorities with economic development (IISD 2017). IISD develops and applies measurement and assessment tools and processes, including indicators, as well as builds capacity and fosters the engagement of policymakers, decision-makers and future leaders. The Air Transport Action Group (ATAG), based in Geneva, Switzerland, brings the industry together to form a strategic perspective on commercial aviation's sustainable development and the role that air transport can play in supporting the sustainability of other sectors of the economy (ATAG 2016). The International Civil Aviation Organization (ICAO) is accelerating developments and steadily progressing in a number of initiatives, which have the potential to benefit the international aviation's contribution across the three pillars of sustainability. The aviation sector is currently working to develop such a measure, in the form of a global offsetting scheme by ICAO for international flights. One of the ICAO assembly resolutions decided to implement a global market-based measure (MBM) scheme in the form of the Carbon Offsetting and Reduction Scheme for the International Aviation (CORSIA). This scheme is to address any annual increase in total CO_2 emissions from international civil aviation (i.e. civil aviation flights that depart in one country and arrive in a different country) above the 2020 levels, taking into account special circumstances and respective capabilities (ICAO 2017a). CORSIA calls for the international aviation industry to address and offset its emissions through the reduction of emissions elsewhere (outside of the international aviation sector), involving the concept of "emissions units". One emissions unit thereby represents one ton of CO_2. Two main types of emissions units exist: "offset credits" from crediting mechanisms and "allowances" from emissions trading schemes. In addition, ICAO has developed several sustainability related tools. 1) Carbon emissions calculator for passenger flights: a methodology to calculate the carbon dioxide emissions from air travel for use in offset programs (ICAO 2017b). The ICAO Carbon Emissions Calculator allows passengers to estimate the emissions attributed to their air travel. The methodology applies the best publicly available industry data to account for various factors such as aircraft types, route specific data, passenger load factors and cargo carried. 2) Fuel savings estimation tool (IFSET): it assists those states without such facilities to estimate the benefits from operational improvements in a harmonized way (ICAO 2017c). IFSET is not intended to replace the use of detailed measurement or modeling of fuel savings. 3) Green meetings calculator: It is a tool designed to support decision-making in reducing the carbon emissions from air travel to attend meetings. The software generates an optimal location for a meeting in terms of CO_2 emissions, taking into consideration the city of origin and the number of participants, as well as other parameters. While many factors may affect the decision for where a meeting should be held, the calculator helps facilitate the planning process (ICAO 2017d).

The Global Sustainability Standards Board (GSSB) has sole responsibility for setting the first globally accepted standards for sustainability reporting – the Global Reporting Initiatives (GRI) Sustainability Reporting Standards (GRI 2017a). GRI is an international, independent organization that helps businesses, governments and other organizations understand and communicate the impact of business on critical sustainability issues such as climate change, human rights, corruption and many others (GRI 2017b). GRI reports should cover aspects that reflect the organization's significant economic, environmental and social impacts; or substantively influence the assessments and decisions of stakeholders.

The National Academy of Sciences (NAS) is a private, non-profit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to further science and technology and to their use for the general welfare (NAS 2017). The National Research Council (NRC) was organized by the National Academy of Sciences. The Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Transportation Research Board (TRB) is one of six major divisions of the National Research Council. The mission of the TRB is to provide leadership in transportation innovation and progress through research and information exchange conducted within a setting that is objective, interdisciplinary, and multimodal (TRB 2017). The Airport Cooperative Research Program (ACRP) is managed by the Transportation Research Board (TRB) of the National Academies and sponsored by the Federal Aviation Administration (FAA). The ACRP is an industry-driven, applied research program that develops practical solutions to problems faced by airport operators (ACRP 2008). ACRP is managed by the Transportation Research Board (TRB) of the National Academies of Sciences, Engineering, and Medicine and is sponsored by the Federal Aviation Administration (FAA). The Airport Sustainability Assessment Tool (ASAT) is an interactive decision-making process guide that allows airports determine, evaluate, and judge what practices would be most applicable and useful for the individual airport situation and environment. Using the ASAT airport managers and other decision-makers can identify sustainable design concepts and technologies that can be considered for implementation in unique operating environments. In addition, it provides information about sustainable design concepts and technologies that are already under consideration by other airport managers and decision-makers. The Sustainable Airport Manual (SAM) is an integral part of Chicago’s ongoing efforts toward implementing more environmentally sustainable buildings and civil infrastructure, incorporating best practice guidance for planning, operations and maintenance of all city airport facilities and functions and those of its tenants (SAM 2012).

Based on the above literature review of organizations’ initiatives, Table 2.2, Table 2.3, and Table 2.4 below summarize the sustainability criteria of different organizations with respect to the three sustainability dimensions of environmental, economic, and social. A lot of work has been done on different segments of airport sustainability. Nevertheless, aviation-related sustainable initiatives related to the environment, economic and social aspects mainly focus on aircraft and airport facilities but not on airport fueling projects. The following tables focused on four organizations' initiatives: ACRP, SAM, IISD, and GRI as they cover similar airport facilities and elements (e.g., buildings and vehicles). These initiatives can be implemented to assess the buildings and vehicles of airport fueling projects only. More specifically, they can be used to assess the vehicle part of the fueling equipment but not other fueling components. This research aims to address this limitation by developing models that would assess the sustainability of these other components such as mobile equipment's fueling components, tank farm, hydrant system and aircraft fueling operation.

The review of the sustainability criteria of these different initiatives shows that most of the environmental aspects are covered in ACRP. However, there are no details on indirect economic impacts. For instance, variables such as net present value (NPV), payback period, and return on asset (ROA) are not explained in detail. Security monitoring system, community engagement and awareness programs are also missing from the ACRP. SAM does not focus on the criteria of administrative procedures, land use and biodiversity. It has no details about noise monitoring systems. Other criteria missing at SAM include the roles and responsibilities of sustainability managers, water resources for fire fighting systems, CO_2 monitoring for indoor environmental quality, occupational health and safety aspects, payback period and ROA. Similarly, IISD has no details on land use and biodiversity, as well as noise pollution. Other missing criteria at IISD include administrative procedures and indoor environmental quality guidelines.

Table 2.2: Environmental sustainability criteria existing in the literature

	Environmental sustainability criteria	ACRP	SAM	IISD	GRI
I	Administrative procedures				
1	Cooperative sustainability policy	x	x		
2	Sustainable procurement policy	x	x		
3	Green procurement policy	x	x		
4	Use of renewable materials	x	x		x
5	Recycle used materials	x	x		x
6	Environmental Impact Assessment (EIA) study	x	x		
7	Environmental certificate	x			
8	Develop or adopt sustainability guidelines and metrics	x			
9	Include sustainable practices in the airport's Minimum Operating Standards	x			
10	Sustainability Training	x			
11	Establish a sustainability oversight committee or "Green Team" to guide, direct, and evaluate the integration of sustainability practices.	x			
12	Sustainability function within the organization	x			
13	Establish a regular meeting schedule to discuss sustainability progress with construction and maintenance contractors, tenants, airlines, local regulators, and/or national civil aviation administration and national environmental protection agency representatives	x			
II	Water efficiency				
1	Wastewater generation	x	x	x	x
2	Water withdrawal	x	x	x	x
3	Storm water management system	x	x	x	x
4	Water recycling and reusing	x	x	x	x
5	Landscaping water use	x	x	x	
6	Water use reduction	x	x	x	
7	Vegetation and Wildlife Management	x		x	
8	Innovative Wastewater Technologies	x		x	
9	Use an external No Foam unit/kit for aircraft rescue and firefighting (ARFF) vehicles and for application on aircraft hangar foam-water suppression systems	x			
III	Indoor environmental quality		x		
1	Indoor ventilation and air quality	x	x		
2	Daylight and views	x	x		
3	Carbon dioxide (CO_2) monitoring	x	x		
4	Use zero- or low-volatile organic compound (VOC) paints and coatings	x			
5	Install volatile organic compound-free natural linoleum flooring, recycled glass tile, or ceramic tile.	x			
6	Environmental Tobacco Smoke Control	x			

	Environmental sustainability criteria	ACRP	SAM	IISD	GRI
IV	Energy				
1	Energy savings from operation of pumps	x	x		
2	Energy savings from operation of buildings	x	x		x
3	Use of Renewable Energy	x	x		
4	Vehicle and mobile equipment fuel savings	x	x		
5	CFC, HFC, and HCFC Reduction	x			x
6	Heating, ventilation, and air conditioning (HVAC) equipment	x			x
7	Energy Performance	x			x
V	Emissions				
1	VOC emissions	x	x		
2	Vehicle and mobile equipment exhaust emissions	x	x		x
3	Utilization of environmentally friendly vehicles	x	x		
4	GHG emissions associated with energy consumption	x	x		x
5	Total number and volume of significant spills.				x
6	Conduct an emissions inventory for all projected construction activities	x	x		
VI	Waste				
1	Hazardous Wastes produced from ad-hoc activities (e.g. commissioning procedures) and spills	x	x		x
2	Hazardous Wastes produced from routine operation and maintenance	x	x		x
3	Non Hazardous Wastes produced from routine operation and maintenance	x	x		x
4	Pollution of land / waterways	x	x		
5	Total weight of waste by type and disposal method.				x
6	Construction Waste Management	x	x		
7	Office Waste Reduction	x	x		
VII	Land Use & Biodiversity				
1	Efficiency of land use	x			x
2	Impact of location and size of land used for operations in biodiversity	x			x
3	Impact of activities in biodiversity	x			
VIII	Noise				
1	Noise pollution	x	x		
2	Conduct a noise modeling study and Install a Noise-Monitoring System (NMS).	x			

Table 2.3: Economic sustainability criteria existing in the literature

	Economic sustainability criteria	ACRP	SAM	IISD	GRI
I	Economic performance analysis				
1	Life-cycle cost	x	x	x	
2	Projects Capital	x	x	x	

3	Land and property value	x	x	x	
4	Significant financial assistance received from government.				x
5	Financial implications and other risks and opportunities for the organization's activities due to climate change				x
II	Economic value retained				
1	Direct economic value generated		x	x	x
2	Economic value retained		x	x	x
3	Financial implications of emissions and climate change			x	
III	Market presence				
1	Standard entry level wage ratio				x
2	Employment opportunity				x
IV	Indirect Economic impacts				
1	Indirect Economic impacts		x		x
2	Non-monetary benefits				x
3	Development and impact of infrastructure investments and services provided primarily for public benefit through commercial, in-kind, or pro bono engagement				x

Table 2.4: Social sustainability criteria existing in the literature

	Social sustainability criteria	ACRP	SAM	IISD	GRI
I	Occupational Health and Safety				
1	Representation in HSSE committees	x			x
2	Work-related injuries and fatalities				x
3	Reduction of work-related injuries and fatalities			x	
4	Occupational diseases, lost days and absenteeism	x		x	
5	Health and safety awareness and prevention	x		x	x
6	Education enhancement on HSSE awareness	x		x	x
7	Health and safety covered in formal agreements with trade unions	x		x	x
8	Personal protective equipment (PPE)	x			
II	Security				
1	Initiatives to improve Security	x	x	x	x
2	Security breach		x		
3	Security Monitoring System		x		
4	Security operations		x		
III	Community				
1	Community awareness program for sustainability	x	x	x	x
2	Community complaints	x	x		
3	Community engagement program	x	x	x	x
4	Community appreciation	x	x	x	x
5	Impacts of operations on local communities	x	x		x
6	Initiatives for community	x	x	x	
7	Compensation to personnel	x	x		
8	Contractors with sustainability orientation	x	x		

	Social sustainability criteria	ACRP	SAM	IISD	GRI
9	Community Diversity	x	x	x	
10	Employee well-being		x	x	
11	Business continuity plan	x	x		
12	Local materials		x		
IV	Employment				
1	Employee hires and turnover	x			x
2	Return to work and retention rates after parental leave, by gender				x
3	Total workforce by employment type, employment contract, and region, broken down by gender.				x
4	Staff localization	x			x
V	Labor / Management Relations				
1	Notices of changes in operations	x			
2	Percentage of employees covered by collective bargaining agreements.				x
3	Hygiene standards	x			
VI	Education and Training				
1	Employees empowerment	x	x		x
2	Skills management of employees	x	x		x
3	Employees performance appraisal	x	x		x
4	On-the-job training	x	x		
5	Sustainability research and development	x	x		
VII	Quality of services				
1	Improve customer satisfaction	x			
2	Sustainable employees' transportation	x			
3	Employee satisfaction	x			
VIII	Regulatory Compliance				
1	Anti-competitive behavior				x
2	Percentage of employees trained in organization’s anti-corruption policies and procedures.				x
3	Percentage and total number of business units analyzed for risks related to corruption				x

2.6 Airport Emissions

The literature has several economic, environmental, and social measures related to emissions, yet the key airport measures summarized in this literature. Environmentally, the main sources of air pollution are exhaust from aircraft and diesel engines, and direct fuel emissions from fueling aircraft (Danish Ecocouncil 2012). The key pollutants can be divided into polycyclic aromatic hydrocarbons (PAH), volatile organic compounds (VOC), inorganic gases like sulphur dioxide

(SO_2) and nitrogen oxides (NO_x), and particulate matter (PM). Volatile organic compounds are a very large group of organic compounds that are mainly present as gases. In airports, VOCs mainly originate from fuel vaporized during fueling and are unburned or partly burned fuel in the exhaust gas. Some VOCs will be bound to particulate matter in exhaust gas (ATAG, 2014). Economically, it was agreed during the ICAO 2013 assembly to develop a global market-based mechanism to address international aviation emissions by 2016, and then apply it by 2020 (European Commission 2015). In addition, there is the recent approach of carbon offsetting that aims to mitigate the effects of emissions on the environment (Air Canada 2015). The emission trading scheme aims to provide a limit on overall emissions from high-emitting industry sectors. Within this limit, organizations can buy and sell emission allowances as needed. The cap-and-trade approach gives organizations the flexibility needed to cut emissions, with the cap divided into transferable units. Under this scheme, the quantity of emission is fixed (capped) and the right to emit becomes a tradable commodity. The EU emission trading scheme is considered the largest example of emissions trading across 30 countries, covering approximately 40% of total EU emissions (Laing et. al. 2014). Carbon offsetting is the utilization of carbon credits to compensate for emissions to meet carbon reduction goals and support the move to a low carbon economy (Carbon Credit Canada 2015). Carbon offsetting is the process where finance is transferred to renewable energy, reforestation (tree planting), and resource conversation projects which generate reductions in greenhouse gas emissions. Reforestation is one of the most popular recommended offsetting projects and has many economic, social and environmental benefits (American Forests 2011; USDA Forest Service 2004). This proposed economic measure considers tree planting for emission offsetting for fueling service emissions at airport fueling project developments (Figure 1.1).

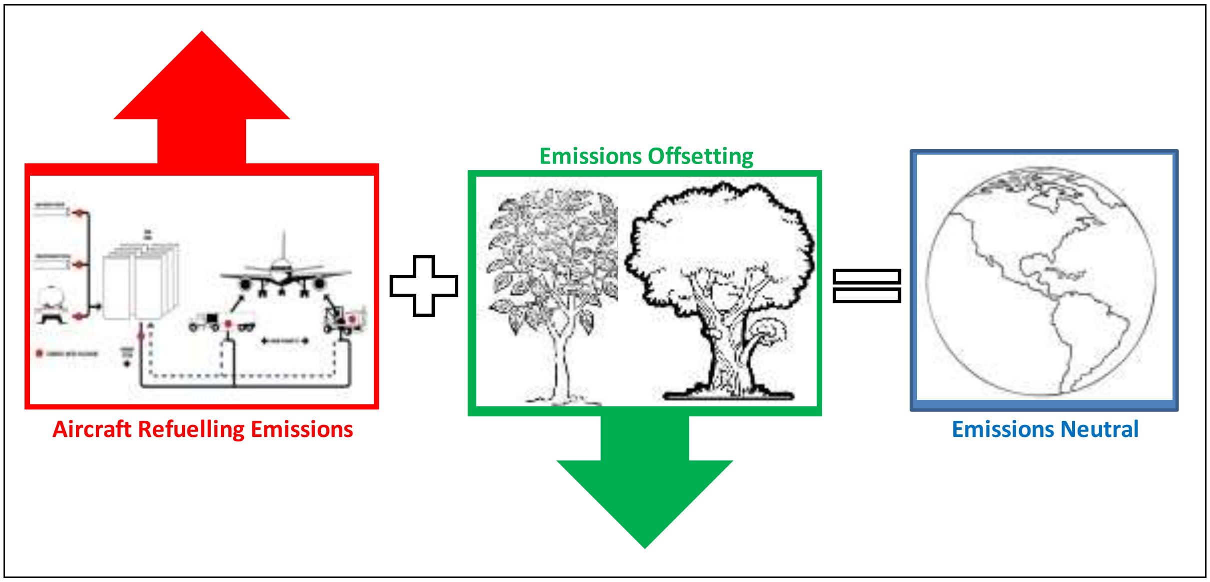


Figure 2.5: Aircraft fueling emissions offsetting

Socially, interest in aircraft and airport air pollutant emissions has increased since the substantial increase in commercial turbojet traffic in the 1970s. For example, airport-related emissions include air contaminants such as NO_x, HC and fine particulate matter (PM), which in turn can involve broader environmental issues related to ground level ozone (O_3), acid rain, climate change, and present potential risks relating to public health and the environment. It is widely recognized that airport-related sources of emissions have the ability to emit pollutants that can contribute to the degradation of air quality of the nearby communities. As such, national and international air quality programs and standards are continually requiring airport authorities and government bodies to address air quality issues in the vicinity of airports (International Civil Aviation Organization 2011). Approximately, 10.5% of cancers in the Chicago-Midway airport vicinity were the result of emissions polluting the air (Environmental Protection Agency 1993). A study conducted by Environ International Corporation (2000) revealed that air toxic risks from O'Hare International Airport in Chicago associated cancer risks with the airport, and exceeded 10-6 for a 1000 square mile area surrounding the airport. Tsoi and Tse (2012) illustrated that an

18% excess risk of lung cancer was linked to professional drivers who were potentially exposed to diesel exhaust, after adjusting for the confounding effect of smoking. Additionally, there is a tendency for a positive lung cancer gradient with increasing years of employment as a professional driver. Nonetheless, an estimated 6% of lung cancer deaths in the United States and United Kingdom are probably caused by diesel exhaust (Vereulen et. al. 2014). A study conducted in the Copenhagen airport illustrated that if a baggage handler inhales air containing 65,000 ultrafine particles per cm^3 on average and inhales 0.5 litres of air per breath 15 times per minute (quiet work), this will result in the inhalation of 500 million particles per minute. This equals 240 billion ultrafine particles per workday, a significant part being deposited in the most critical parts of the lungs and releasing some of the toxic compounds to the particle surface directly into the bloodstream (Danish Ecocouncil 2012). In conclusion, exposure to emissions has severe impacts on health, including the risk of developing cancers.

2.6.1 Reporting of Emissions

Significant improvements have been made over the past two decades regarding the fuel efficiency of fueling, passenger vehicles and other technical improvements to reduce emissions. However, these advancements may be offset in the future by the forecasted growth of airport operations and other aviation activities associated with the storage and handling of aviation fuels (ATAG, 2014). The Climate Change Act (2008) defined what it is required to quantify and report emissions of the following greenhouse gases (GHGs): carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Some organizations already report emissions data for regulatory schemes such as the EU Emissions Trading System (2015), the Climate Change Act (2008) or the CRC Energy Efficiency Scheme (2015). The total GHG emissions of an organization are known as its corporate carbon footprint. In most areas, air quality is regulated by a combination of national, regional or local regulations that establish standards on emissions sources or ambient (outdoor) levels of various pollutants, and define the procedures for achieving compliance with these standards.

2.6.2 Greenhouse Gases

A number of gases contribute to climate change. The Kyoto Protocol – the international agreement addressing climate change - covers six main GHGs: carbon dioxide (CO_2), methane (CH_4), hydrofluorocarbons (HFCs), nitrous oxide (N_2O), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). GHGs trap heat in the atmosphere; hence, they are called greenhouse gases. This section provides information on emissions and the removal of the main greenhouse gases to and from the atmosphere (Environmental Protection Agency 2015). Carbon dioxide (CO_2) enters the atmosphere through the burning of fossil fuels (coal, natural gas and oil), solid waste, trees and wood products, and the result of certain chemical reactions (e.g., manufacturing of cement). Carbon dioxide is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle. Methane (CH_4) is emitted during the production and transport of coal, natural gas and oil. Methane emissions also result from livestock and other agricultural practices, and by the decay of organic waste in municipal solid waste landfills. Nitrous oxide (N_2O) is emitted during agricultural and industrial activities, as well as during the combustion of fossil fuels and solid waste. Fluorinated gases (i.e., hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride and nitrogen trifluoride) are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for stratospheric ozone-depleting substances. These gases are typically emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases (High GWP gases). GHG emissions can be reported in terms of the metric tons of gas emitted or metric tons of carbon dioxide equivalent (CO_2e). Gases are converted to CO_2e by multiplying by their global warming potential (GWP). To convert the emission factors listed in the table below to CO_2e, the emissions must be multiplied by the corresponding GWP (Environmental Protection Agency 2015).

2.6.3 Global Warming

Based on the National Oceanic and Atmospheric Administration's (NOAA) data centres, known as the National Centers for Environmental Information (NCEI), the year 2014 was the earth's warmest year since surface temperature measurements began in 1880. Moreover, 14 out of the 15 warmest years on record all happened in the 21st century (NOAA 2015). This is due to carbon dioxide being released into the atmosphere and remaining for 100 to 200 years, causing an increase of carbon dioxide in the atmosphere. Therefore it raises the average temperature on earth.

The emission of greenhouse gases is the major cause of global warming. 72% of the total emitted greenhouse gases are carbon dioxide (CO_2), 18% is methane (CH_4) and 9% is nitrous oxide (N_2O). Therefore, carbon dioxide emissions are the most important cause of global warming and are inevitably created by burning fuels (e.g., oil, natural gas, diesel, organic-diesel, petrol, organic-petrol and ethanol). In addition, the emissions of CO_2 have dramatically increased within the last 50 years and are still increasing by almost 3% each year.

2.6.4 Air Pollutants

There are a variety of air pollutants present as gaseous and particulate emissions from aviation-related activities that can potentially have an impact on human health and the environment. Not all of them are relevant or needed for emission inventories depending on state requirements. Generally the following common species could be considered as primary species with environmental significance and are usually required by current legislation (ICAO 2011).

Table 2.5: The emission gases (ICAO 2011)

Emission species	Symbol
Carbon Dioxide	CO_2
Nitrogen Oxides	NO_x
Nitrous Oxide	N_2O
Sulphur Dioxide	SO_2
Carbon Monoxide	CO
Methane	CH_4
Volatile Organic Compounds	VOC
Particulate matter (PM), fraction size less than 10 microns	PM_{10}
Particulate matter (PM), fraction size less than 2.5 microns	$PM_{2.5}$

2.6.5 Vehicle Movement

Large trucks are mostly powered by diesel engines, in contrast to cars which are mostly powered by gasoline engines. Diesel engines emit the same pollutants as gasoline engines except that they produce much higher amounts of NO_x and $PM_{2.5}$ and lower amounts of VOCs and CO. Diesel PM is considered particularly harmful because the particles are extremely small and can be inhaled easily (Vehicle Emissions 2015). This section provides additional information for other emissions. Nitrogen oxides (NO_x) is created during combustion. Vehicle engines burn a small proportion of the nitrogen that is present in the air plus nitrogen compounds found in vehicle fuels. Diesel engines generally produce much larger amounts of NO_x than gasoline engines due to the higher combustion temperatures. Volatile organic compounds (VOCs) are a group of commonly used chemicals that evaporate when exposed to air. VOCs are a large class of carbon-containing compounds. In vehicle exhaust, VOCs come from unburned or partially-burned fuel. Additional VOC emissions come from the evaporation of fuel (particularly during fueling). Gasoline engines emit a higher proportion of VOCs than diesel engines due to the greater volatility of the fuel. However, given the broad range of VOCs and their multitude of uses, it is not practical to give an exhaustive list of the processes that produce them. The results of a recent study show total global anthropogenic VOC emissions of about 110,000 Gg/yr. A global inventory of volatile organic compound emissions from anthropogenic sources can be found in Piccot et. al. (1991). Carbon monoxide (CO) results from the incomplete combustion of vehicle fuels. Gasoline engines emit a higher proportion of CO than diesel engines, due to the lower combustion temperature. Sulphur dioxide (SO_2) is emitted from the combustion of sulphur contained in the fuel. Most SO_2 is from diesel engines as diesel has much more sulphur than gasoline.

Particle matters (PM), also called particulate matter, is a mixture of solids and liquid droplets floating in the air. Some particles are released directly from a specific source, while others form in complicated chemical reactions in the atmosphere. Particles come in a wide range of sizes. Those that are less than or equal to 10 micrometres in diameter are so small they can get into the lungs, potentially causing serious health problems. Ten micrometres is less than the width of a single human hair. Fine particulate matters ($PM_{2.5}$) some of these tiny particles are formed during combustion (primary PM); others are formed in the atmosphere through chemical reactions between the various pollutants found in exhaust (secondary PM). $PM_{2.5}$ may contain many substances including metals, acids, carbon and polycyclic aromatic hydrocarbons. Diesel engines emit far greater amounts of PM than gasoline engines. Particles can be carried over long distances by wind and then settle on the ground or water. The effects of this settling can make lakes and streams acidic, change the nutrient balance in coastal waters and large river basins, deplete the nutrients in soil, damage sensitive forests and farm crops, and affect the diversity of ecosystems. Particle pollution can also stain and damage stone and other materials, including culturally important objects such as statues and monuments.

2.6.6 Exposure Limits

The Clean Air Act, which was last amended in 1990, requires the EPA to set National Ambient Air Quality Standards (40 CFR part 50) for pollutants considered harmful to public health and the environment. The Act identifies two types of national ambient air quality standards. Primary standards provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children and the elderly. Secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation and buildings. The EPA has set the National Ambient Air Quality Standards for six principal pollutants, called "criteria" pollutants (Table 2.6). Units of measure for the standards are parts per million (ppm) by volume, parts per billion (ppb) by volume, and micrograms per cubic metre of air ($\mu g/m^3$) (Environmental Protection Agency 2015e).

Table 2.6: Exposure limits (national ambient air quality standards) (Environmental Protection Agency 2015e)

Pollutant (final rule cite)		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide		Primary	8 – hour	9 ppm	Not to be exceeded more than once per year
(76 FR 54294, Aug 31, 2011)			1 – hour	35 ppm	
Lead		Primary and secondary	Rolling 3 month	0.15 µg/m³	Not to be exceeded
(73 FR 66964, Nov 12, 2008)			Average		
Nitrogen Dioxide		Primary	1 – hour	100 ppb	98th percentile of 1 - hour daily maximum
(75 FR 6474, Feb 9, 2010)					concentrations, averaged over 3 years
(61 FR 52852, Oct 8, 1996)		Primary and secondary	Annual	53 ppb	Annual Mean
Ozone		Primary and secondary	8 – hour	0.075 ppm	Annual fourth-highest daily maximum
(73 FR 16436, Mar 27, 2008)					8-hr concentration, averaged over 3 years
Particle Pollution	$PM_{2.5}$	Primary	Annual	12 µg/m³	Annual mean, averaged over 3 years
Dec 14, 2012		Secondary	Annual	15 µg/m³	Annual mean, averaged over 3 years
		Primary and secondary	24 – hour	35 µg/m³	98th percentile, averaged over 3 years
	PM_{10}	Primary and secondary	24 – hour	150 µg/m³	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide		Primary	1 – hour	75 ppb	99th percentile of 1 - hour daily maximum
(75 FR 35520, Jun 22, 2010)					
(38 FR 25678, Sep 14, 1973)		Secondary	3 - hour	0.5 ppm	Not to be exceeded more than once per year

2.6.7 Emission Factors

An emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of the pollutant divided by a unit weight, volume, distance or duration of the activity emitting the pollutant (e.g., kilograms of particulate emitted per mega gram of coal burned). Such factors facilitate an estimate of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category (a population average). The general equation for emissions estimation is (ICAO 2011):

$$E = A \times EF$$

Where; E: emissions, A: activity rate, EF: emission factor

2.7 Airport Energy and Fuel Consumption

Airport operations require significant energy consumption before a plane takes off or lands. The daily electricity and thermal power used by a large airport compares to that of a city of 100,000 people (Digital Agenda for Europe 2015). The European Commission has launched a project called "CASCASE - ICT for Energy Efficient Airports" to help airports reduce their energy needs and cut the CO_2 emissions caused specifically by their high-consuming heating, ventilating and air conditioning (HVAC) plants by 20% in the short term. The aim of the project is to help airport maintenance teams implement corrective actions and improve the performance of equipment in their plants. The EPA's POWER STAR program provides guidance on how to save power, save money and protect the environment. The objective of the program is to have products, buildings, and homes that are independently certified to use less power and cause fewer emissions that contribute to climate change (Environmental Protection Agency 2015).

All forms of electricity generation have a different environmental impact on the air, water and land of the total power consumed in the United States. About 40% is used to generate electricity, making electricity use an important part of each person’s environmental footprint (Environmental Protection Agency 2015). Producing and using electricity more efficiently reduces both the amount of fuel needed to generate electricity and the amount of greenhouse gases and other air pollution emitted as a result. Electricity from renewable resources such as solar, geothermal and wind generally does not contribute to climate change or local air pollution since no fuels are combusted. In general, optimizing the design, modifying operating practices, promoting other energy-efficient applications, and switching to cleaner power sources are some of the current opportunities that airports can adopt to encourage sustainable development in commercial air transportation.

2.7.1 Energy Consumption of Pumps and Other Equipment

There are several reasons for saving as much energy as possible from pumps. Any saved energy means a direct saving in costs, but energy saving also contributes significantly to the improvement of the environment. A study by a German energy agency (Dena 2015) revealed that in 2000, the industry in the European Community consumed 951 TWh of energy (1 TWh = 1 000 000 MWh) in total. About 65% of this energy was consumed by machines driven by electric motors, many of which were pumps. Therefore, any saving in pump energy consumption will lead to potentially huge savings. The pump capacity chosen should never be unnecessarily high. The choice of pump capacity does not affect energy consumption when transporting a particular quantity. Although a lower pump capacity means the engine power is lower, the pump will operate longer. So the total amount of energy consumed remains the same. However, a reduction of the pump capacity is important with closed systems. When a lesser amount of liquid with a higher difference in temperature is circulated in these systems, less pump energy will be required. Moreover, such circulation systems are often in continuous operation. It is possible to save many hours' worth of energy during the time these pumps are operating simply by reducing the chosen pump capacity.

The efficiency rate of the pump, transmission and drive should all be kept as high as possible. Energy savings can be achieved by highly efficient pumps and electro-motors, but the efficiency rate will depend largely on the load. It is extremely important to choose and use pumps and drives that are specifically designed for the task. This can be done by calculating what will happen in various operational circumstances. It does not pay to design a system with the best efficiency at design conditions if the system is only rarely going to be used under these conditions. It is worthwhile determining what the most common operating conditions will be at an average load profile over the course of the year. If a system is then designed so it operates most efficiently at that capacity, it will certainly be benefiting from a higher efficiency rate over a long period of time.

2.7.2 Energy Consumption of Buildings

Commercial buildings consume approximately 19% of all energy and account for 18% of all CO_2 emissions in the U.S. By 2035 commercial building floor space is expected to increase by 28% in the U.S. compared to the total floor space area in 2009, reaching 103 billion sq. ft. (U.S. DOE 2012a, 2012b). This makes commercial buildings a significant target for achieving sustainability at airport and fuel handling locations. Energy management is of critical importance in achieving energy conservation and reducing the environmental impact of commercial buildings, and knowledge of future energy consumption can bring critical value in this case (Rivard 2005). For example, the prediction of energy consumption decomposition helps analyze the energy consumption patterns and efficiencies as well as waste, and identifies the prime targets for energy conservation.

2.7.3 Energy Consumption of Vehicles

The fuel economy of an automobile is the fuel efficiency relationship between the distance travelled and the amount of fuel consumed by the vehicle. Consumption can be expressed in terms of volume of fuel to travel a distance, or the distance travelled per unit volume of fuel consumed. Since fuel consumption of vehicles is a significant factor in air pollution, and the importation of motor fuel can be a large part of a nation's foreign trade, many countries impose requirements for fuel economy. Different measurement cycles are used to approximate the actual performance of the vehicle. The energy in fuel is required to overcome various losses (i.e., wind resistance, tire drag) in propelling the vehicle and in providing power to vehicle systems such as the ignition or air conditioning. The average fuel economy in 2008 for new cars, light trucks and SUVs in the United States was 26.4 mpg (8.9 L/100 km). The average fuel consumption of 2008 model year cars classified as "midsize" by the US EPA (2015) ranged from 11 to 46 mpg (21 to 5 L/100 km). However, due to environmental concerns caused by CO_2 emissions, new EU regulations are being introduced to reduce the average emissions of cars sold beginning in 2012 to 130 g/km of CO_2. This is equivalent to 4.5 L/100 km (52 mpg US, 63 mpg imp) for a diesel-fuelled car, and 5.0 L/100 km (47 mpg US, 56 mpg imp) for a gasoline (petrol)-fueled car.

2.8 Airport and Aircraft Fueling

An airport is a complex system consisting of different buildings, facilities and areas (e.g., land side, airside and service area). Figure 2.6 shows a real sample of such a complex system with different buildings and facilities. The airside area is located inside the air operations area and has the highest safety and security restrictions at every airport. The airside area may include but is not limited to runways, taxiways, airside roads and perimeter roads, storm water conveyance systems, storm water detention facilities, electrical lighting systems, navigational aids, airport utility systems, vehicle parking facilities and fencing. The landside area is located outside of the air operations area. This area has much less safety and security restrictions. It may include but is not limited to guard posts, roads, tunnels and bridges, perimeter roads, storm water conveyance systems, storm water detention facilities, electrical lighting systems, airport utility systems, vehicle parking facilities, fencing and railroad (Janic 2010).

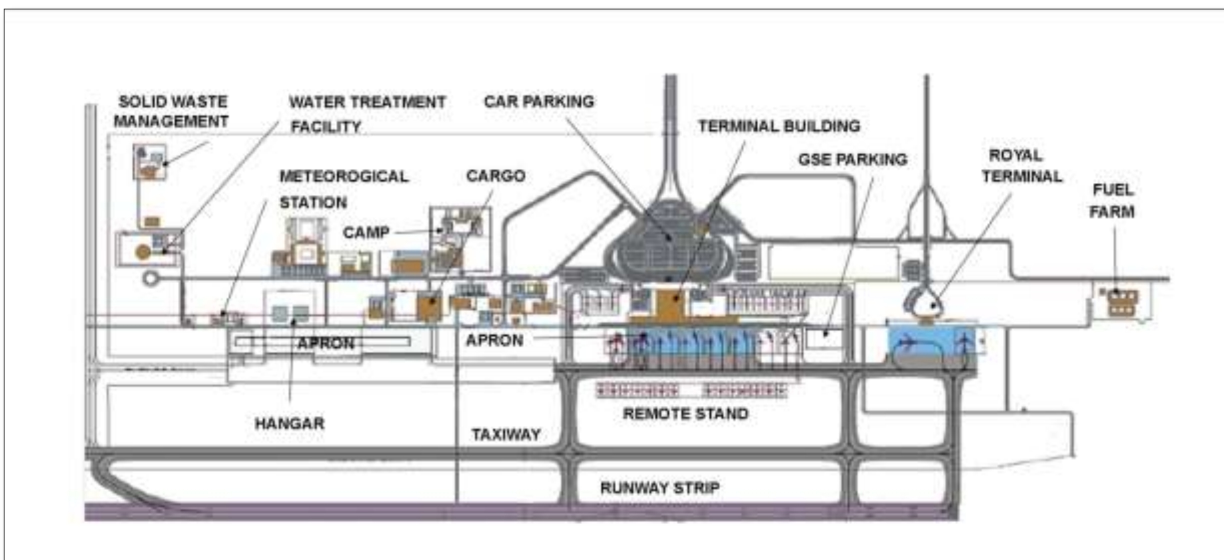


Figure 2.6: Example of airport layout

Aircraft fueling is considered an essential element and service in any airport with much complicated technical design and operations specifications and requirements compared to other ground services. Aircraft fueling consists of fuel system (FS) and into-plane (ITP) services (Figure 2.7) (JIG1, 2016; JIG2, 2016; IATA, 2013). Airport Fuel System includes Tank farm and hydrant system. Tank farm is referred to as the airport fuel depot as well in some airports. It consists of several buildings (e.g., administration, maintenance, control room, pump room, security) in addition to equipment such as aircraft fuel tanks (vertical or horizontal), off-loading rack (fuel receiving pumps, filters and meters), hydrant system pumps, filters and meters, loading rack (fuel loading pumps, filters and meters), pipes, valves and gages, firefighting system (i.e., water tank, foam tank, pumps), controls and instrumentations. Aircraft fuel might be received at tank farm through pipelines or road tankers from refineries or bulk plants. On the other hand, the fuel could be delivered to the aircraft through a “refueler” or “hydrant system”. Hydrant system is an underground pressurized fuel pipeline network from the fuel tank farm to the aircraft parking (apron) area. The fuel could be delivered to the aircraft through a “hydrant dispenser”.

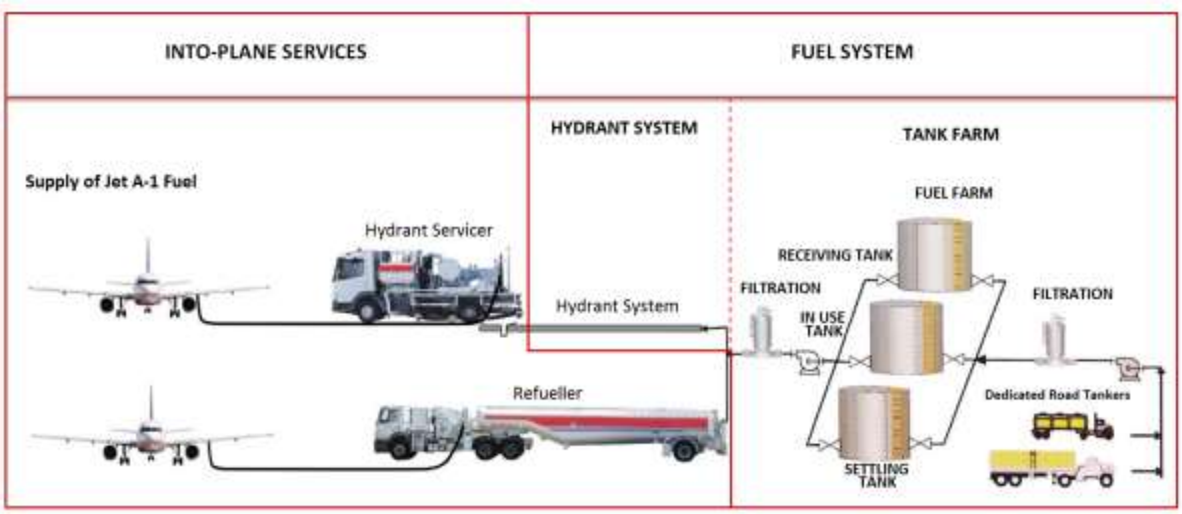


Figure 2.7: Airport fueling system and services

Into-Plane Service (ITP) includes buildings (i.e. administration, operations, maintenance, security) and parking area (for service vehicles and mobile equipment). There are two types of mobile equipment for the into-plane service as illustrated previously in section 1.5 “Research Scope” in details.

2.9 Valuation, Quantification and Aggregation Methods

The following subsections provide an overview of the Multi-Critical Decision Making (MCDM) and the Multi-Attribute Utility Theory (MAUT) methods.

2.9.1 Multi-Criteria Decision Making

The Multi-Critical Decision Making (MCDM) approach was developed over the past decades to solve management problems. It is a structured framework for analyzing decision problems characterized by complex multiple objectives and has two main categories (Ananda & Herath, 2009; Hwang & Yoon, 1981). Multi-Attribute Decision Making (MADM) can be used for the selection of the “best” alternative among other pre-specified alternatives described in terms of multiple attributes. Multi-Objective Decision Making (MODM) can be used for the selection of the alternatives’ designs by optimizing the stakeholders’ multiple objectives. In addition, MCDM has several methods and techniques that are classified into two major groups based on evaluated alternatives (Wallenius et al., 2008; Ananda & Herath, 2009). Continuous methods deal with multiple criteria optimization problems. These methods deal with sets of alternatives that consist of an infinite amount of alternatives defined by a system of equations. Examples of such cases include energy planning, engineering component design, and research and development project selection. Methods such as Linear Programming, Goal Programming and the Aspiration-based Model are considered continuous. Discrete methods deal with multiple criteria discrete alternatives and discrete alternative problems. Examples of such problems include choosing the location for a project and selecting the kind of computer network. Methods such as the Multi-Attribute Utility Theory (MAUT), the Multi-Attribute Value Theory (MAVT), the Analytic Hierarchy Process (AHP) and the Simple Additive Weight (SAW) are the most common discrete methods.

2.9.2 Multi-Attribute Utility Theory

The Multi-Attribute Utility Theory (MAUT) presented by Fishburn (1970) provides the means to evaluate the desirability of multi-attribute consequences and facilitates multi-attribute decision-making. MAUT is an approach that depends on measuring the assessor's preference and starts with unifying decision alternatives into an interval scale (0 to 1). The assessor then assigns weights to their preferences, based on certain techniques, to determine and aggregate the utilities of each alternative. One of the main strengths of MAUT is the ability to deal with both stochastic and deterministic decision environments (Zionts, 1992). The overall evaluation is defined by the following overall function (Schafer, 2001), where v(x) of an object x is defined as the weighted addition of its evaluation with respect to its relevant evaluation dimension:

$$v(x) = \sum_{i=1}^{n} w_i \, v_i(x)$$

where

vi(x): is the evaluation on the i-th dimension di

wi: is the weight (relative importance) of the i-th dimension on the overall evaluation

n: is the number of different dimension, and

$$\sum_{i=1}^{n} w_i = 1$$

The best alternative is the one with the maximum number.

There are many tools within the literature for assessing the sustainability of civil engineering projects. Generally, there are two main approaches for these tools: the Multi-Criteria Analysis (MCA) approach and rating approach (Oltean-Dumbrava et al., 2013). Many sustainability assessment tools use the rating approach, which rates the performance of sustainability criteria for an alternative on a set scale. The alternative with the higher overall score will be considered the most sustainable alternative. The rating approach is widely implemented in different domains due to its simplicity, which is one of its main advantages. However, the MCA approach is more accurate (Oltean-Dumbrava et al., 2013). It starts with identifying the overall decision objective and structuring the criteria that best represents the identified objective. Then one of the multi-criteria decision-making (MCDM) tools (e.g., Multi-Attribute Utility Theory (MAUT) and analytical hierarchy process (AHP)) would be implemented to evaluate the multiple sustainability criteria. The best alternative would be the one with the highest overall aggregated score. MCA approach allows the assessor to identify and analyze all related sustainability criteria in order to facilitate decision making (Duarte & Reis, 2006). In addition, it has the advantage of incorporating both qualitative and quantitative data into the assessment process (Wrisberg et al., 2002). MAUT has been recommended as a methodology for assessing sustainability. It is a flexible and accurate tool that can fit any assessment type (Gasparatos and Scolobig, 2012). MAUT also enables the assessment of a higher number of criteria and alternatives compared to AHP. Whereas AHP derives weights of the criteria by pairwise comparisons, MAUT considers probabilities as the weights of the decision criteria. However, MAUT considers the uncertainty and is less sensitive than AHP. In addition, MAUT's final result will be based on the quantification of the data and the decision maker's expertise while AHP's final result will be based on the decision maker's expertise only (Shanmuganathan et. al., 2018)

2.10 Model Validation

Validation is the process of determining the degree of accuracy of a model in representing the real world from the intended user's perspective (Thacker et al. 2004). The validation process could provide evidence of the model's correctness or accuracy for a specific scenario, and consequently would be sufficiently correct for its intended application. However, the validation process cannot confirm the model's correctness for all potential scenarios or applications (Thacker et al. 2004). The model validation method could be determined based on the model type and intended application, yet it varies from domain to domain. Therefore, there is no single standard method or tool for validation presented in the literature.

Construction project sustainability criteria could be validated using several methods such as questionnaire-based survey, expert interviews, or focus groups (Ugwu et al. 2006b; Oltean-Dumbrava et al. 2013). A questionnaire-based survey is a detailed questionnaire that would usually be shared with experts to evaluate the identified criteria. Then, the participants' feedback would be analyzed statistically for validation. Expert interview is a method that would formally interview and survey a number of domain's experts to evaluate the model. Those selected would be based on their years of experience in the field and the diversity of their expertise. The interview would include a survey to test the applicability, categorization, representation and usability of the model. Focus groups are a fast, widely used and cost-effective method to gather the opinions of a group of people (potential users) about a certain product or idea (Kontio et al.

2004). A detailed demonstration of the model and its functionality would be conducted for a group of six to eight potential users. Then the users would be asked to use the model and fill out a questionnaire for their feedback. Despite their advantages, focus groups have several limitations such as the tendency for some participants to dominate the research process and the difficulty for other participants' thoughts to emerge (Smithson 2000). Another concern is how discussing a topic in a focus group session can lead to another topic. Raising and discussing several related topics during a session's limited time can also be a challenge for the focus group's moderator. Therefore, focus groups should be used with these limitations in mind.

This literature review was conducted to identify existing validating methods for MAUT and other similar multi-attribute decision making methods. The literature covered many applications of MCDM in several domains (e.g., engineering, healthcare, management). Table 2.7 summarizes several literature sources for related applications (multi-criteria selection or evaluation).

Table 2.7: MCDM Literature review summary

Author	**Year**	**Field/Area**	**Decision Tool**	**Validated by**
Chang	2008	Management	MAUT	Case study
Claudio & Okudan	2010	Healthcare	MAUT	Case study
Feeny et al.	2002	Healthcare	MAUF	Survey and statistical analysis
Dey	2006	Management	AHP	Case study
Duarte & Reis	2004	Engineering project management	MAVT	Case study
Myllyviita et al.	2013	Bioenergy	AHP	Case study
Sun and Li	2010	Aerospace engineering	SAW	Case study
Ugwu et al.	2006a & b	Construction management	SAW	Case study
Ustinovichius et al.	2007	Construction management	MCDM	Case study
Yadollahi et al.	2014	Civil engineering	AHP	Case study

The above-mentioned literatures from different domains (e.g., engineering, management, healthcare) are related to multi-criteria evaluation or selection problems that are similar to this research problem. Different MCDM models (e.g. MAUT, AHP, SAW) were validated by case studies. Using case studies for validation provides flexible and real data, studies the full and real complexity of the model, and has the ability for generating hypotheses (Fortunet and Quevedo 2005).

CHAPTER 3 : Methodology

This chapter presents the methodology used to achieve the four research objectives. It starts with the methodology for development of a sustainability model for airport fueling projects. Then, the chapter presents the methodology for development of aircraft fueling emissions and energy consumption analysis models for airport fueling projects. Finally, the chapter describes the methodology of evaluation conducted through a focus group session and two case studies for all three research objectives.

3.1 Objective #1: Development of a Sustainability Model for Airport Fueling Projects

This section presents the methodology for the development of a sustainability model for airport fueling projects that consists of two main subsections: identifying the sustainability criteria for the research model and the development of the sustainability assessment model.

3.1.1 Identifying Sustainability Criteria

The Top-Down-Bottom-Up (TDBU) methodology has been used to identify the relevant set of sustainability assessment criteria for civil engineering projects (Oltean-Dumbrava et al. 2013). The TDBU main steps for identifying the sustainability criteria of an airport fueling project during its life cycle are summarized below (Figure 3.1).

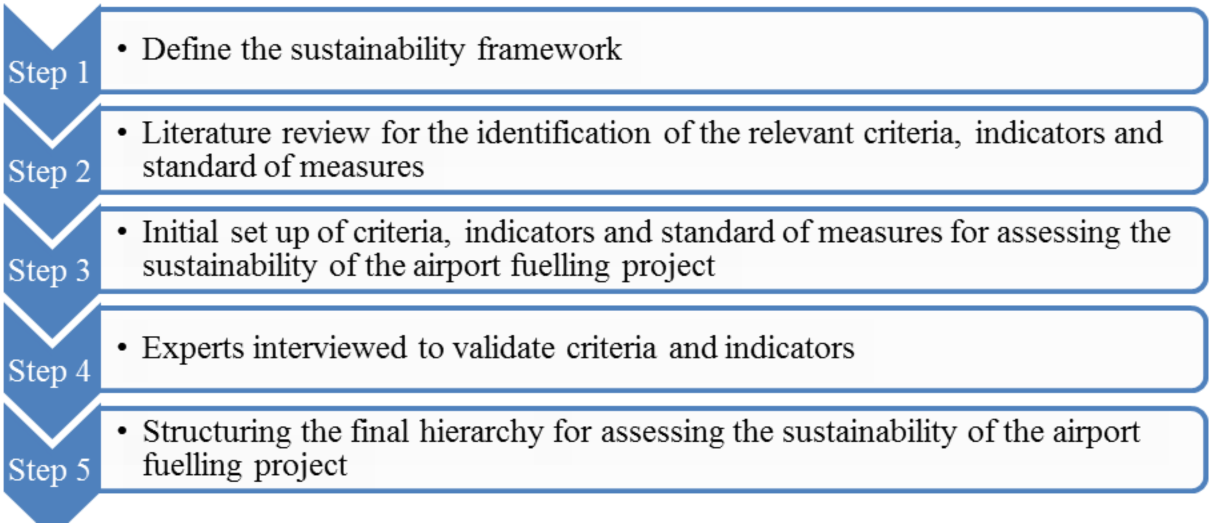


Figure 3.1: TDBU main steps

TDBU methodology starts by defining sustainability dimensions among stakeholders, the assessment framework, and the initial potential set of main criteria, indicators and standard of measures that characterize the sustainability of the airport fueling project. Then, it will involve validating the proposed set of sustainability (economic, environmental and social) criteria through interviews and questionnaire surveys with experts. Consequently, a final set of criteria for an airport fueling project will be defined.

3.1.1.1 Factors for Selection of Sustainability Assessment Criteria:

The selection of sustainability assessment criteria and indicators for the airport fueling project depends mainly on a number of factors. This research considered the following factors; 1) comprehensive enough to cover the main sustainability dimensions aspects (economic, environmental and social), 2) relevance to airport fueling project by careful selection, revisiting, and refining of criteria and indicators, 3) applicability to a broad range of airport fueling project-related working environments and needs, 4) diversity to cover both qualitative and quantitative criteria and indicators, and 5) systematic in a way that could provide an organized and simple implementation approach.

3.1.1.2 Define the Sustainability Framework:

Defining sustainability and framework, where the criteria and indicators will be arranged, is the first important step of TDBU methodology. A practical definition that could be agreed upon and utilized among stakeholders is needed before any assessment, as some assessments consider different dimensions and factors (i.e. technical, operational). Therefore, this research defines the sustainability of airport fueling projects as the ideal consideration of economic, environmental, and social factors during the design, construction, operation, maintenance, and demolition phases of the project. Consequently, the sustainability framework will consider the economic, environmental and social dimensions during the airport fueling projects' life cycles.

3.1.1.3 Literature Review for the Identification of Potential Relevant Criteria, Indicators and Standard of Measures:

The literature review involved: 1) Reviewing the literature concerning general sustainability dimensions, criteria and indicators from other fields. This includes a literature review of academic researchers as well as guidelines and best practices. 2) Reviewing the literature on sustainability dimensions, criteria and indicators for other civil engineering projects (i.e., buildings, roads, bridges, tunnels) in addition to other airport facility-related projects (i.e., terminals, other buildings, taxiways, runways). 3) Reviewing the literature pertaining to airport fueling projects and their specific sustainability, as well as the related standards, regulations, manuals, guidelines and best practices. 4) Reviewing the literature on the economic, environmental and social impacts of airport fueling projects across their entire life cycles. 5) Reviewing the literature on existing assessment tools and databases currently used for assessing sustainability (in general and for other industries) to further identify potential criteria, indicators and standard of measures that could be transferrable or adapted to suit the context of airport fueling projects. This step will also evaluate the possibility of any transferrable criteria or indicators from other sustainability projects, with its results to be added to the potential criteria, indicators and standard of measures database for screening at a later stage.

3.1.1.4 Structuring the Initial Hierarchy of Criteria and Indicators:

This step is to structure a tentative hierarchical set of relevant sustainability assessment criteria, indicators, and standard of measures for assessing the sustainability of the airport fueling project.

3.1.1.5 Expert Interview and Validation:

Experts reviewed and validated the initial proposed set of criteria and indicators for the whole project life cycle for airport fueling. The experts' validation process started by an interview followed by a questionnaire survey to evaluate the usability, categorization, representation, coverage and quality of the hierarchy in a structured manner (appendix K). Experts' interviews were to enhance the knowledge of the main sustainability issues that might need to be considered during the airport fueling project life cycle and to validate the proposed initial hierarchy. Questionnaire surveys filled out by the experts and analyzed their feedback to validate the proposed primary hierarchy, including a series of criteria for the sustainability assessment of airport fueling projects. A questionnaire-based survey contains the proposed set of sustainability criteria, whereby the respondents were asked to rate, rank, add, or remove criteria. In addition, the respondents had the ability to validate and comment on the proposed set of sustainability criteria. The questionnaire consists of two major parts. The first part addresses the three sustainability factors (economic, environmental and social) and asks the respondents to rank the related primary criteria in terms of their relative importance. The respondents had also given the choice to add or remove primary criteria. The second part asks the respondents to rate on a 5-point Likert scale how important they consider each primary and secondary criterion, where 1 =

Very important, 2 = Important, 3 = Moderately important, 4 = Of little importance, 5 = Unimportant. An option is also provided to add any further primary criteria they consider important for assessing the sustainability of airport fueling projects.

The sustainability criteria validation questionnaire-based survey conducted to gain a range of responses from a group of experts. Selecting these respondents was based on different criteria that include: 1) Expertise in airport construction and operations, and aircraft fueling operations (including familiarity with the challenges and needs of planning, design, construction, operations and maintenance). 2) Covering different sub-domains of airport fueling construction and operations (design, planning, construction, operation, maintenance, safety, quality and security). 3) Awareness of airport sustainability development-related issues. 4) At least five years of professional experience in the industry. The calculation of Kendall's coefficient of concordance for the ranking data and the two-way analysis of variance (ANOVA) for the rating data for each criterion with their standard deviation were primarily used to analyze the data collected in determining the experts' agreement for the said criteria (Oliterean-Dumbrava et al. 2014).

A general question included to determine which sustainability factors the respondents think are the most important to consider throughout the whole life of the airport fueling project. Respondents had been asked to rank the three sustainability factors (economic, environmental and social) in the order of importance, with rank position 1 denoting the most important to consider and rank position 3 denoting the least important. Then, the experts had been asked to validate the proposed set of primary economic, environmental and social criteria for the sustainability assessment of airport fueling projects, and quantify their significance. In particular, they had been asked to: rank the four proposed primary criteria in order of relative importance (1 to 4), propose additional criteria that may be worth including in the assessment and rate the primary criteria in the 1-5 Likert scale, where 1 = Very important, 2 = Important, 3 = Moderately important, 4 = Of little importance, 5 = Unimportant.

3.1.1.6 Final Set of Sustainability Criteria:

The final hierarchy of the sustainability criteria and indicators for the airport fueling project had been revised based on the experts' validation. Their feedback had been analyzed in order to remove, add, and validate the criteria, indicators, and standard of measures through a quantitative and qualitative analysis of the questionnaire surveys.

3.1.2 Sustainability Assessment Model

The basic assumption for formulating the mathematical model for airport fueling project sustainability assessment was adopted from previous MCA approaches, such as the Sustainability Appraisal in Infrastructure Projects (SUSAIP) (Ugwu et al. 2006a), that included the following:

The discrete set of possible project Alternatives (A) is represented as: A= {A1, A2, …, Am}.

The sustainability Dimensions (D) (economic, environmental, and social) denoted as: D={D1, D2, …, Dd}, as the mathematical model provide the flexibility to consider more sustainability dimensions (e.g., Technical).

The sustainability Dimensions' Weights (WD) presented by a scalar vector: WD=(WD1, W D2, …, W Dn)T

The sustainability Criteria (C) are denoted by: C={C1, C2, …, Cn}.

The sustainability Criteria' Weights (WC) presented by a scalar vector: WC=(WC1, WC2, …, WCn)T

The mathematical model formulation begins by considering the assessment of the airport fueling project sustainability problem as a decision-making problem with M project alternative (A), K sustainability dimensions (D), and N sustainability criteria (C) as follows:

Each project alternative denoted as Ai, where (i= 1, 2, …, M).

Each sustainability dimension denoted as Dd, where (d= 1, 2, …, K).

For each sustainability dimension Dd, stakeholder assigns a weight WDd.

Each sustainability criterion denoted as Cj, where (j= 1, 2, …, N).

For each sustainability criterion Cj, stakeholder assigns a weight WCj.

Consequently, the performance measure of a given project alternative Ai with respect to sustainability criterion Cj is assigned as aij (for i= 1, 2,…M and j= 1,2, …N).

The sustainability evaluation translated into a multi-criteria decision-making (MCDM) problem is presented in the following decision matrix table (Table 3.1):

Table 3.1: Sustainability evaluation decision matrix

	D1		D2		D_K	
Project Alternative	W_{D1}		W_{D1}		W_{DK}	
A1	C_1	C_2	C_3	C_4	C_5	C_N
A2	W_{C1}	W_{C2}	W_{C3}	W_{C4}	W_{C5}	W_{CN}
	$a_{1.1}$	$a_{1.2}$	$a_{1.3}$	$a_{1.4}$	$a_{1.5}$	$a_{1.N}$
A_m	$a_{2.1}$	$a_{2.2}$	$a_{2.3}$	$a_{2.4}$	$a_{2.5}$	$a_{2.N}$
	$a_{3.1}$	$a_{3.2}$	$a_{3.3}$	$a_{3.4}$	$a_{3.5}$	$a_{M.N}$

Key: Ai: Project Alternative i, Dd: Sustainability Dimension d, WDd: Weight assigned to Dd, Cj: Sustainability Criterion j, WCj: Weight assigned to Cj, ai,j: assigned utility of Ai on a given Cj .

The sustainability index for each project alternative has been determined using the Multi-Attribute Utility Theory. The index has been defined as the overall sustainability index resulting from aggregating all sustainability criterion utilities of a project alternative along with its sustainability dimensions (economic, environmental and social) (Ugwu et al. 2006a). Similarly, each sustainability dimension index (SDI) has been determined by aggregating the utilities of the related sustainability criteria (economic, environmental and social). Consequently, the sustainability index of project alternative Ai denoted as: SIi (for i= 1, 2, …, M), and the sustainability dimension index of project alternative Ai and sustainability dimension Dd denoted as: SDIid (for i= 1, 2, … M and d= 1, 2, …, K).

According to MAUT, SIi of project alternative Ai can be calculated as a weighted addition of evaluation with respect to sustainability dimensions using the following formulas (Schafer 2001):

$$SI_i = \sum_{d=1}^{K} SDI_{id}\ W_{Dd}$$

where WDd is the important weight that will be assigned by the stakeholder to sustainability dimensions and:

$$\sum_{d=1}^{K} W_{Dd} = 1$$

K=3 in the case of three sustainability dimensions only (economic, environmental and social). However, the model has the flexibility to consider more sustainability dimensions.

For each sustainability dimension Dd, the related sustainability dimension index SDIid is defined as

$$SDI_{id} = \sum_{j \in Dd} a_{dj}\ W_{dj}$$

where

$$\sum_{j \in Dd} W_{dj} = 1$$

and Dd is the set of sustainability criteria relevant sustainability dimension d.

The preferred project alternative will be the one that gives the highest value of the sustainability index.

3.2 Objective #2: Development of Emissions Analysis Model for Airport Fueling Projects

This section presents the methodology for the development of aircraft fueling emissions analysis model for airport fueling projects. It starts with the summary of research equations contributions related to the second research objective followed by the details of equations and calculations related to aircraft fueling emissions.

3.2.1 Summary of Research Equations Contributions

Table 3.2 below summarizes the used equations and highlights the research contribution with respect to emissions calculation. Where “New” shows the new contribution introduced in this research, where no previous equations in the literature considered airport fueling services activities; “Adopted with extension” refers to an in-depth extension of current equations in the literature that have been introduced in this research to cater for coverage of airport fueling project operation sub-elements. This extension will facilitate the implementation of current initiatives and equations for the airport fueling project domain; “Adopted” means adopted from current equation in the literature for implementation without any extension.

Table 3.2: Summary of research contribution for emission calculation

Research contribution	Airport fueling project emission	Current calculation method		Research contribution	
		Equation number	Limitation	Equation number	Description
Adopted with extension	Overall airport fueling emissions	1	Current equation is a high-level abstract formula not covering detailed implementation of airport fueling project sub-elements	3	Providing detailed analysis of operational related emissions
Adopted	Aircraft fueling and defueling	4 & 5	- -	- -	- -
Adopted with extension	Fuel storage and handling	6	Current equation is high level abstract not covering detailed implementation of airport fueling project sub-elements	8	Providing detailed analysis of operation related emissions and comprehensive framework for detailed calculations
New	Hydrant system routine operations	N/A	Fueling system: No equations in place	9 & 10	Introducing Evaporative (VOC) emissions from the vents of the hydrant low point vehicle, during flushing operations
		11	Vehicle/Tuck: Current equation is high level abstract not covering detailed implementation of airport hydrant flushing mobile equipment operation	14	Introducing several emissions operational factors that affect the overall engine running time of hydrant flushing mobile equipment (e.g. number of hydrant pits, flushing quantity)
Adopted with extension	Vehicles and mobile equipment traffic	11	Vehicle/Tuck: Current equation is high level abstract not covering detailed implementation of airport fueling mobile equipment operation	12	Introducing several emission operational factors that affect the overall engine running time of refueling (e.g. the uplift size, the delivery flow rate)

3.2.2 Emission Model Equations and Calculation

The general equation for calculating emissions of airport fueling available in the literature is (ICAO 2011):

$$\text{Total Emission} = \text{Total Emissions (kg VOC)} + \text{Total Emissions (Total } CO_2\text{)} \qquad (1)$$

Equation (1) could be expanded based on this research detailed investigation and analysis of airport fueling project and its elements and operation understanding as follow:

$$\begin{aligned} = & (\text{VOC Aircraft refueling emissions}) + (\text{VOC Fuel storage and handling related emissions}) \\ & + (\text{VOC Hydrant system operations emissions}) \\ & + (CO_2 \text{ Vehicle traffic emissions}) \end{aligned} \qquad (2)$$

$$\begin{aligned} = & (\text{VOC Emissions from fueling equipment vents during loading tank trucks} + \\ & \text{VOC Emissions from the aircraft tank}) + (\text{VOC Emissions from standing storage tanks} + \\ & \text{VOC Emissions from filling storage tanks} + \\ & \text{VOC Hydrant lowpoint emissions from hydrant lowpoint flushing operations}) + \\ & (CO_2 \text{ Emissions from refulling vehicle exhausts} + \\ & CO_2 \text{ Emissions from hydrant lowpoint flushing vehicle exhausts}) \end{aligned} \qquad (3)$$

The details of each item at these equations will be explained in more detail in the following sections based on Table 3.2.

3.2.2.1 Aircraft Fueling and Defueling Operations Emissions:

$$\text{Emissions from refueler vents during loading tank trucks [kg VOC]} = \text{(Jet fuel loaded into refuelers} \times \text{Jet fuel density} \times \text{Jet fuel emission factor} + \text{Avgas loaded into refuelers} \times \text{Avgas density} \times \text{Avgas emission factor)} \quad (4)$$

$$\text{Emissions from the aircraft tank during fueling [kg VOC]} = \text{(Jet fuel delivered by hydrant dispensers} \times \text{Jet fuel density} \times \text{Jet fuel emission factor} + \text{Jet fuel delivered by refuelers} \times \text{Jet fuel density} \times \text{Jet fuel emission factor} + \text{Jet fuel defuelled from aircraft into a tank truck} \times \text{Jet fuel density} \times \text{Jet fuel emission factor} + \text{Avgas delivered by refuelers} \times \text{Avgas density} \times \text{Avgas emission factor)} \quad (5)$$

The application of the above equations require an in-depth understanding of aviation operations, operations of hydrant dispensers and of the principles of hydrant fuel systems, operations of mobile refueling equipment (refuelers) and of aircraft refueling operations. Operation of hydrant dispensers, where fuel is supplied by an underground network of fuel pipes (Hydrant system), through an intake hose which is connected to an appropriate supply point of the hydrant system (hydrant pit valve) and through a closed-circuit which includes rigid pipework, filter, meter, to the delivery hose which is connected to the aircraft fuel adapter. The fueling operation is closed-circuit, hence the only emissions occurring during aircraft fueling by means of hydrant dispensers are the emissions from the aircraft vents, while the delivered fuel volume is progressively displacing an equal volume of fuel vapors from the aircraft tanks to the atmosphere through the aircraft vents. Operation of tank trucks (refuelers), a different type of operation where fuel delivered by a fuel-containing tank on a mobile refueling truck (semi-rigid or trailer). Fuel is loaded into the tank-truck from the airport storage, generating emissions from the refueler vents, while the loaded fuel volume is progressively displacing an equal volume of fuel vapors from the refueler tank to the atmosphere through the refueler vents. In addition, the fuel delivered to the aircraft will also generate an equal amount of fuel vapors from the aircraft vents, while the delivered fuel volume is progressively displacing an equal volume of fuel vapors from the aircraft tanks to the atmosphere. The uplift size (amount of delivered fuel to the aircraft) and subsequently the amount of emitted fuel vapors will vary significantly, depending on a number of parameters that need careful consideration for the effective calculation of emissions, including the aircraft type. Aircraft refueling operation depends on other factors such as long haul vs short haul flights, modern or older aircraft models, with different fuel consumption rates and as a result with different uplift demands for the same distance travelled.

3.2.2.2 Fuel Storage Tanks and Handling:

Fuel storage tanks emit VOC from both “standing” (storage) and “working” (withdrawal or refilling) activities. Important variables that have an effect on the amounts of emissions released include the vapor pressure of the fuel, the storage and throughput volumes, the types of tanks (e.g. above-ground, floating roof) and climate conditions (temperature and humidity). Both “standing” and “working” evaporative emissions will be considered in the calculations as follow (ICAO 2011):

$$\text{Evaporative emissions from storage tanks [kg VOC]} = \text{Evaporative emissions from standing storage tanks} + \text{Evaporative emissions from working storage tanks} \quad (6)$$

Which could be expanded based on the research investigation and analysis of airport fueling projects and operations understanding as follows:

$$= \text{Number of Jet fuel tanks} \times (\text{breathing loss} + \text{standing loss} + \text{flashing loss}) + \text{Number of Avgas tanks} \times (\text{breathing loss} + \text{standing loss} + \text{flashing loss}) \quad (7)$$

$$= \text{Number of Jet fuel tanks} \times (\text{Turnovers Jet fuel tanks} \times \text{Jet fuel vapor density} \times \text{Jet fuel vapor expansion factor} \times \text{Jet fuel vapor saturation factor} \times \text{fraction ROG} - \text{Evaporative losses} + \text{Jet fuel molecular weight} \times \text{TVP} \times \text{throughput} \times \text{turnover factor} \times \text{production factor} \times \text{fraction ROG} - \text{evaporative losses} + \text{Jet fuel throughput} \times \text{vented vapor volume} \times \text{vapor density} \times \text{fraction ROG} - \text{flashing losses}) + \text{Number of Avgas tanks} \times (\text{Turnovers Avgas tanks} \times \text{Avgas vapor density} \times \text{Avgas vapor expansion factor} \times \text{Avgas vapor saturation factor} \times \text{fraction ROG} - \text{evaporative losses} + \text{Avgas molecular weight} \times \text{TVP} \times \text{throughput} \times \text{turnover factor} \times \text{product factor} \times \text{fraction ROG} - \text{evaporative losses} + \text{Avgas throughput} \times \text{vented vapor volume} \times \text{vapor density} \times \text{fraction ROG} - \text{flashing losses}) \quad (8)$$

The implementation of the above calculations requires an in-depth understanding of the different types and designs of tanks, as determined by international specifications and standards. There are different design of aviation storage tanks, such as horizontal or fixed roof vertical tanks or fixed roof vertical tanks with an internal floating roof or cover. Tanks shall be fitted with pressure or vacuum relief valves for above-ground tanks storing Avgas, which control the emissions for the more volatile Avgas vapors. Free vent devices may be used for buried Avgas tanks and for jet fuel storage. For locations storing Jet fuel where high ambient temperatures are expected, pressure or vacuum relief valves may be installed in place of free vents, or additional safeguards. Free vents are fitted with screens to prevent the ingress of foreign bodies with a coarse mesh of approximately 5mm (0.2 inch) holes. Local legislation may also require the use of flame arrestors. The above design specifications shall be carefully determined as the standing and breathing losses through the tank vents will depend on the specific configuration of each storage tank. The provision of fuel recovery systems or recovery storage tanks is required by international operating standards and operational practice. Therefore, the calculations for emissions from fuel storage shall also include the recovery systems, in addition to storage tank systems.

The operation of aviation storage tanks is a key. Settling times (for the settlement of free water and sediments) following product receipt is a mandatory procedural provision for aviation fuel storage, in accordance with international industry standards. The settling times will range from one hour up to 24 hours. One hour for horizontal tanks that meet a minimum set of design requirements. Two hours for vertical tanks that meet a minimum set of design requirements. Up to 24 hours for tanks that lack some of the minimum design requirements expected by the international operating standards. The determination of the settling period, depending on the design and local practice, during which there are evaporative emissions from standing storage tanks, is critical for the effective calculation of the emissions. For product quality purposes, for a storage tank that is in service, the valves of the inlet lines are required to remain closed, as it is not permitted to receive product for a tank supplying the airport. When the contents of the tank have been exhausted, and the level of the fuel in the tank has been lowered down to a minimum height, the tank may receive product again up to max permitted capacity. During the service period of a tank, a working loss is not expected but evaporative emissions from standing storage tanks shall be calculated. Therefore, the determination of whether a tank is in service or not is critical for the effective calculation of the emissions. For tanks in receipt mode, evaporative emissions shall be calculated. As fuel is loaded into the storage tank, emissions are generated while the loaded fuel volume is progressively displacing an equal volume of fuel vapors from the storage tank to the atmosphere through the tank vents.

3.2.2.3 Hydrant System Operations:

Emissions from routine hydrant operations that will be addressed in this research include: 1) Evaporative (VOC) emissions from the vents of the hydrant low point vehicle, during low point flushing operations. 2) Vehicle exhaust emissions from the movement of the hydrant low pint flushing vehicle.

$$\text{Hydrant lowpoint vehicle emissions from hydrant low point flushing operations [kg VOC]} = \text{Emissions from hydrant low point flushing vehicle vents during loading from low points} \quad (9)$$

$$= \text{Number of low points flushed} \times \text{Average quantity flushed per low point} \times \text{Jet fuel density} \times \text{Jet fuel emission factor} \quad (10)$$

The calculations of the above equations require an in-depth understanding of hydrant operations and low point flushing activities. The design of hydrant systems (pipework) is such that low points are formed, where free water and sediment are expected to accumulate and therefore should periodically be removed, through a low point flushing operation has to be conducted periodically. The loaded fuel volume is progressively displacing an equal volume of fuel vapors from the low point flushing vehicle to the atmosphere through the vehicle vents. The understanding of the operations and determination of the number of flushing operations performed for every low point are critical parameters for the effective calculation of the emissions. The requirement in the operating standards is every hydrant low point must be flushed at least weekly. Therefore, the number of low points flushed every day at an airport location will depend on the size of the airport, size of the hydrant system and number of low points, as well as on the availability of low point flushing vehicles and operators allocated to that task. An effective determination of the size of the system in terms of number of low points and the operating capability are critical parameters for the effective calculation of the emissions.

3.2.2.4 Vehicle and Mobile Equipment Exhaust Emissions:

Emissions from airport-related surface transportation can constitute a significant portion of the total emissions associated with airport activities. This research focuses on methods for calculating emissions from both landside and airside "on-road" motor vehicles and fueling mobile equipment (i.e. refuelers, dispensers) as follows (ICAO 2011):

$$\text{Vehicle exhaust emissions} =$$
$$\text{Emissions from vehicle exhausts [kg VOC]} + \text{Emissions from vehicles} = \text{exhausts [kg } CO_2\text{]} \quad (11)$$

Which could be expanded based on this research detailed investigation and analysis of airport fueling projects as follow:

$$\text{Total emissions VOC} + \text{Total Emissions } CO_2 =$$

$$\text{Total Road length HDDV (Heavy Duty Diesel Vehicles)} \times \text{VOC Emission factor (driving)} +$$
$$\text{Total Road length HDGV (Heavy Duty Gasoline Vehicles)} \times \text{VOC Emission factor (driving)} +$$
$$\text{Total Road length LDDV (Low Duty Diesel Vehicles)} \times \text{VOC Emission factor (driving)} +$$
$$\text{Total Road length LDGV (Low Duty Gasoline Vehicles)} \times \text{VOC Emission factor (driving)} +$$
$$\text{Total Idle time HDDV} \times \text{VOC Emission factor (idling)} + \text{Total Idle time HDGV} \times$$
$$\text{VOC Emission factor (idling)} + \text{Total Idle time LDDV} \times \text{VOC Emission factor (idling)} +$$

$$\text{Total Idle time LDGV} \times \text{VOC Emission factor (idling)} +$$
$$\text{Total Road length HDDV (Heavy Duty Diesel Vehicles)} \times CO_2 \text{ Emission factor (driving)} +$$
$$\text{Total Road length HDGV (Heavy Duty Gasoline Vehicles)} \times CO_2 \text{ Emission factor (driving)} +$$
$$\text{Total Road length LDDV (Low Duty Diesel Vehicles)} \times CO_2 \text{ Emission factor (driving)} +$$
$$\text{Total Road length LDGV (Low Duty Gasoline Vehicles)} \times CO_2 \text{ Emission factor (driving)} +$$
$$\text{Total Idle time HDDV} \times CO_2 \text{ Emission factor (idling)} + \text{Total Idle time HDGV} \times$$
$$CO_2 \text{ Emission factor (idling)} + \text{Total Idle time LDDV} \times CO_2 \text{ Emission factor (idling)} +$$
$$\text{Total Idle time LDGV} \times CO_2 \text{ Emission factor (idling)} + CO_2 - \text{e factor for } CH_4 \text{ (25)} \times$$
$$\text{Total Road length HDDV (Heavy Duty Diesel Vehicles)} \times CH_4 \text{ Emission factor (driving)} +$$
$$\text{Total Road length HDGV (Heavy Duty Gasoline Vehicles)} \times CH_4 \text{ Emission factor (driving)} +$$
$$\text{Total Road length LDDV (Low Duty Diesel Vehicles)} \times CH_4 \text{ Emission factor (driving)} +$$
$$\text{Total Road length LDGV (Low Duty Gasoline Vehicles)} \times CH_4 \text{ Emission factor (driving)} +$$
$$\text{Total Idle time HDDV} \times CH_4 \text{ Emission factor (idling)} + \text{Total Idle time HDGV} \times$$
$$CH_4 \text{ Emission factor (idling)} + \text{Total Idle time LDDV} \times CH_4 \text{ Emission factor (idling)} +$$
$$\text{Total Idle time LDGV} \times CH_4 \text{ Emission factor (idling)} + CO_2 - \text{e factor for } N_2O \text{ (295)} \times$$
$$\text{Total Road length HDDV (Heavy Duty Diesel Vehicles)} \times N_2O \text{ Emission factor (driving)} +$$
$$\text{Total Road length HDGV (Heavy Duty Gasoline Vehicles)} \times N_2O \text{ Emission factor (driving)} +$$
$$\text{Total Road length LDDV (Low Duty Diesel Vehicles)} \times N_2O \text{ Emission factor (driving)} +$$
$$\text{Total Road length LDGV (Low Duty Gasoline Vehicles)} \times N_2O \text{ Emission factor (driving)} +$$
$$\text{Total Idle time HDDV} \times N_2O \text{ Emission factor (idling)} + \text{Total Idle time HDGV} \times$$
$$N_2O \text{ Emission factor (idling)} + \text{Total Idle time LDDV} \times N_2O \text{ Emission factor (idling)} +$$
$$\text{Total Idle time LDGV} \times N_2O \text{ Emission factor (idling)} \qquad (12)$$

$$\text{Emissions from hydrant lowpoint flushing vehicle exhausts [kg VOC]} + \text{Emission from hydrant lopoint flushing vehicle exhausts [kg } CO_2] \quad (13)$$

$$= \text{Total road length HDDV (Heavy Duty Diesel Vehicles)} \times \text{VOC Emission factor (driving)} + \text{Total Idle time HDDV} * \text{VOC Emission factor (idling)} + \text{Total Road length HDDV (Heavy Duty Diesel Vehicles)} \times CO_2 \text{ Emission factor (driving)} + \text{Total Idle time HDDV} \times CO_2 \text{ Emission factor (idling)} + CO_2 - \text{e factor for } CH_4 \text{ (25)} \times \text{Total Road length HDDV (Heavy Duty Diesel Vehicles)} \times CH_4 \text{ Emission factor (driving)} + \text{Total Idle time HDDV} \times CH_4 \text{ Emission factor (idling)} + CO_2 - \text{e factor for } N_2O \text{ (295)} \times \text{Total Road length HDDV (Heavy Duty Diesel Vehicles)} \times N_2O \text{ Emission factor (driving)} + \text{Total Idle time HDDV} \times N_2O \text{ Emission factor (idling)} \quad (14)$$

The application of the above equations requires an in-depth understanding of aviation operations, of types of aircraft and hydrant servicing vehicles and operational practice for driving and standing of vehicles associated with aircraft refueling operations. The application of the above emission equations during mobile equipment is standing with the engine running (idling) is directly associated with the type of the vehicle and the understanding of associated operations details. In accordance with international operating standards, the engines of tank trucks during loading operations shall remain off. Therefore, standing losses are not to be calculated for the fuel loading operations. The engine of the refueling vehicles shall be running throughout the refueling activity. The overall time that the engine is running for the refueling or defueling activity will depend on the uplift size, the delivery flow rate, and the time required prior to commencement of fuel flow depending on the aircraft or customer (e.g. for low cost carriers, the time is minimal). It also depends on the time require post-fueling, prior to departure, and the time required for the vehicle to remain standing at the designated staging areas of the airport until the aircraft has parked in the appropriate stand, the anti-collision lights have been switched off and the chocks at the aircraft tires have been effectively applied. An effective calculation of the emissions during the standing period requires an in-depth analysis of total idle time, considering all factors mentioned above that contribute to the time a vehicle's engine remains idle daily.

The application of the above equations for the emissions during driving is directly associated with the vehicle type, the vehicle engine and the understanding of the operations details. The distance travelled on a daily basis by a hydrant dispenser and a tank truck that delivers the same amount of fuel is expected to vary significantly. A tank truck requires topping up after delivery of the fuel contained in the tank, and depending on the average uplift size at an airport and the distance from the apron to the tank truck loading facility and allowed driving routes by the airport authorities, the overall distance travelled will vary significantly. A hydrant dispenser, on the other hand, is not required to be driven back to its basis after completion of a refueling but may remain parked (in idle position or with the engine switched off) at an appropriate staging area of the airport, until the time of the next refueling. Therefore, an understanding and analysis of the specifics of the operations at an airport location is essential for the correct application of the above calculations.

The emissions of vehicles will vary depending on the engine type (i.e., diesel or gasoline) of the vehicle. However, for aircraft refueling units, most international operating standards prohibit the use of gasoline engines for refueling vehicles, thus calculations for refueling units will be based on emissions of diesel engines. The tank trucks should be considered as heavy duty diesel vehicles, whereas the hydrant dispensers shall be considered as light duty diesel vehicles. The emissions by passenger vehicles used by aircraft fuel supervisors and managers for apron checks and inspections also need to be taken into account. The distance travelled by these vehicles is often quite significant, depending on the size of the airport and the proximity of the airport apron to the facilities of the operation. Therefore, a careful evaluation of distances travelled and of the times the engines of the vehicles remain in idle position is required, with consideration to the different engine types. The distance travelled on a daily basis by hydrant dispensers and tank trucks will also depend on the size of the fleet at the airport, the availability of other refueling units at a given time during the day, taking into account that vehicles will drive longer distances at peak times or during peak periods for seasonal airports (summer or winter destinations) and the shift patterns at an airport. Therefore, an understanding and analysis of the specifics of airport operations at an airport is essential for the effective and accurate application of the above calculations.

3.3 Objective #3: Development of Energy Consumption Analysis Model for Airport Fueling Projects

This section presents the methodology for development of aircraft fueling energy consumption analysis model for airport fueling projects. It starts with the summary of research equations contributions related to the third research objective followed by the details of equations and calculations related to aircraft fueling energy consumption.

3.3.1 Research Equations Contribution Summary

This section summarizes research equations contribution with respect to the third research objective (i.e., the development of energy consumption analysis model for airport fueling projects). Table 3.3 represents the used equations and research contribution related to energy calculations. “New” shows the new contribution introduced at this research, where no previous equations at the literature that considered airport fueling services activities; “Adopted with compilation” refers to a compilation of current energy equations in the literature that have been introduced. This compilation will facilitate the understanding and implementation of current generic equations for the airport fueling project energy consumption elements (i.e., pumps, buildings, instruments, and vehicles); “Adopted” means adopted from current equation in the literature for implementation without any compilation.

Table 3.3: Summary of research contribution form energy consumption calculations

Research contribution	Airport Fueling Project Energy Consumption	Current calculation method		Research contribution	
		Equation number	Limitation	Equation number	Description
New	Overall energy consumption	N/A	No overall equation for airport fueling project energy consumption	15	Introducing main equation for total energy consumption
				16	Introducing main equation for total electric energy consumption
				17	Introducing main equation for total fuel energy consumption
Adopted with compilation	For Pumps	19 & 20	Current equation is generic for pump not covering detailed implementation of airport fueling project operation	18	Developing compiled energy consumption equation for pumps
Adopted with compilation	For Instruments	22 & 23	Current equation is generic for instruments not covering detailed implementation of airport fueling project operation	21	Developing compiled energy consumption equation for instruments
Adopted with compilation	For Buildings	25	Current equation is generic for buildings not covering detailed implementation of airport fueling project operation	24	Developing compiled energy consumption equation for buildings
Adopted with compilation	For Vehicles	27	Current equation is generic for vehicles not covering detailed implementation of airport fueling project operation	26	Developing compiled energy consumption equation for vehicles

3.3.2 Energy Consumption Equation and Calculations

The scope of this research covers the following types of energy consumption related to aircraft fueling elements (i.e. tank farm, hydrant system, building, mobile equipment, service vehicles, and fueling operation): energy consumption by pumps, energy consumption by instruments and energy consumption by buildings, fuel consumption by all vehicles. Therefore, the general equation for calculating energy consumption of aircraft fueling project could be as follow:

$$\text{Total energy consumption} = \text{Total fuel enery consumption} + \text{Total electric energy consumption} \qquad (15)$$

$$\text{Total Electric energy consumption [kWh]} = \text{Energyconsumption by pumps} + \text{Energy consumption by instruments} + \text{Energy consumption by buildings} \qquad (16)$$

$$\text{Total fuel energy consumption [Liter of diesel or Liter of gasoline consumed]} = \text{Total fuel consumption forall service vehicles} + \text{Total fuel consumption for all mobile equipment} \qquad (17)$$

3.3.2.1 Energy Consumption for Pumps

The pumps associated with the airport tank farm and hydrant system include: jet fuel pumps, pumps for slop tanks, transfer or recovery pumps, unloading pumps, foam pumps, fire water pumps and fuel hydrant pumps. Therefore, for an effective calculation of the energy profile of a facility, a precise determination of the number and type of all pumps in accordance with the list above is required. To calculate the energy consumption profile for airport fuel system, it is first essential to understand the specifics of the operation and the application for the pumps under consideration. For pump applications such as product receipt, typically there is only one pump in operation at a time, for a location receiving product by tank trucks. Receipt by pipelines is another complex operation that requires additional energy resources. In addition, for fuel hydrant systems, the pump house will typically comprise a series of pumps required to maintain the pressure at the hydrant system at the range of 10 bars, and a number of pumps will be working concurrently depending on the demand or consumption of fuel from the hydrant system (which varies by airport and for a given airport varies depending on the peak times). Additional pumps will start when the hydrant pressure drops below a certain level. Therefore, the application of the equations for pump energy consumption requires a detailed analysis of the specifics of each operation and consideration of the parameters in Table 3.4.

Table 3.4: Input data for calculation of pumps electricity consumption

Input	Description
# of pumps working concurrently	# of pumps working concurrently
Concurrency factor	Ranging from No operation (0), Low Operation (0.3), High operation (0.7), and Full operation (1)
Operating hours per day	Average number of daily operating hours
Density	JET and/or AVGAS density for the respective pumps and liquid density for other pumps (e.g. for water pumps, density will be specified as 1000kg/m³ and for fire pumps density may be specified as 1200kg/m³)
Output	Output pump flow rate
Delivery height	Delivery height
Efficiency of pump	Data from the manufacturer
Efficiency of motor	Data from the manufacturer

Based on the above in-depth understanding of aircraft fueling operation, that include tank farm and hydrant system operation, the calculations of energy consumption could be summarized as follow:

$$\begin{aligned}&\text{Energy consumption by pumps}\\&\quad = \text{Energy consumption by Pumps for Tank Farm}\\&\quad + \text{Energy consumption by Pumpus for Hydrant system}\end{aligned} \tag{18}$$

$$\begin{aligned}&\text{Energy consumption by pumps for Tank farm}\\&\quad = (\text{Number of pumps in the tank farm working concurrently}\\&\quad \times \text{Concurrency factor } \times \text{Operating hours per day}\\&\quad \times \text{Pump Output flow rate } \left(\frac{\text{m}^3}{\text{Hr}}\right) \times \text{Delivery height (m)} \times \text{Density } \left(\frac{\text{kg}}{\text{m}^3}\right)\\&\quad \times \text{Gravity } (\text{g} = 9.81\frac{\text{m}^2}{\text{s}} \div (\text{Overall efficiency } \times 3.6 \times 10^6))\end{aligned} \tag{19}$$

Energy consumption by pumps for Hydrant system

$$= (\text{Number of hydrant pumps working concurrently } \times \text{Concurrency factor} \times \text{Operating hours per day } \times \text{Pump Output flow rate } \left(\frac{\text{m}^3}{\text{Hr}}\right) \times \text{Delivery height (m)} \times \text{Density } \left(\frac{\text{kg}}{\text{m}^3}\right) \times \text{Gravity (g} = 9.81\frac{\text{m}^2}{\text{s}} \div (\text{Overall efficiency } \times 3.6 \times 10^6)) \quad (20)$$

3.3.2.2 Energy Consumption for Instruments

The instrumentation used at airport tank farm and hydrant system includes the following: electrical actuators, cathodic protection of underground pipelines, hydrant systems and storage tanks, outdoor spotlights on poles, outdoor fluorescent light fittings and instruments. An understanding of the number and type of instruments required concurrently is thus the main factor to be determined for an effective application of the calculations in Table 3.5.

Table 3.5: Input data for calculation of instruments electricity consumption

Input	Description
Electrical actuators	Number of electrical actuators used
Instruments	Number of electrical instruments used
Outdoor spotlights on poles	Number of outdoor spotlights on poles used
Outdoor fluorescent light fittings	Number of outdoor fluorescent light fittings used
Cathodic protection	Number of cathodic protection systems used
Concurrency factor for each of the above	No operation: 0, Low operation: 0.3, High operation:0.7, Full operation: 1
Operating hours	Specify an average number of daily operating hours
Estimated energy consumption	Use data from the manufacturer or use the default values given on the calculator

$$\text{Energy consumption by instruments [kWh]} = \text{Energyconsumption by instruments for tank farm} + \text{Energy consumption by instruments for hydrant system} \quad (21)$$

$$\text{Energy consumption by instruments for tank farm [kWh]} = (\text{Number of instruments in the tank farm working concurrently} \times \text{Concurrency factor} \times \text{Operating hours per day} \times \text{Estimated energy consumption} \quad (22)$$

$$\text{Energy consumption by instruments for hydrant system [kWh]} = (\text{Number of hydrant instruments working concurrently} \times \text{Concurrency factor} \times \text{Operating hours per day} \times \text{Estimated energy consumption} \quad (23)$$

3.3.2.3 Energy Consumption for Buildings

The calculations for the energy consumption of buildings are more straightforward but also require an understanding of the specific design and operating conditions of buildings used by airport operators. The main sources of electricity consumption at aircraft fueling buildings (e.g. admin offices, workshop and warehouse) are from lighting and sockets. The input data summarized in Table 3.6 is needed for calculating electricity consumption by air-conditioning (A/C), sockets and lights of buildings and offices.

Table 3.6: Input data for calculation of building electricity consumption

Input	Description
Quantity of A/C units	Number of A/C used building with low energy consumption: 0 A/C building with high energy consumption: specify number of A/C units
Lump of sockets, lights	For every 25kW power rating of total sockets and lights, specify one lump of sockets and lights in the calculator, using the following power rating values as a guide (Energy Consumption Calculator 2015; Energy Use Calculator 2015): 1 heater: 2kW 1 fan: 0.075 kW 1 desktop computer: 0.1 kW 1 laptop computer: 0.05 kW 1 printer: 0.040 kW 1 Wi-Fi router: 0.006 kW 1 stove top: 1.5 kW 1 oven: 2.4 kW 1 refrigerator: 0.2 kW 1 electric kettle: 2 kW 1 toaster: 1.2 kW 1 coffee maker: 0.8 kW 1 microwave: 1.2 kW 1 television: 0.07 kW 1 water heater: 4 kW 1 CFL light bulb: 0.014 kW 1 incandescent light bulb: 0.060 kW
Concurrency factor	No operation: 0, Low operation: 0.3, High operation:0.7, Full operation: 1
Operating hours	Specify an average number of daily operating hours
Power rating	Use data from the manufacturer or use the default values given on the calculator

An understanding of the number of units is required and is the main factor to be determined for an effective application of the following calculations:

$$\begin{aligned}
&\text{Energy consumption for buildings [kWh]} \\
&\quad = (\text{Energy consumption for buildings in tank farm} \\
&\quad + \text{Energy consumption for buildings in into} - \text{plane facilities} \\
&\quad + \text{Energy consumption for buildings in the hydrant system}) \\
&\quad = (\text{Energy consumption for AC tank farm} \\
&\quad + \text{Energy consumption for all sockets, lights tank farm} \\
&\quad + \text{Energy consumption for AC into plane buildings} \\
&\quad + \text{Energy consumption for all sockets, light into plane buildings} \\
&\quad + \text{Energy consumption for AC hydrant system buildings} \\
&\quad + \text{Energy consumption for all sockets, lights hydrant system buildings})
\end{aligned} \tag{24}$$

Where,

$$\begin{aligned}
&\text{Energy consumption} \\
&\quad = \text{Quantity of units } \times \text{Power rating (kWh) } \times \text{Hours used per day (hr)} \\
&\quad \times \text{Concurrency factor}
\end{aligned} \tag{25}$$

3.3.2.4 Fuel Energy Consumption

The distances travelled by each vehicle and idle times are very significant. The motor-vehicle categories typically included in an aircraft fueling operations are light-duty (service vehicles) and heavy-duty trucks (i.e. hydrant dispensers and refuelers). As such, emissions are considered to be generated while travelling over distances and during idling periods of vehicles.

The application of calculations for fuel consumption of vehicles (fueling mobile equipment and service vehicles) requires an in-depth understanding of fueling operations, types of aircraft, hydrant servicing vehicles and operational practice for driving and standing of mobile equipment associated with aircraft fueling operations.

The following input data is needed for the calculation of vehicle energy consumptions.

Table 3.7: Input data for calculating vehicle energy consumption

Input	Description
Total road length	Specify total road length (km) driven by: Diesel-power vehicles (high duty) Diesel-powered vehicles (low duty) Gasoline-power vehicles (high duty) Gasoline-powered vehicles (low duty)
Total idle time	Specify total idle time (min) for: Diesel-power vehicles (high duty) Diesel-powered vehicles (low duty) Gasoline-power vehicles (high duty) Gasoline-powered vehicles (low duty)
Average consumption during driving	Specify an average fuel consumption (liter/100km) for every vehicle category that applies
Average consumption during idling	Use location specific data if available or use the default values given on the calculator (EPA, 2015f)

Where,

$$\begin{aligned} &\text{Fuel consumption calculations for vehicles [liter of diesel or liter of gasoline consumed]} \\ &= (\text{Fuel consumption for into plane vehicles (diesel engines)} \\ &+ \text{Fuel consumption for hydrant vehicles (diesel engines)} \\ &+ \text{Fuel consumption for into plane vehicles (gasoline engines)} \\ &+ \text{Fuel consumption for hydrant vehicles (gasoline engines)}) \end{aligned} \quad (26)$$

And

$$\text{Fuel consumption} = \text{Sum of all fuel types} \times [\text{Distance driven per day (km)} \times \text{consumption during driving (Liter / 100 km)} + \text{Time in idle per day (min)} \times \text{consumption during idling (Liter/min)} \quad (27)$$

Factors and coefficients used:

Jet fuel density=0.80 kg/liter

Avgas Density = 0.75 kg/liter

CO_2 factor for electricity = 0.8 kgCO_2/kWh

CO_2 emissions per liter consumed (Diesel) = 2.7 kg CO_2/liter cons.

CO_2 emissions per liter consumed (Gasoline) = 2.3 kg CO_2/liter cons.

VOC Emission factor (gr/km driven) = 0.347 (HDDV); 1.232 (HDGV); 0.147 (LDDV); 1.051 (LDGV)

VOC Emission factor (gr/min idling) = 0.073 (HDDV); 0.135 (HDGV); 0.056 (LDDV); 0.084 (LDGV)

CH_4 Emission factor (gr/km driven) = 0.004 (HDDV); 0.0038 (HDGV); 0.001 (LDDV); 0.0027 (LDGV)

CH_4 Emission factor (gr/min idling) = 0.001 (HDDV); 0.008 (HDGV); 0.000 (LDDV); 0.005 (LDGV)

N_2O Emission factor (gr/km driven) = 0.003 (HDDV); 0.0068 (HDGV); 0.001 (LDDV); 0.0039 (LDGV)

N_2O Emission factor (gr/min idling) = 0.001 (HDDV); 0.014 (HDGV); 0.000 (LDDV); 0.008 (LDGV)

CO_2 Emission factor (gr/km driven) = 870.0 (HDDV); 924.0 (HDGV); 374.0 (LDDV); 400.0 (LDGV)

CO_2 Emission factor (gr/min idling) = 174.0 (HDDV); 184.8 (HDGV); 74.8 (LDDV); 80.0 (LDGV)

3.4 Objective #4: Models Validation

This section presents the evaluation process conducted through a focus group session of two case studies for the three research objectives, the sustainability assessment model for airport fueling projects, the airport fueling emissions-oriented sustainability analysis model, and the airport fueling energy consumption-oriented sustainability analysis model. The focus group protocol has been approved by the University of Manitoba Human Ethics Research Board (Appendices G, L, M, and N).

3.4.1 Preparation of the Focus Group Session

The main purpose of conducting focus group sessions was to evaluate the research models and obtain the experts' feedback on the usability of the models. A focus group is a fast, widely used and cost-effective method to gather the opinions of a group of people (i.e., the potential users) about a certain product, concept, or idea (Kontio et al. 2004). Basically, a group of six to eight experts would be given a demonstration of the models and their functionality. They would then be requested to evaluate the different models and fill a questionnaire. Therefore, the same selection criteria used previously for selecting the experts for interview to validate the sustainability assessment criteria were followed (presented previously in details at section 3.1.1.5).

The focus group was composed of eight people who were invited to participate in the session based on the selected criteria highlighted in the research method. These individuals were part of the group involved in the validation process for the sustainability assessment criteria. As the eight selected participants were experts in the field and had a similar background, the session was faster to arrange, cost effective, more efficient, easier to manage and interact, richer and gave more qualitative feedback. Table 3.8 summarizes the focus group experts' profiles.

Table 3.8: Focus group participants' profile

Participant	Stakeholder Type / Background	Roles & Responsibilities	Years of Experience
1	Fueling Services – Engineering	Design, specifications, commissioning of fueling projects	38
2	Fueling Services – Planning	Capital & operational budgeting, feasibility study, payback period	18
3	Fueling Services – Operation	Usability, staff & equipment scheduling, operation optimization	15
4	Fueling Services - HSSE	Safety management manual, hazard identification, risk assessment	10
5	Fueling Services – Engineering	Design, specifications, commissioning of fueling projects	20
6	Fueling Services - Maintenance	Reliability of facility & equipment, preventive maintenance program, minimizing breakdowns & maximizing availability	19
7	Fueling Services – Operation	Supply chain management and fuel logistics	10
8	Fueling Services - HSSE	Safety management manual, hazard identification, risk assessment	28

3.4.2 Conducting the Focus Group Session

The focus group session was conducted in a quiet room with no disturbances. The participants sat around an oval meeting table with an overhead projector. The session lasted two hours and included five main parts: an introduction, a presentation, a demonstration an interaction with the models, an open discussion and a written questionnaire.

The focus group session started with an introduction of the session that included an introduction of the researcher and participants, the purpose of the focus group, the procedure and documentation of the focus group session as well as the requested input (i.e., participants' review, evaluation, discussion and written questionnaire). Part 2 was a PowerPoint presentation that was conducted to present the overall objectives, scope, methodologies, applications and outcomes of the models. The presentation included screen shots of the models (e.g., instruction pages, input and calculation in addition to the output pages and graphs). Part 3 was a demonstration conducted for all three models with actual data from the two case studies. The group had the chance to navigate through the models and enter data to evaluate different options and alternatives. The demonstration and experimental session involved interacting with the models' instruction pages and links, the models' input, criteria and sub-criteria, the models' calculations and formulas, as well as the models' output and charts. Part 4 consisted of an open discussion. This was encouraged after the presentation and demonstration to discuss suggestions, strengths and weaknesses of the models. Several examples were given and discussed to illustrate participants' questions. Part 5 was a written questionnaire distributed to the participants after the discussion session. It was divided into three sub-sections, with each sub-section designed to gather feedback for a different model.

Table 3.9: Assessment of the airport fueling sustainability assessment model

#	Airport fuel sustainability assessment model
A1	Representation
A1.1	The proposed assessment model contains a sufficient number of criteria, so it can adequately represent the domain of sustainable airport fueling projects.
A1.2	The proposed assessment model contains no redundancy among its criteria, indicators or standard of measures.
A2	Ease of use
A2.1	It is easy to locate certain sustainability criteria.
A2.2	It is easy to use the assessment model (reading instructions and entering data).
A3	Flexibility/Expandability
A3.1	The classification of the sustainable criteria is flexible to expand and include additional airport-specific sustainability criteria.
A4	Categorization
A4.1	Do you agree with the categorization of the sustainability criteria?
A5	Usability
A5.1	The proposed assessment model will be useful for airport fueling projects.
A5.2	The proposed assessment model will be beneficial for assessing airport fueling project sustainability.
A6	Relevancy
A6.1	The model output provides a sufficient relevance indicator for project sustainability.

Table 3.10: Assessment of the aircraft fueling emissions-oriented sustainability analysis model

#	Emissions model
B1	Applicability
B1.1	The proposed model is capable of being applied to GCC airport fueling facilities.
B2	Flexibility/Expandability
B2.1	The proposed model is flexible to include airport fueling facilities with different design elements and operational requirements.
B3	Scalability
B3.1	The proposed model has the ability to be implemented at different airport fueling facilities with different sizes and capacities.
B4	Ease of use
B4.1	It is easy to use the assessment model (reading instructions and entering data).
B5	Usability
B5.1	Do you agree there are potential benefits of using the proposed model?
B6	Coverage
B6.1	The proposed model adequately covers the main sources of airport fueling facilities emissions.

Table 3.11: Assessment of the aircraft fueling energy-oriented sustainability analysis model

#	Energy consumption model
B1	Applicability
B1.1	The proposed model is capable of being applied to GCC airport fueling facilities.
B2	Flexibility/Expandability
B2.1	The proposed model is flexible to include airport fueling facilities with different design elements and operational requirements.
B3	Scalability
B3.1	The proposed model has the ability to be implemented at different airport fueling facilities with different sizes and capacities.
B4	Ease of use
B4.1	It is easy to use the assessment model (reading instructions and entering data).
B5	Usability
B5.1	Do you agree there are potential benefits of using the proposed model?
B6	Coverage
B6.1	The proposed model adequately covers the main sources of airport fueling facilities energy consumption.

The questionnaire-based survey was distributed to the participants who were asked to: 1) Select whether they agreed or disagreed with each statement in the questionnaire as presented above; 2) Select the level of agreement in the scale of "1" to "5", where "1" represents the highest level of agreement and "5" represents the lowest level of agreement where 1: Strongly agree; 2: Agree; 3: Neither agree nor disagree; 4: Disagree; and 5: Strongly disagree. The survey and its protocol has been approved by the University of Manitoba Human Ethics Board and included in this research (Appendix G, L, M, and N).

3.4.3 Case Studies

The models were applied to two case studies of international airport fueling projects in the GCC: the King Abdulaziz International Airport (KAIA) and Prince Mohammed bin Abdulaziz International Airport (PMIA). The case studies used the models to analyze the sustainability of different project alternatives for aircraft fueling projects (including tank farms, hydrant systems, into-plane mobile equipment and buildings).

3.4.3.1 Case Study 1: Prince Mohammed Bin Abdulaziz International Airport (PMIA) Project

The PMIA is located in Madina, Saudi Arabia, and has a total cost of approximately US$1.5 billion. It is one of the most important airports in Saudi Arabia and one of two main entry points for passengers arriving for holy site pilgrimages. The new project has incorporated a new terminal building, aprons and fast exit roads, fuel tank farm and jet fuel hydrant system. The construction of the state-of-the-art passenger terminal had to be completed in the first half of 2015. The annual capacity of the PMIA will increase to 8 million passengers from the 2014 capacity of 5.7 million passengers, after which annual capacity will be further increased to 16 million passengers prior to 2035. The PMIA passenger terminal became the first gold Leadership in Energy and Environmental Design (LEED) certified building given by the United States Green Buildings Council (USGBC) in the Middle East-North Africa (MENA) region in December 2014 (TAV Airports 2015). Two aircraft fueling companies were awarded the contract to build, operate, and maintain the tank farm and hydrant system in addition to providing into-plane services. This case study handles the aircraft fuel supply project at the PMIA that includes the into-plane fueling companies' facility project and tank farm project.

<u>Into-plane (ITP) Fueling Facility:</u>

The into-plane fueling companies' facility project mainly consists of buildings (i.e., offices and workshop) and a mobile equipment parking area. This research considered different operation and location options to evaluate the sustainability of different alternatives.

Operation (O) options: Two assigned companies operate the into-plane services at the airport. Each company has more than six mobile fueling equipment and over 13 operational staff. Both companies have the option to operate independently or jointly in providing the aircraft into-plane fueling services. When two or more companies agree to combine their operations as a way to share costs and reduce operating expenses, they enter into a joint operating agreement. The benefits involve utilizing resources, cost savings and economies of scale. A joint operation enables the participating companies to operate with fewer employees, eliminate duplicate facilities, fueling equipment and functions, and save through bulk purchases of supplies and materials. Consequently, an into-plane facility could have different design options for independent and joint operations (i.e., different building size, number of offices, and number of mobile equipment parking spaces). This research evaluated the two operations scenario (joint operations (O1) and independent operations (O2)) as part of the assessed alternatives.

Location (L) options: The research evaluated two different possible locations for the into-plane facility. The first option is located at the assigned location for the new tank farm, while the second option is a new land space on the opposite side of the tank farm. Figure 3.2 shows the general airport layout and the above-mentioned locations and distances.

Roundtrip distance from Old MAC	
To new apron	14.0 km
To new ITP	6.6 km
To new MAC	1.5 km

Roundtrip distance from new MAC	
To new apron	15.5 km
To new ITP	8.1 km
To new MAC	1.5 km

Roundtrip distance from new ITP	
To new apron	6.8 km
To new ITP	8.1 km
To new MAC	6.6 km

Figure 3.2: Case study #1: PMIA layout and distances

The four considered options for the into-plane project are: O1: joint operations scenario, O2: independent operations scenario, L1: new tank farm location, L2: new into-plane building location. Consequently, the combined into-plane project alternatives assessed in this case study are; O1+L1, O1+L2, O2+L1, and O2+L2.

<u>Fuel tank farm:</u>

The new tank farm is required to serve the new airport's needs and the expected increase in aircraft traffic for 25 years. In addition, it has to fulfill the operational requirements and technical specifications in order to be integrated with the new hydrant system installed by the airport authority. This fuel hydrant system has two feeder lines from the fuel tank farm to the aircraft aprons. The system was designed to have two X 20" feeder lines that were then reduced to a 16" pipeline looping within the apron area. The designed maximum flow rate will reach up to 36,000 LPM for a simultaneous 11 fuel uplift operation using hydrant dispensers. The new tank farm includes an off-loading facility, a refueler loading facility, a fuel hydrant pump and filtration system, a control system, and a firefighting system. The fuel tank farm consists of three vertical tanks (5 million litres) connected to the hydrant system. This research considered different design and location options to evaluate the sustainability of different alternatives.

Design (D) options: The research considered two design options: to upgrade the current facility or to build a new tank farm. The current fuel tank farm consists of four tanks with a total capacity of 3,949 K-litres (803 K-litres, 776 K-litres, 970 K-litres, 1,400 K-litres respectively. In addition, the tank farm is not connected to any hydrant system (i.e., servicing into-plane through refuelers). Therefore, in order to upgrade the current facility to fulfill future operational requirements, additional tanks would be needed to cater for the increased demand and the required pumps, filters and control system to serve the new hydrant system. Several upgrades would also be needed for other equipment and instruments in order to serve the new tanks and equipment.

The new tank farm design consists mainly of three units of 5 million litres storage tanks (with a total capacity of 15 million litres). This capacity will be sufficient to serve the airport operations for 15 years. The design considers an additional space area for a future tank of 5 million litres after 2025.

Location (L) options: There are two location options considered in this research case study based on the above-mentioned facts: the current tank farm location and a different new location. The current tank farm location has no space for any future expansion and is surrounded by the aircraft maintenance workshop. The new tank farm location has more area and closer to the new hydrant system.

Therefore, the four considered options for the tank farm project are summarized as follows; D1: design option 1- new facility, D2: design option 2- current facility, L3: new tank farm location, L4: current tank farm location. Consequently the combined tank farm project alternatives assessed in this case study are; D1+L3, and D2+L4.

The overall project has eight alternatives that are summarized below:

Table 3.12: Case 1 project alternatives

Project Alternatives	Into-plane	Tank Farm
Alternative 1	O1+L1	D1+L3
Alternative 2	O1+L2	D1+L3
Alternative 3	O2+L1	D1+L3
Alternative 4	O2+L2	D1+L3
Alternative 5	O1+L1	D2+L4
Alternative 6	O1+L2	D2+L4
Alternative 7	O2+L1	D2+L4
Alternative 8	O2+L2	D2+L4

All eight alternative-related data have been entered into the three models: the sustainability assessment model for airport fueling projects, the airport fueling emissions-oriented sustainability analysis sub-model, and the airport fueling energy-oriented sustainability analysis sub-model.

3.4.3.2 Case Study 2: King Abdulaziz International Airport (KAIA) Project

The King Abdulaziz International Airport (KAIA) is located in Jeddah, Saudi Arabia, with an estimated cost of US$7.19 billion and is expected to start operations in 2017. It is the gateway to the holy cities of Makkah and Madina, and has been the most dynamic and fastest growing airport in the kingdom. The objective of the new airport expansion is to develop the KAIA into a domestic and international hub airport, with capacity increasing from 17 million to 30 million passengers annually. The project incorporates a passenger terminal complex, 670,000 square metres of floor area, a state-of-the-art facility spread over a spectacular twin crescent footprint, 46 contact gates, 94 boarding bridges including a double deck for the new Airbus 380 aircraft, a sophisticated baggage handling system, over 60 km of belts, a 60-million litre fuel tank farm, and a hydrant network (KAIA 2014). Six aircraft fueling companies currently operate the into-plane services at the airport while one joint venture company operates and maintains the tank farm and hydrant system. This case study handles the aircraft fuel supply project at KAIA that includes the into-plane fueling companies' facility project and tank farm project.

Into-plane (ITP) Fueling Facility:

The into-plane fueling companies' facility project mainly consists of buildings (i.e., offices and workshop) and a mobile equipment parking area. This research considered different operations and location options to evaluate the sustainability of different alternatives.

Design (D) options: Two design options are considered in this case study. Both options should accommodate the six into-plane fueling companies' needs and requirements. The options should accommodate more than 200 staff and around 100 mobile equipment (refuelers and dispensers). The main difference between the two design options is the consideration of a refueler loading rack into the facility, as one option does not include that detail. In that scenario, after each aircraft fueling operation the refuelers have to drive a certain distance to fill up their tanks from another assigned loading rack and be ready to serve any aircraft upon request. This research evaluated the two design options (the into-plane fueling companies' facility with (D1) and without (D2) a refueler loading rack) as part of the assessed alternatives.

Location (L) options: The research evaluated two different possible locations for the into-plane facility. The first option is located at the old into-plane facility location (L1), while the second option is new land assigned for the new project (L2). Figure 3.3 and Figure 3.4 show the airport's general layout and the above-mentioned locations and distances.

Distances from old ITP location:	
To Apron 1 & 2	4.98 km
To Apron 3 & 4	3.93 km
To Apron 5	4.65 km
To Royal Pavilion	9.26 km
To Apron 7	5.50 km
To Hajj Terminal	6.91 km
To Royal Hanger	7.00 km
To Cargo and Jet Aviation	11.00 km
To New Apron	22.00 km
Old ITP to JAFTO	23.00 km
Total (one trip/day)	**98.23 km**

Figure 3.3: Case study #2: KAIA layout and distances for first location option

Distances from New ITP location:	
To Apron 1 & 2	2.10 km
To Apron 3 & 4	3.15 km
To Apron 5	4.19 km
To Royal Pavilion	9.00 km
To Apron 7	8.00 km
To Hajj Terminal	5.64 km
To Royal Hanger	9.66 km
To Cargo and Jet Aviation	8.75 km
To New Apron	18.00 km
Old ITP to JAFTO	21.00 km
Total (one trip/day)	**89.31 km**

Figure 3.4: Case study #2: KAIA layout and distances for second location option

The four considered options for the into-plane project are: D1: into-plane facility with loading rack, D2: into-plan facility without loading rack, L1: old into-plane location, L2: new into-plane location. Consequently the combined into-plane project alternatives assessed in this case study are: D1+L1, D1+L2, D2+L1, and D2+L2.

Fuel tank farm:

The required new tank farm must serve the new airport project's needs and the expected increase in aircraft traffic for 25 years. In addition, it has to fulfill the required operational requirements and technical specifications in order to be integrated with the new hydrant system installed by the airport authority. The development of this new tank farm and hydrant system is estimated to cost U$213 million. The new fuel depot will be composed of eight tanks with a capacity of 10 million litres each. The development includes a new filtration system, pumping units, power generators and a central control unit for the entire fuel system components.

This research considered one design option and one location option to evaluate the sustainability of different alternatives. The two considered options for the tank farm project are; D3: new tank farm design, and L3: new tank farm location. Consequently the combined tank farm project alternative assessed in this case study is D3+L3. The overall project has four alternatives that are summarized below:

Table 3.13: Case 2 project alternatives

Project Alternative	Into-plane	Tank farm
Alternative 1	D1+L1	D3+L3
Alternative 2	D1+L2	D3+L3
Alternative 3	D2+L1	D3+L3
Alternative 4	D2+L2	D3+L3

All four alternative related data have been entered into the three models: the sustainability assessment model for airport fueling projects, the airport fueling emissions-oriented sustainability analysis sub-model, and the airport fueling energy-oriented sustainability analysis sub-model.

CHAPTER 4 : Results and Discussion

This chapter presents the results of the four research objectives. It starts with the results for development of a sustainability model for airport fueling projects followed by the results for development of airport fueling emissions and energy consumption analysis model for airport projects. Finally, it presents the validation results of the three research objectives through the focus group for two case studies.

4.1 Results and Discussion of Objective #1 - Development of a Sustainability Model for Airport Fueling Projects

This section presents the results for the development of a sustainability model for airport fueling projects that consists of two main sections, the sustainability criteria for the research model and the sustainability assessment model.

4.1.1 Model Criteria

Based on the literature review, the research sustainability assessment criteria for aircraft fueling project consist of the following three types: 1) new criteria introduced in this research for assessing the sustainability of aircraft fueling projects from aircraft fueling industry manuals and procedures such as: fueling vehicles safety devices, fueling vehicles safety equipment, fuel storage safety devices, and fuel storage safety equipment, 2) other predefined criteria have been introduced as sustainability assessment criteria for aircraft fueling projects. These predefined criteria were not implemented before as sustainability assessment criteria at existing initiatives or literature such as: capital to sales ratio, operating expenses to sales, operating expenses efficiency, maintenance to assets cost, working capital to sales, net present value (NPV) of cash flow, payback period, return on assets (ROA), service and product marketability, employment opportunity, service and product affordability, and finance leverage. 3) all other criteria were adopted from different sustainability assessment initiatives of other domains, where no previous implementation for sustainability assessment of aircraft fueling project domain.

The following tables (Table 4.1, Table 4.2 and Table 4.3 below) summarize the research contributions with respect to the environmental, economic and social indicators and standard of measures. Where "New" means new indicator or standard of measure introduced in this research and that were not demonstrated before in existing sustainability initiatives or literature, and "Adopted" means adopted indicator or standard of measure from other domains or existing sustainability initiatives, not related to airport fueling project and found in the literature.

Table 4.1: Environmental sustainability criteria

	Environmental sustainability Criteria	Indicator	Standard of Measure
A1	Administrative procedures		
A1.1	Cooperative sustainability policy	Adopted	Adopted
A1.2	Sustainable procurement policy	Adopted	Adopted
A1.3	Green product procurement policy	Adopted	New
A1.4	Program for the use of renewable materials	Adopted Adopted	Adopted New
A1.5	Program for the recycle used materials	Adopted Adopted	Adopted New
A1.6	Environmental Impact Assessment (EIA) study	Adopted	Adopted
A1.7	Environmental certificate	New	New
A1.8	Sustainability Training	New	New
A1.9	Sustainability function within the organization	New	New
A2	Water efficiency		
A2.1	Wastewater generation	Adopted Adopted	Adopted New
A2.2	Water withdrawal	Adopted Adopted	Adopted New
A2.3	Storm water management system	Adopted New	Adopted New
A2.4	Water recycling and reusing	Adopted Adapted	Adopted New
A2.5	Landscaping water use	Adopted	Adopted
A2.6	Water use reduction	Adopted	New

	Environmental sustainability Criteria	Indicator	Standard of Measure
A3	Indoor environmental quality		
A3.1	Indoor ventilation and air quality	Adopted Adopted Adopted	Adopted New Adopted
A3.2	Low or free-VOC indoor finishing materials	New	New
A3.3	Carbon dioxide (CO_2) monitoring	New	New
A4	Energy		
A4.1	Energy savings from operation of pumps	New New	New New
A4.2	Energy savings from operation of buildings	Adopted Adopted	Adopted Adopted
A4.3	Use of renewable energy	Adopted Adopted	Adopted Adopted
A4.4	Vehicle and mobile equipment fuel savings	Adopted New	Adopted New
A5	Emissions		
A5.1	Reduction of VOC emissions	Adopted Adopted	Adopted New
A5.2	Vehicle and mobile equipment exhaust emissions	Adopted Adopted	Adopted New
A5.3	Utilization of environmentally friendly vehicles	Adopted	Adopted
A5.4	GHG emissions associated with energy consumption	Adopted Adopted	Adopted New
A6	Waste		
A6.1	Hazardous wastes produced from ad-hoc activities (e.g., commissioning procedures) and spills	Adopted	Adopted
A6.2	Hazardous wastes produced from routine operation and maintenance	Adopted Adopted Adopted	New Adopted New
A6.3	Non-hazardous wastes produced from routine operation and maintenance	Adopted Adopted	Adopted New
A6.4	Pollution of land / waterways	Adopted	Adopted
A7	Land use & biodiversity		
A7.1	Efficiency of land use	Adopted	Adopted
A7.2	Impact of location and size of land used for operations in biodiversity	Adopted	Adopted
A7.3	Impact of activities in biodiversity	Adopted	Adopted
A8	Noise		
A8.1	Noise pollution	Adopted	Adopted

Table 4.2: Economic sustainability criteria

	Economic Sustainability Criteria	Indicator	Standard of Measure
B1	Economic performance analysis		
B1.1	Life cycle cost	Adopted	Adopted
B1.2	Projects Capital	Adopted	Adopted
B1.3	Environmental mitigation and protection expenditures	Adopted	Adopted
B1.4	Land and property value	Adopted	Adopted
B1.5	Capital to sales ratio	Adopted	New
B1.6	Operating expenses to sales	Adopted	New
B1.7	Operating Expenses Efficiency	Adopted	New
B1.8	Maintenance to assets cost	Adopted	New
B1.9	Working capital to sales	Adopted	New
B2	Economic value retained		
B2.1	Direct economic value generated	Adopted	Adopted
B2.2	Economic value retained	Adopted	Adopted
B2.3	Net present value (NPV) of discounted cashflow	Adopted	New
B2.4	Payback period	Adopted	New
B2.5	Return on assets (ROA)	Adopted	New
B2.6	Financial implications of emissions and climate change	Adopted	Adopted
B3	Market presence		
B3.1	Service and product marketability	Adopted	New
B3.2	Standard entry level wage ratio	Adopted	Adopted
B3.3	Employment opportunity	Adopted	Adopted
B3.4	Service and product affordability	Adopted	Adopted
B3.5	Long-term plan	Adopted	Adopted
B4	Indirect economic impacts		
B4.1	Indirect economic impacts	Adopted	Adopted
B4.2	Non-monetary benefits	Adopted	Adopted
B4.3	Finance leverage	Adopted	New

Table 4.3: Social sustainability criteria

	Social Sustainability Criteria	Indicator	Standard of Measure
C1	Occupational health and safety		
C1.1	Representation in Health, Safety, Security and Environment (HSSE) committees	Adopted New	Adopted New
C1.2	Work-related injuries and fatalities	Adopted New	Adopted New
C1.3	Reduction of work-related injuries and fatalities	Adopted New	Adopted New
C1.4	Occupational diseases, lost days and absenteeism	Adopted Adopted	New New
C1.5	Health and safety awareness and prevention	Adopted	Adopted
C1.6	Education enhancement on HSSE awareness	New	New
C1.7	Health and safety coverage with trade unions	Adopted	Adopted
C1.8	Fueling vehicles safety devices	New New New	New New New
C1.9	Fueling vehicles safety equipment	New	New
C1.10	Fuel storage safety devices	New New New New	New New New New
C1.11	Fuel storage safety equipment	New	New
C1.12	Personal protective equipment (PPE)	New	New
C2	Security		
C2.1	Initiatives to improve security	Adopted New New New New New	Adopted New New New New New
C2.2	Security breach	New	New
C3	Community well-being and engagement		
C3.1	Community awareness program for sustainability	Adopted	Adopted
C3.2	Community complaints	New	New
C3.3	Community engagement program	Adopted	Adopted
C3.4	Impacts of operations on local communities	Adopted	New
C3.5	Sustainability orientation of contractors	Adopted	Adopted

	Social Sustainability Criteria	Indicator	Standard of Measure
C3.6	Community Diversity	Adopted	Adopted
C3.7	Employee well-being	Adapted	Adopted
C3.8	Business continuity plan	New	New
C3.9	Local materials	Adopted	New
C4	Employment		
C4.1	Employee hires and turnover	Adopted Adopted	Adopted New
C4.2	Staff localization	New	New
C5	Labor / management relations		
C5.1	Notices of changes in operations	Adopted	Adopted
C5.2	Hygiene standards	New	New
C6	Education and training		
C6.1	Employees empowerment	Adopted New	Adopted New
C6.2	Skills management of employees	Adopted New	Adopted New
C6.3	Employee performance appraisal	Adopted New	Adopted New
C6.4	On-job training	New	New
C6.5	Sustainability research and development	Adopted	Adopted
C7	Quality of services		
C7.1	Improve customer satisfaction	Adopted New	Adopted New
C7.2	Sustainable employee transportation	Adopted	Adopted
C7.3	Employee satisfaction	Adopted New	Adopted New
C8	Regulatory compliance		
C8.1	Anti-competitive behavior	New New	New New
C9	Cultural heritage		
C9.1	Financial contributions to cultural institutions	Adopted	Adopted

4.1.2 Expert Interviews and Validation

Expert interviews were conducted to review and validate the initial proposed set of criteria, indicators and standard of measures for the whole project life cycle for airport fueling. Questionnaire surveys have been filled out by the experts and their feedbacks have been analyzed to validate the proposed primary hierarchy, including a series of criteria for the sustainability assessment of airport fueling projects. The survey and its protocol has been approved by the University of Manitoba Human Ethics Board and included in this research (Appendix G, H, J, and K). The sustainability criteria validation questionnaire-based survey has been conducted to gain a range of responses from a group of experts. These experts included airport authorities, contractors, consultants and fueling service providers with different roles (i.e., operations, engineering, maintenance, quality, health, safety, security, and environment (HSSE)). Table 4.4 summarizes the participants' profiles, where 20 targeted specific participants were involved in the process. They represent more than a 10% sample of airport fueling project stakeholders to provide a significant representative sample (Joseph, 2013). A non-random and non-probability sampling method was used to select the predefined group of participants, as such method could be used when recruiting rare specialized experts for an industry (Trochim, 2001). The aviation fueling industry is a specialized industry that has limited specialized experts in the world and consequently it is not an easy task to access them due to their availability.

Table 4.4: Experts interview participants' profile

Participant	Stakeholder Type / Background	Roles & Responsibilities	Years of Experience
1	Fueling Services - Engineering	Design, Specifications, commissioning of fueling projects	38
2	Fueling Services - Planning	Capital & Operational Budgeting, Feasibility Study, Pay Back Period	18
3	Fueling Services - Operation	Usability, staff & equipment scheduling, operation optimization	15
4	Fueling Services - HSSE	Safety management manual, hazard identification, risk assessment	10
5	Fueling Services - Operation	On time delivery, capacity resource planning	8
6	Fueling Services - Engineering	Design, Specifications, commissioning of fueling projects	20
7	Fueling Services - Maintenance	Reliability of facility & equipment, preventive maintenance program, minimizing breakdowns & maximizing availability	19
8	Fueling Services - Quality	Quality control checks, clear & bright fuel, filtration process, quality management system	16
9	Fueling Services - Operation	Supply chain management and fuel logistics	10
10	Fueling Services - HSSE	Safety management manual, hazard identification, risk assessment	7
11	Fueling Services - HSSE	Safety management manual, hazard identification, risk assessment	28
12	Fueling Services - Operation	Usability, staff & equipment scheduling, operation optimization	6
13	Consultant	Ensure the implementation of latest aviation quality & safety standards	15
14	Fueling Services - Engineering	Design, Specifications, commissioning of fueling projects	17
15	Airport Authority	Create a safe and secure aviation environment, build modern airport system, state-of-the-art service	14
16	Contractor	Construct fuel facilities in accordance with provided specs and drawings	35
17	Contractor	Installation of fuel hydrant system	14
18	Contractor	Implementation of civil & mechanical works	25
19	Consultant	Implementation of latest JIG standards for fuel facility and mobile equipment, effective implementation of the latest aviation policies & procedures	34
20	Airport Authority	Create a safe and secure aviation environment, build modern airport systems, state-of-the-art service	12

4.1.2.1 Ranking of Sustainability Factors

A general question was included to determine which sustainability factors the respondents thought were the most important to consider throughout the whole life of the airport fueling project. The main purpose of this question was to investigate the views and agreements of the project stakeholders, considering their different backgrounds, on the sustainability factors. Respondents were asked to rank the three sustainability factors (economic, environmental and social) in order of importance, with rank position 1 denoting the most important to consider and rank position 3 denoting the least important. Table 4.5 shows the mean rank data for each sustainability factor along with the calculated Kendall's coefficient of concordance (W), which gauges the degree of agreement between the respondents.

Table 4.5: The mean rank data for each sustainability factor

Sustainability factor	Average ranked position
Social	2.4
Economic	1.9
Environmental	1.8
Kendall's W	0.10

The results of the calculation of the Kendall coefficient of concordance W show that for k=20 respondents and the number of ranked items N=3 (sustainability factors), the value of coefficient W = 0.1. The weak correlation coefficient of concordance W indicated that the responders did not generally agree on the order of significance for the three sustainability factors. This variation in the views was the result of the respondents working in different sectors of the airport industry and their own unique work experiences and responsibilities. The backgrounds of the respondents also resulted in different interests and perspectives regarding the relative significance of the three sustainability factors. Therefore, an additional investigation was conducted to calculate the Kendall coefficient of concordance W for each group of participants by their type and background. Table 4.6 below shows a significant improvement of W values for each group of participants with the same background. This indicates general agreement on the order of significance for the three sustainability factors for each group of participants.

Table 4.6: W values by participants' group for sustainability factors

S. No.	Participant	W
1	Fueling Services - Operation	0.438
2	Fueling Services - Engineering	0.333
3	Airport Authority	0.250
4	Fueling Services - HSSE	0.778
5	Contractor	1.000
6	Consultant	1.000

Based on the proximity of the mean ranked position values shown in Table 4.10, it can be concluded there is no clear order of significance for the three factors. All three sustainability factors should be considered as equally important for the sustainability assessment of airport fueling projects to account for the different views of stakeholders with different backgrounds and interests.

4.1.2.2 Ranking of Primary Environmental Criteria

The second part of the questionnaire focused on validating the proposed set of primary environmental criteria for the environmental sustainability assessment of airport fueling projects, and quantifying their significance. In particular, the respondents were asked to rank the eight proposed primary environmental criteria in order of relative importance (1 to 8) and propose additional criteria that may be worth including in the assessment. Table 4.7 shows the mean rank data for each of the eight primary environmental criteria along with the calculated Kendall coefficient of concordance W, which gauges the degree of agreement between respondents.

Table 4.7: The mean rank data for each of the 8 primary environmental criteria

Sustainability factor	Average ranked position
Administrative procedures	2.9
Energy	5.0
Waste	5.2
Water efficiency	3.9
Emissions	4.8
Indoor environmental quality	4.5
Land use & biodiversity	4.9
Noise	5.0
Kendall's W	0.10

Table 4.8 shows the average ratings for each of the eight primary environmental criteria along with the average ranking data. The SD, mode and median values were also calculated and presented to support the analysis.

Table 4.8: The average ratings for each of the 8 primary environmental criteria

Order Rated	Rank	Sustainability factor	Average rating	SD	Mode	Median	Interpretation Median
1	2	Energy	1.7	0.7	1.0	2.0	Important
2	3	Waste	1.7	1.0	1.0	1.0	Very Important
3	6	Indoor environmental quality	2.0	1.1	1.0	2.0	Important
4	1	Administrative procedures	2.5	0.6	2.0	2.0	Important
5	5	Emissions	2.2	0.9	2.0	2.0	Important
6	4	Water efficiency	2.4	0.9	2.0	2.0	Important
7	7	Land use & biodiversity	2.3	1.1	1.0	2.0	Important
8	8	Noise	2.4	1.4	1.0	2.0	Important

Table 4.8 shows that "Administrative procedures" and "energy" are considered to be the relatively most important among the proposed criteria, as they exhibit the two highest mean ranked values. As the mean ranked values for these two criteria are very close to each other, it could be said that the respondents could not clearly favor one over the other. Thus, both criteria should be considered to be of equal importance. The top two ranked criteria appear to be a discrete distance away from the mean ranked values of the following three criteria: "waste",

"water efficiency" and "emission", which have also quite similar mean ranked values. Thus, these three elements should be considered of equal importance. Likewise, "Indoor environmental quality" and "land use and biodiversity" all with similar mean ranked values, are the next group in the ranking order. Finally, "noise" was ranked last, with a discrete distance from the previous three, demonstrating a relative degree of agreement among respondents that "noise" is indeed last in the ranking of the nine proposed criteria.

The results of the calculation of the Kendall coefficient of concordance W show that for k=20 respondents and the number of ranked items N=8 (primary environmental sustainability factors), the value of coefficient W = 0.10. The correlation coefficient of concordance W indicates that the respondents do not strongly disagree on the order of significance of the eight environmental criteria. Although the coefficient value does not indicate a strong agreement either and there appears to be variations in the views of the respondents, the results in Table 4.15 indicate an agreement amongst respondents to rank a few 'groups of factors', as explained above. Each group is comprised of two to three factors with quite similar mean ranked values, which makes it hard to differentiate one from the other. However, the Kendall coefficient of concordance W for each group of participants by their type and background shows an improvement of W values among participants with the same background. This indicates general agreement on the order of significance for the eight environmental factors for some group of participants.

Table 4.9: W values by participants' group for environmental factors

S. No.	Participant	W
1	Fueling Services - Operation	0.182
2	Fueling Services - Engineering	0.412
3	Airport Authority	0.857
4	Fueling Services - HSSE	0.365
5	Contractor	0.317
6	Consultant	0.833

On the other hand, the average ratings for the same eight environmental factors presented in Table 4.8 correlate quite well with the mean rankings. The "energy" and "waste" criteria received the top rankings. Interestingly, "Indoor environmental quality" is considered important for the respondents, based on the average rating and median value, despite the low average ranking position (ranked sixth out of eight criteria). The range of average ratings is quite narrow, with the mean rating values ranging from 1.7-2.4. Even for the lowest ranked criterion of "noise", the average rating was 2.4, which indicates it is still considered significant. When interpreting the median values, all proposed criteria are considered important or more (on the Likert scale). Based on the above, it can be concluded that the respondents considered all eight proposed criteria to be significant for the environmental sustainability assessment.

4.1.2.3 Ranking of Primary Economic Criteria

The experts were asked to validate the proposed set of primary economic criteria for the economic sustainability assessment of airport fueling projects, and to quantify their significance. In particular, they were asked to 1) rank the four proposed primary economic criteria in order of relative importance (1 to 4), and 2) propose additional criteria that may be worth including in the assessment. Table 4.10 shows the mean rank data for each of the four primary economic criteria along with the calculated Kendall's coefficient of concordance W, which gauges the degree of agreement between respondents.

Table 4.10: The mean rank data for each of the 4 primary economic criteria

Sustainability factor	Average ranked position
Economic performance analysis	1.7
Economic value retained	2.4
Market presence	2.6
Indirect economic impacts	3.4
Kendall's W	0.30

Table 4.11 shows the average ratings for each of the four primary economic criteria with the average ranking data. The SD, mode and median values were also calculated and presented to support the analysis.

Table 4.11: The average ratings for each of the 4 primary economic criteria

Rating	Rank	Sustainability factor	Average rating	SD	Mode	Median	Interpretation Median
1	1	Economic performance analysis	1.5	0.7	1.0	1.0	Very important
2	2	Economic value retained	1.7	0.8	1.0	1.5	Important to very important
3	3	Market presence	2.0	0.9	2.0	2.0	Important
4	4	Indirect economic impacts	2.1	0.9	2.0	2.0	Important

It appears economic performance analysis is ranked the highest. It also received the highest median value which is considered as very important by the respondents. This is followed by the economic value retained, market presence, and lastly indirect economic impacts.

The results of the calculation of the Kendall coefficient of concordance W show that for k=20 respondents and the number of ranked items N=4 (primary economic sustainability factors), the value of coefficient W = 0.30. The correlation coefficient of concordance W indicates that respondents do in general agree with the order of significance for the four economic criteria, as explained above. Furthermore, the Kendall coefficient of concordance W for each group of participants by their type and background shows an improvement of W values with same background. Table 4.12 below indicates general agreement in the order of significance for the economic factors for most groups of participants.

Table 4.12: W values by participants' group for economic factors

S. No.	Participant	W
1	Fueling Services - Operation	0.450
2	Fueling Services - Engineering	0.911
3	Airport Authority	0.100
4	Fueling Services - HSSE	0.644
5	Contractor	0.111
6	Consultant	0.900

The economic performance analysis and economic value retained are considered the two most important, whereas for the market presence and indirect economic impacts, it appears that respondents consider them of equal importance for the economic sustainability assessment. Based on the interpretation of the median values, all proposed criteria are considered important or more (on the Likert scale). Based on the above, it can be concluded that responders considered all four proposed criteria to be significant for the environmental sustainability assessment.

4.1.2.4 Ranking of Primary Social Criteria

Experts were asked to validate the proposed set of primary social criteria for the social sustainability assessment of airport fueling projects, and to quantify their significance. In particular, respondents were asked to 1) rank the nine proposed primary social criteria in order of relative importance (1-9), and 2) propose additional criteria that may be worth including in the assessment. Table 4.13 shows the mean rank data for each of the nine primary social criteria along with the calculated Kendall coefficient of concordance W, which gauges the degree of agreement between respondents.

Table 4.13: The mean rank data for each of the 9 primary social criteria

Sustainability factor	Average ranked position
Occupational Health and Safety	1.6
Education and training	4.5
Quality of services	6.5
Security	4.3
Employment	5.9
Regulatory compliance	4.1
Labour / management relations	4.2
Community well-being and engagement	5.7
Cultural heritage	8.4
Kendall's W	0.48

Table 4.14 shows the average ratings for each of the nine primary social criteria along with the average ranking data. The SD, mode and median values were also calculated and are presented in Table 4.14 to support the analysis.

Table 4.14: Average ratings for the primary social criteria

Rating	Rank	Sustainability factor	Average rating	SD	Mode	Median	Interpretation Median
1	1	Occupational Health and Safety	1.7	0.9	1.0	1.0	Very important
2	2	Education and training	1.6	0.9	1.0	1.0	Very important
3	3	Quality of services	1.9	1.0	2.0	2.0	Important
4	6	Regulatory compliance	1.8	0.8	1.0	2.0	Important
5	4	Security	2.1	1.2	1.0	2.0	Important
6	5	Employment	2.0	1.2	1.0	2.0	Important
7	7	Labour / management relations	2.1	1.0	1.0	2.0	Important
8	8	Community wellbeing and engagement	2.4	0.9	2.0	2.0	Important
9	9	Cultural heritage	3.0	1.0	3.0	3.0	Moderately important

It is clear from the average ranked data that the "occupational health and safety" is ranked as the top social criterion, and by a good margin from the second. This is also supported by the low median value, which reflects the view of respondents that this is a very important criterion. Respondents gave very similar average rankings for the following group of four criteria (i.e., "education and training", "security", "regulatory compliance", "labour/management relations"), followed by three criteria (i.e., "employment", "quality of service", and "community well-being and engagement") with similar average rankings, then, and last "cultural heritage". Note that "education and training" is also considered to be very important based on the median value.

The results of the calculation of the Kendall coefficient of concordance W show that for k=20 respondents and the number of ranked items N=9 (primary social sustainability factors), the value of coefficient W = 0.48. The correlation coefficient of concordance W indicates that respondents do in general agree with the order of significance for the nine social criteria, as explained above. Moreover, the Kendall coefficient of concordance W for each group of participants by their type and background shows an improvement of W values with same background (Table 4.15).

Table 4.15: W values by participants' group for social factors

S. No.	Participant	W
1	Fueling Services – Operation	0.777
2	Fueling Services – Engineering	0.826
3	Airport Authority	0.825
4	Fueling Services – HSSE	0.519
5	Contractor	0.622
6	Consultant	0.792

Based on the interpretation of the median values (Table 4.14), eight out of the nine proposed criteria are considered important or very important (in the Likert scale). "Occupational health and safety" and "education and training" are considered very important, whereas "cultural heritage" is considered moderately important. Nevertheless, even for "cultural heritage" having the lowest median value, the corresponding importance level (to the Likert scale) is moderately important which is considered acceptable by this researcher (see introductory section on the criteria for acceptance or withdrawal). Based on the above, it can be concluded that respondents considered all proposed criteria to be significant for the social sustainability assessment.

4.1.2.5 Secondary Criteria

The experts were asked to validate the proposed set of secondary economic, environmental and social criteria for the sustainability assessment of airport fueling projects, and to quantify their significance. In particular, the respondents were asked to: 1) determine which of the proposed secondary criteria to keep and what to remove, 2) rate the secondary criteria in the 1-5 Likert scale as: 1 = Very important, 2 = Important, 3 = Moderately important, 4 = Of little importance, 5 = Unimportant, 3) validate the proposed indicators for the selected secondary criteria, and 4) propose additional criteria that may be worth including in the assessment or propose some criteria that may be removed.

Table 4.16 - Table 4.18 show the mean rating data for each of the secondary criteria for the economic, environmental and social sustainability assessment, and the corresponding median values of the valid responses. The interpretation (presented in the last column of each table) is based on the median values. The same tables also highlight the criteria that some respondents proposed to be removed. The color-coding applied in the tables denotes the number of respondents who proposed to remove the same criterion:

For number of suggestions to remove = 1-2	For number of suggestions to remove = ≥3

Figure 4.1: Number of responders proposed to remove the same criterion

The proposed criteria to be removed corresponded to higher median values and the relatively lower importance, which are reflected in the results. As explained in the introductory section, the following criteria have been used to assess whether to keep or remove the proposed secondary criteria: 1) Median value: If less than 3.0 (moderately important and above in the Likert scale), the sub-criterion should be kept, and 2) Number of suggestions to remove: If three or more respondents suggested removing a given sub-criterion, then the sub-criterion should be removed.

Based on the results presented in Table 4.16 - Table 4.18, it can be concluded that respondents considered most criteria to be “moderately important” and above in the Likert scale. These are considered important for the group of experts who participated in the survey and should be kept in the model for the sustainability assessment, except for several criteria where more than three respondents proposed to remove them and they were less than “important” in the Likert scale: “sustainability procurement policy”, “environmental certificates”, “water use reduction”, and “community engagement program”. Therefore, the above-mentioned criteria have been removed from the final list.

I. Ranking of secondary environmental criteria

Table 4.16: Average rating for the secondary environmental criteria
(Sorted by increasing average rating)

	Secondary criteria	Average rating	Median	Interpretation Median
A1.2	Sustainable procurement policy	4.0	4.0	Of Little Importance
A1.7	Environmental certificate	4.0	4.0	Of Little Importance
A1.5	Program for the recycle used materials	2.8	3.0	Moderately Important
A1.6	Environmental Impact Assessment (EIA) study	2.7	3.0	Moderately Important
A1.8	Sustainability Training	2.6	2.0	Important
A1.3	Green product procurement policy	2.5	2.0	Important
A1.4	Program for the use of renewable materials	2.5	2.5	Moderately Important to Important
A1.1	Cooperative sustainability policy	2.4	2.5	Moderately Important to Important
A1.9	Sustainability function within the organization	2.2	2.0	Important
A2.6	Water use reduction	3.4	3.0	Moderately Important
A2.5	Landscaping water use	3.0	3.0	Moderately Important
A2.4	Water recycling and reusing	2.8	3.0	Moderately Important
A2.2	Water withdrawal	2.7	2.0	Important
A2.3	Storm water management system	2.6	2.5	Moderately Important to Important
A2.1	Wastewater generation	2.4	2.0	Important
A3.3	Carbon dioxide (CO_2) monitoring	2.3	2.0	Important
A3.2	Low or free-VOC indoor finishing materials	2.2	2.0	Important
A3.1	Indoor ventilation and air quality	2.0	1.5	Important to Very Important
A4.4	Vehicle and mobile equipment fuel savings	2.5	2.0	Important
A4.3	Use of renewable energy	2.0	2.0	Important
A4.2	Energy savings from operation of buildings	1.9	2.0	Important
A4.1	Energy savings from operation of pumps	1.8	2.0	Important
A5.4	GHG emissions associated with energy consumption	2.8	3.0	Moderately Important
A5.3	Utilization of environmentally friendly vehicles	2.8	3.0	Moderately Important
A5.2	Vehicle and mobile equipment exhaust emissions	2.3	2.0	Important

	Secondary criteria	Average rating	Median	Interpretation Median
A5.1	VOC emissions	2.2	2.0	Important
A6.3	Non-hazardous wastes produced from routine operation and maintenance	2.2	2.0	Important
A6.2	Hazardous waste produced from routine operation and maintenance	2.0	2.0	Important
A6.4	Pollution of land / waterways	1.9	2.0	Important
A6.1	Hazardous waste produced from ad-hoc activities (e.g., commissioning procedures) and spills	1.9	2.0	Important
A7.1	Efficiency of land use	2.6	2.0	Important
A7.3	Impact of activities in biodiversity	2.8	2.5	Moderately Important to Important
A7.2	Impact of location and size of land used for operations in biodiversity	2.7	3.0	Moderately Important
A8.1	Noise pollution	2.4	2.0	Important

II. Ranking of secondary economic criteria

Table 4.17: Average rating for the secondary economic criteria (Sorted by increasing average rating)

	Secondary criteria	Average rating	Median	Interpretation Median
B1.7	Operating Expenses Efficiency	2.3	2.0	Important
B1.3	Environmental mitigation and protection expenditures	2.2	2.0	Important
B1.8	Maintenance to assets cost	2.1	2.0	Important
B1.4	Land and property value	2.1	2.0	Important
B1.5	Capital to sales ratio	2.1	2.0	Important
B1.6	Operating expenses to sales	2.1	2.0	Important
B1.2	Project Capital	1.8	1.0	Very Important
B1.1	Life cycle cost	1.4	1.0	Very Important
B2.6	Financial implications of emissions and climate change	2.9	3.0	Moderately Important
B2.2	Economic value retained	2.4	2.0	Important
B2.1	Direct economic value generated	2.2	2.0	Important
B2.4	Payback period	2.1	2.0	Important
B2.5	Return on assets (ROA)	2.1	2.0	Important
B2.3	Net present value (NPV)	1.8	2.0	Important
B3.3	Employment opportunity	2.6	2.0	Important
B3.4	Service and product affordability	2.5	3.0	Moderately Important
B3.2	Standard entry level wage ratio	2.3	2.0	Important
B3.1	Service and product marketability	2.3	2.0	Important

	Secondary criteria	Average rating	Median	Interpretation Median
B3.5	Long-term plan	2.3	2.0	Important
B4.2	Non-monetary benefits	2.8	3.0	Moderately Important
B4.1	Indirect economic impacts	2.6	2.0	Important
B4.3	Finance leverage	2.3	2.0	Important

III. Ranking of secondary social criteria

Table 4.18: Average rating for the secondary social criteria (Sorted by increasing average rating)

	Secondary criteria	Average rating	Median	Interpretation Median
C1.11	Fuel storage safety equipment	2.8	3.0	Moderately Important
C1.8	Fueling vehicles safety devices	2.5	2.0	Important
C1.7	Health and safety covered in formal agreements with trade unions	2.3	2.5	Moderately Important to Important
C1.1	Representation in HSSE committees	2.2	2.0	Important
C1.12	Personal protective equipment (PPE)	2.2	2.0	Important
C1.2	Work-related injuries and fatalities	2.1	2.0	Important
C1.9	Fueling vehicles safety equipment	2.0	2.0	Important
C1.10	Fuel storage safety devices	2.0	2.0	Important
C1.3	Reduction of work-related injuries and fatalities	1.9	1.5	Important to Very Important
C1.4	Occupational diseases, lost days and absenteeism	1.8	1.0	Very Important
C1.5	Health and safety awareness and prevention	1.8	2.0	Important
C1.6	Education enhancement on HSSE awareness	1.8	1.5	Important to Very Important
C2.1	Initiatives to improve security (O&P)	2.1	2.0	Important
C2.2	Security breach	2.1	2.0	Important
C3.2	Community complaints	2.9	2.5	Moderately Important to Important
C3.1	Community awareness program for sustainability	2.7	3.0	Moderately Important
C3.3	Community engagement program	3.8	5.0	
C3.10	Local materials	2.8	3.0	Moderately Important
C3.8	Employee well-being	2.7	3.0	Moderately Important
C3.4	Impacts of operations on local communities	2.7	3.0	Moderately Important
C3.5	Community prevention and mitigation measures program	2.6	3.0	Moderately Important

	Secondary criteria	Average rating	Median	Interpretation Median
C3.9	Business continuity plan	2.6	3.0	Moderately Important
C3.7	Community Diversity	2.4	2.0	Important
C3.6	Contractors with sustainability orientation	2.3	2.0	Important
C4.2	Staff localization	2.2	2.0	Important
C4.1	Employee hires and turnover	2.2	2.0	Important
C5.1	Notices of changes in operations	2.5	2.0	Important
C5.2	Hygiene standards	2.2	2.0	Important
C6.2	Skills management of employees	2.0	2.0	Important
C6.5	Sustainability research and development	2.0	2.0	Important
C6.3	Employee performance appraisal	1.9	2.0	Important
C6.4	On-the-job training	1.9	2.0	Important
C6.1	Employee empowerment	1.8	1.0	Very Important
C7.2	Improve customer satisfaction	2.4	2.5	Moderately Important to Important
C7.4	Employee satisfaction	2.3	2.5	Moderately Important to Important
C7.3	Sustainable employee transportation	2.1	2.0	Important
C7.1	Customer complaints	1.8	1.0	Very Important
C8.2	Compliance with regulations	2.2	2.0	Important
C8.1	Anti-competitive behavior	1.9	2.0	Important
C9.1	Financial contributions to cultural institutions	3.0	3.0	Moderately Important

4.1.2.6 Final Set of Sustainability Criteria

The final set of sustainability criteria and indicators for airport fueling projects has been revised based on the experts' validation. Their feedback has been analyzed in order to remove, add, and validate the criteria, indicators and standard of measures through a quantitative and qualitative analysis of the questionnaire surveys. Table 4.19 lists the defined sustainability criteria and sub-criteria for the three sustainability dimensions.

Table 4.19: Environmental, economic, social sustainability criteria and sub-criteria

A	Environmental	B	Economic	C	Social
A1	Administrative procedures	B1	Economic performance analysis	C1	Occupational health and safety
A1.1	Cooperative sustainability policy	B1.1	Life cycle cost	C1.1	Representation in Health, Safety, Security and Environment (HSSE) committees
A1.3	Green product procurement policy	B1.2	Projects Capital	C1.3	Reduction of work-related injuries and fatalities
A1.4	Use of renewable materials	B1.3	Environmental mitigation and protection expenditures	C1.4	Occupational diseases, lost days and absenteeism
A1.5	Recycle used materials	B1.4	Land and property value	C1.5	Health and safety awareness and prevention
A1.6	Environmental Impact Assessment (EIA) study	B1.5	Capital to sales ratio	C1.6	Education enhancement on HSSE awareness
A1.8	Sustainability Training	B1.6	Operating expenses to sales	C1.7	Health and safety coverage with trade unions
A1.9	Sustainability function within the organization	B1.7	Operating Expenses Efficiency	C1.8	Fueling vehicles safety devices
		B1.8	Maintenance to assets cost	C1.9	Fueling vehicles safety equipment
A2	Water efficiency	B1.9	Working capital to sales	C1.10	Fuel storage safety devices
A2.1	Wastewater generation			C1.11	Fuel storage safety equipment
A2.2	Water withdrawal	B2	Economic value retained	C1.12	Personal protective equipment (PPE)
A2.3	Storm water management system	B2.1	Direct economic value generated		
A2.4	Water recycling and reusing	B2.2	Economic value retained	C2	Security
A2.5	Landscaping water use	B2.3	Net present value (NPV)	C2.1	Initiatives to improve security
		B2.4	Payback period	C2.2	Security breach
A3	Indoor environmental quality	B2.5	Return on assets (ROA)		
A3.1	Indoor ventilation and air quality	B2.6	Financial implications of emissions and climate change	C3	Community well-being and engagement
A3.2	Low or free-VOC indoor finishing materials			C3.1	Community awareness program for sustainability

A	Environmental	B	Economic	C	Social
A3.3	Carbon dioxide (CO_2) monitoring (O&P)	B3	Market presence	C3.2	Community complaints
		B3.1	Service and product marketability	C3.4	Impacts of operations on local communities
A4	Energy	B3.2	Standard entry level wage ratio	C3.5	Sustainability orientation of contractors
A4.1	Energy savings from operation of pumps	B3.3	Employment opportunity	C3.6	Community Diversity
A4.2	Energy savings from operation of buildings	B3.4	Service and product affordability	C3.7	Employee well-being
A4.3	Use of renewable energy	B3.5	Long-term plan	C3.8	Business continuity plan
A4.4	Vehicle and mobile equipment fuel savings			C3.9	Local materials
		B4	Indirect economic impacts		
A5	Emissions	B4.1	Indirect economic impacts	C4	Employment
A5.1	Reduction of VOC emissions	B4.2	Non-monetary benefits	C4.1	Employee hiring and turnover
A5.2	Vehicle and mobile equipment exhaust emissions	B4.3	Finance leverage	C4.2	Staff localization
A5.3	Utilization of environmentally friendly vehicles				
A5.4	GHG emissions associated with energy consumption			C5	Labor / management relations
				C5.1	Notice of changes in operations
A6	Waste			C5.2	Hygiene standards
A6.1	Hazardous wastes produced from ad-hoc activities (e.g., commissioning procedures) and spills				
A6.2	Hazardous waste produced from routine operation and maintenance			C6	Education and training
A6.3	Non-hazardous waste produced from routine operation and			C6.1	Employee empowerment

A	Environmental	B	Economic	C	Social
	maintenance				
A6.4	Pollution of land / waterways			C6.2	Skill management of employees
				C6.3	Employee performance appraisal
A7	Land use & biodiversity			C6.4	On-job training
A7.1	Efficiency of land use			C6.5	Sustainability research and development
A7.2	Impact of location and size of land used for operations in biodiversity				
A7.3	Impact of activities in biodiversity			C7	Quality of services
				C7.1	Improve customer satisfaction
A8	Noise			C7.2	Sustainable employee transportation
A8.1	Noise pollution			C7.3	Employee satisfaction
				C8	Regulatory compliance
				C8.1	Anti-competitive behavior
				C9	Cultural heritage
				C9.1	Financial contributions to cultural institutions

4.1.3 Sustainability Assessment Model

The assessment model structure is presented in Figure 4.2 and will be explained in more detail in subsequent subsections.

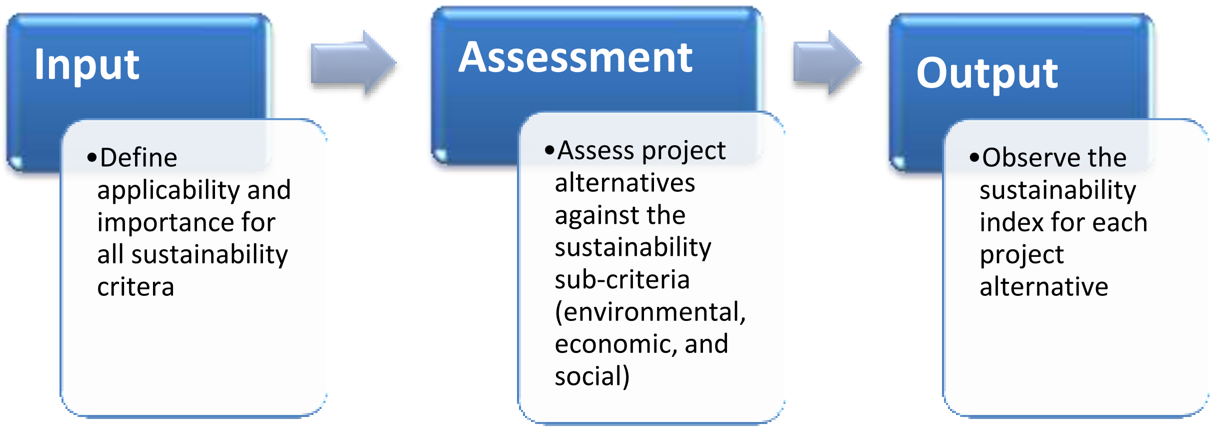


Figure 4.2: Sustainability model structure

4.1.3.1 Model Input:

The model input is intended to define the applicability and importance of the sustainability dimensions, criteria and sub-criteria to stakeholders. The following information will be requested; Sales volume (liters) projected for the assessment period; Importance (weight) for each of the three sustainability dimensions (economic, environmental, social), WDd; Importance (weight) for the assigned criteria under each sustainability dimension, WCj; Importance (weight) for the assigned sub-criteria under each sustainability criterion, WCjk. Table 4.20 shows the model input of the sustainability assessment model.

Table 4.20: Input of the sustainability assessment model

Project Sales
Year
Volume (Liter)
Sales ($)

Shareholders are requested to define the applicability of the primary and secondary criteria to the project (using input as "Yes" or "No"). They also are requested to define the importance of the three sustainability dimensions, the primary and secondary criteria (using the scale of; 1: Not important, 2: Slightly important, 3: Moderately important, 4: Important, 5: Very important).

Table 4.21: Input of sustainability assessment model – environmental

A	Environmental	Applicability	Importance (0-5)
A1	Administrative procedures		
A1.1	Cooperative sustainability policy		
A1.3	Green product procurement policy		
A1.4	Use of renewable materials		
A1.5	Recycle used materials		
A1.6	Environmental Impact Assessment (EIA) study		
A1.8	Sustainability Training		
A1.9	Sustainability function within the organization		
A2	Water efficiency		
A2.1	Wastewater generation		
A2.2	Water withdrawal		
A2.3	Storm water management system		
A2.4	Water recycling and reusing		
A2.5	Landscaping water use		
A3	Indoor environmental quality		
A3.1	Indoor ventilation and air quality		
A3.2	Low or free-VOC indoor finishing materials		
A3.3	Carbon dioxide (CO_2) monitoring (O&P)		
A4	Energy		
A4.1	Energy savings from operation of pumps		
A4.2	Energy savings from operation of buildings		
A4.3	Use of renewable energy		
A4.4	Vehicles and mobile equipment fuel savings		
A5	Emissions		
A5.1	Reduction of VOC emissions		
A5.2	Vehicles and mobile equipment exhaust emissions		
A5.3	Utilization of environmentally friendly vehicles		
A5.4	GHG emissions associated with energy consumption		
A6	Waste		
A6.1	Hazardous wastes produced from ad-hoc activities (e.g., commissioning procedures) and spills		
A6.2	Hazardous wastes produced from routine operation and maintenance		

A	Environmental	Applicability	Importance (0-5)
A6.3	Non-hazardous wastes produced from routine operation and maintenance		
A6.4	Pollution of land / waterways		
A7	Land use & biodiversity		
A7.1	Efficiency of land use		
A7.2	Impact of location and size of land used for operations in biodiversity		
A7.3	Impact of activities in biodiversity		
A8	Noise		
A8.1	Noise pollution		

Table 4.22: Input of sustainability assessment model - economic

B	Economic	Applicability	Importance (0-5)
B1	Economic performance analysis		
B1.1	Life cycle cost		
B1.2	Projects Capital		
B1.3	Environmental mitigation and protection expenditures		
B1.4	Land and property value		
B1.5	Capital to sales ratio		
B1.6	Operating expenses to sales		
B1.7	Operating Expenses Efficiency		
B1.8	Maintenance to assets cost		
B1.9	Working capital to sales		
B2	Economic value retained		
B2.1	Direct economic value generated		
B2.2	Economic value retained		
B2.3	Net present value (NPV)		
B2.4	Payback period		
B2.5	Return on assets (ROA)		
B2.6	Financial implications of emissions and climate change		
B3	Market presence		
B3.1	Service and product marketability		
B3.2	Standard entry level wage ratio		
B3.3	Employment opportunity		
B3.4	Service and product affordability		
B3.5	Long-term plan		
B4	Indirect economic impacts		
B4.1	Indirect economic impacts		
B4.2	Non-monetary benefits		
B4.3	Finance leverage		

Table 4.23: Input of sustainability assessment mode - social

C	Social	Applicability	Importance (0-5)
C1	Occupational health and safety		
C1.1	Representation in Health, Safety, Security and Environment (HSSE) committees		
C1.3	Reduction of work-related injuries and fatalities		
C1.4	Occupational diseases, lost days and absenteeism		
C1.5	Health and safety awareness and prevention		
C1.6	Education enhancement on HSSE awareness		
C1.7	Health and safety coverage with trade unions		
C1.8	Fueling vehicles safety devices		
C1.9	Fueling vehicles safety equipment		
C1.10	Fuel storage safety devices		
C1.11	Fuel storage safety equipment		
C1.12	Personal protective equipment (PPE)		
C2	Security		
C2.1	Initiatives to improve security		
C2.2	Security breach		
C3	Community well-being and engagement		
C3.1	Community awareness program for sustainability		
C3.2	Community complaints		
C3.4	Impacts of operations on local communities		
C3.5	Sustainability orientation of contractors		
C3.6	Community Diversity		
C3.7	Employee well-being		
C3.8	Business continuity plan		
C3.9	Local materials		
C4	Employment		
C4.1	Employee hires and turnover		
C4.2	Staff localization		
C5	Labor / management relations		
C5.1	Notices of changes in operations		
C5.2	Hygiene standards		
C6	Education and training		
C6.1	Employees empowerment		
C6.2	Skills management of employees		
C6.3	Employees performance appraisal		
C6.4	On-job training		
C6.5	Sustainability research and development		
C7	Quality of services		
C7.1	Improve customer satisfaction		
C7.2	Sustainable employees' transportation		
C7.3	Employees satisfaction		
C8	Regulatory compliance		

C	Social	Applicability	Importance (0-5)
C8.1	Anti-competitive behavior		
C9	Cultural heritage		
C9.1	Financial contributions to cultural institutions		

The importance of each sustainability dimension, criterion, and sub-criterion has been defined in the model input using the Likert scale 1-5 shown below (Table 4.24):

Table 4.24: Likert scale 1-5 for defining importance

1	2	3	4	5
Not important	Slightly important	Moderately important	Important	Very important

4.1.3.2 Model Assessment:

There are three dimensions in the sustainability assessment model for computing the sustainability index of each project alternative: economic, environmental or social. The defined criteria and sub-criteria under each sustainability dimension have two main groups: qualitative and quantitative. For all standard of measures, regardless of categorization, the respondent has to select from the different options. Each option has different scale from 0 to 1. Specific assessment criteria have been defined on a case-by-case basis, using data from industry standards, practices, regulations and industry best practices.

Table 4.25 provides an example of the quantitative criteria and the scale used to define the assessment criteria for the environmental sustainability dimension.

Table 4.25: Example of objective criteria for environmental sustainability

#	Environmental Criteria	Assessment Standard of measure	Assessment criteria 0	 0.25	 0.50	 0.75	 1
A4.1	Energy savings from operation of pumps	Percentage of electricity consumption savings as a result of the energy saving initiatives.	<15%	15%-20%	20%-25%	25%-30%	>30%
A4.2	Energy savings from operation of buildings	Percentage of electricity consumption savings as a result of the energy saving initiatives.	<15%	15%-20%	20%-25%	25%-30%	>30%
A4.3	Use of renewable energy	Percentage of renewable energy utilization for on-site activities.	<4.5 %	4.5%-6%	6%-7.5%	7.5%-9%	>9%
A4.4	Vehicle and mobile equipment fuel savings	Percentage of fuel consumption savings as a result of the fuel saving initiatives.	<10%	10%-20%	20%-30%	30%-40%	>40%
A5.1	Reduction in VOC emissions	Percentage of the VOC reduction as a result of the VOC monitoring and reduction initiatives.	<10%	10%-20%	20%-30%	30%-40%	>40%
A5.2	Vehicle and mobile equipment exhaust emissions (GHG)	Percentage of CO_2 reduction as a result of the CO_2 monitoring and reduction initiatives.	<15%	15%-20%	20%-25%	25%-30%	>30%
A6.2	Hazardous wastes produced from routine operation and maintenance	Percentage of hazardous wastes reduced by implementing specific initiatives.	<10%	10%-20%	20%-30%	30%-40%	>40%

In order to assess the sustainability of each project alternative based on the qualitative criteria (policies and programs, incentives and awareness, or plans for improving efficiencies and ongoing sustainable performance), the respondent can select from five criteria that reflect the performance scale shown in Table 4.26. This scale describes variable degrees of sustainability importance with increasing significance, which subsequently results in increasing scoring from 0 to 1 (Airport Cooperative Research Program 2008).

Table 4.26: Assessment scale 1-5 for sub-criteria

Qualitative Criteria	0	0.25	0.50	0.75	1
Process, Program or Policy	No process, program or policy in place.	Limited process, program or policy in place to address issues.	Process, program or policy is well developed and reflects good practice from the industry.	Process, program or policy embedded in airport operations and reflects best practice from the industry.	Industry leading process, program or policy. Long-term planning horizon.
Incentives and Awareness	Issue not on radar screen, relevancy to the organization undetermined. No budget allocation for activity.	Problems identified. Stakeholders take the lead in raising issue. Limited budget allocation for managing issue.	Some awareness of issue inside organization. Policy or program is communicated and enforced. Funding allocation to manage issue established on annual basis.	Strong internal awareness, recognition and understanding of issues. Investment deemed a priority.	Feedback loops in place, continuous surveying of stakeholders. Performance goals incentivized.
Plans for Performance Monitoring and Reporting	Risks have not been assessed and performance is/will not be monitored.	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance.	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization.	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization.	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.

Note that assessment criteria that are relevant to performance may not be applied for new airport fueling projects due to the lack of performance data and history. However, the assessment could be made against future plans in order to be used as a monitoring tool of sustainability performance. In case an assessment criterion is based on actual performance data, it is anticipated the criterion will be set as “Not Applicable” at the initial stage of project assessment. However, the data collected under the first performance review will become the baseline for each subsequent review. This flexibility will allow stakeholders to reassess the project or use the model during the project's other life phase (e.g. operation and maintenance) where actual data are available.

The tables in Appendices D, E, and F present the research updated environmental, economic, and social sustainability assessment criteria, indicators, and standard of measures. Different relevant scopes have been introduced for the sustainability criteria (i.e. Buildings, Tank Farm, Vehicles, Fueling Equipment, and Operation & Procedure). The tables also identify the applicable phases for criteria (i.e. Planning & Design, Construction, and Operation & Planning). Some criteria might be relevant for more than one scope and applicable at more than one phase based on their nature.

4.1.3.3 Model Output:

The model output presents the aggregation and calculations of the sustainability index for each project alternative using MAUT. The results of the analysis are displayed both numerically and graphically in the model output. This will provide the opportunity to present and compare the sustainability index of different project alternatives graphically (Figure 4.3).

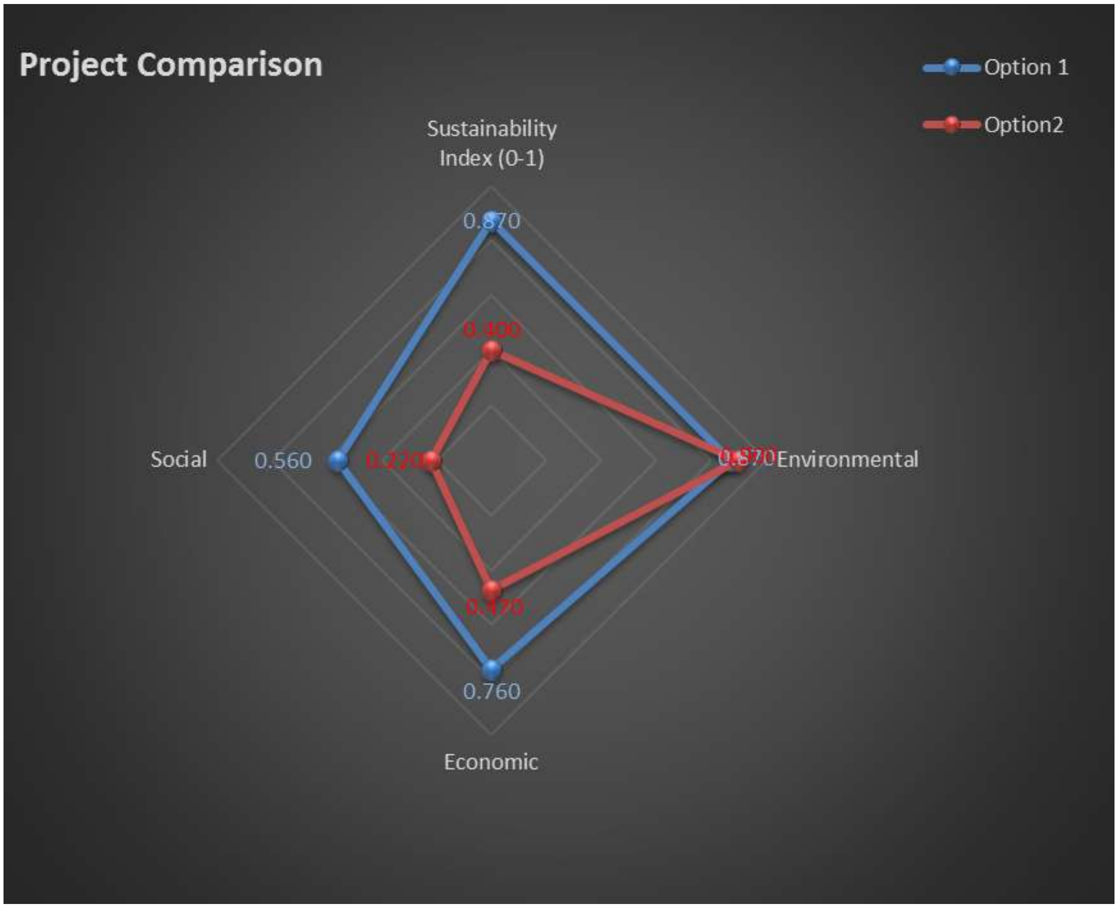


Figure 4.3: Graphical display (radar graph) of sustainability index for different project alternatives

4.1.4 Discussion: Objective #1 Development of a Sustainability Model for Airport Fueling Projects

The research's first objective was motivated by the lack of systematic mathematical models for assessing the sustainability of airport fueling projects. In order to achieve this objective, the research first defined a set of sustainability criteria, indicators and standard of measures for the sustainability of airport fueling projects considering the related quantitative and qualitative sustainability criteria. Secondly, and after defining the set of sustainability criteria, indicators and standard of measures, the research developed a domain-specific comprehensive assessment model that can help in assessing and managing the sustainability of airport fueling projects across their life cycle.

Using the TDBU methodology, the model identifies and assesses relevant sets of sustainability assessment criteria through quantitative and qualitative indicators that are compared against standard of measures. The proposed mathematical model uses MCA to evaluate project alternatives based on a set of economic, environmental, and social sustainability criteria and indicators, as well as an overall sustainability index. The MAUT is used to aggregate the different indicators and calculate the sustainability index of each project alternative. The models were evaluated on their merit by two case studies of two mega airport projects and a focus group composed of different stakeholders of airport operations. The analysis of the results supported that the suggested models were appropriate to assess the sustainability of airport fueling projects. The data indicates that the implementation of the proposed models would aid in collecting information that would assist in the evaluation of airport sustainability, and would provide a comprehensive analysis that would allow airport fueling projects to operate more efficiently.

4.2 Results and Discussion of Objective #2 - Development of Emissions Analysis Model for Airport Fueling Projects

The emission model structure (Figure 4.4) will be explained in more detail in subsequent sections.

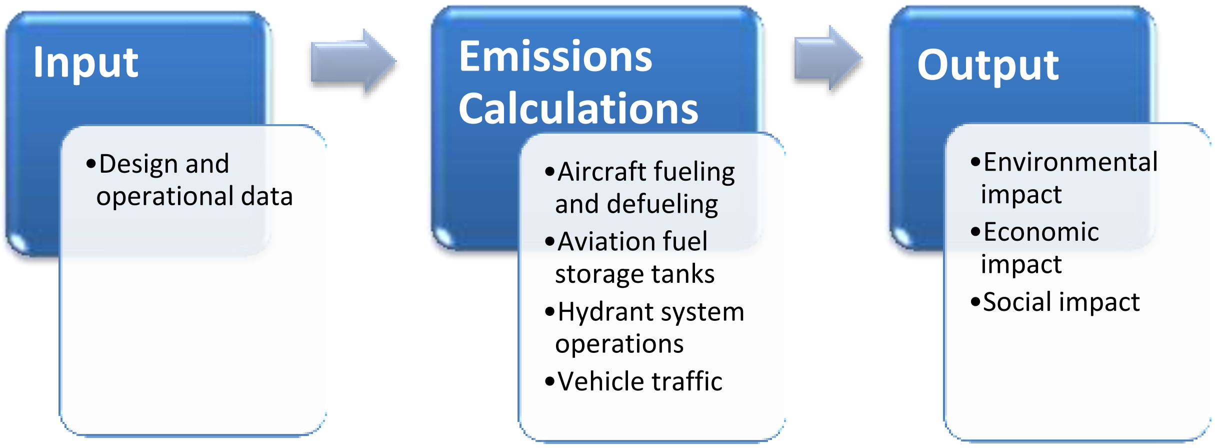


Figure 4.4: Emission model structure

4.2.1 Introduction

Figure 4.5 shows the model's instructions and an explanation for the user. Figure 4.6 shows the model's inputs that require the user to enter different operational and design data related to general airport information, aircraft fueling operations, tank details, hydrant systems and vehicle movement.

Sustainability of Airport Operations

Part 1: Emissions associated with Aviation fuel storage and handling activities

Instructions
1. Fill in all applicable data required in the "INPUT" tab
1.1 Ensure the data correspond to 1 day
1.2 Ensure the values reported correspond to the units displayed next to each data box
2. Once all data have been provided, go to the Output tabs (in yellow):
2.1 Environmental Impact: calculated emissions based on the input provided
2.2 Financial Impact: costs corresponding to offseting/recovering the calculated emissions
2.3 Social Impact: estimations of health-related impact of VOC and equivalency of CO2 emissions into every days' (community) terms
3. References tab: Includes a list of references (for info)
4. Calculation sheets (for info)
4.1 Calculator tabs are locked to protect against accidental loss of calculation equations and data

Contents

Topic	Link
INPUT	Link
Environmental Impact	Link
Financial Impact	Link
Social Impact	Link
A. Emissions related to aircraft refuelling	Link
B. Emissions from tank farms	Link
C. Emissions from vehicle traffic	Link
D. Emissions from Hydrant operation	Link
References	Link

Figure 4.5: Emission model - instructions

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Input tab

Reported values should correspond to 1 day

Airport: PMIA

Aircraft Fuelling

	Daily	Units
Jet Fuel delivered	50,000.0	lt
Jet fuel by Hydrant System	80.0%	%
Jet Fuel density	0.80	kg/lt
Jet fuel by Refueller	20.0%	%
Jet fuel defuelled into Refueller	1,000.0	lt
Avgas delivered by Refueller		lt
Avgas density		kg/lt

Airport Area

Total area of the airport	27,126,850.0	sq. miles

Hydrant operation

Number of low points flushed daily	1.0	# low points
Average quantity flushed per low point	200.0	lt

Tank Farm

	Daily		
Basic Input Data	**JET A1 Tanks**	**Avgas Tanks**	Units
Vapor recovery system present?	No		Yes/No
Tank Data			
Diameter	22.5		m
Capacity	5,000,000.0		lt
[C]onical or [D]ome roof?	C		"C" or "D"
Shell height	13.5		m
Liquid Data			
Maximum daily throughput	50,000.0		lt/day/tank
Number of tanks in tankfarm	3.0		

Vehicle Movement - ITPO vehicles

	Daily				
	HDDV	HDGV	LDDV	LDGV	Units
Total Road length - all vehicles (by type)	474.0		185.1		Km
Total Idle time - all vehicles (by type)	2,982.0		1,290.0		min
Average consumption, lt/100km	215.0		40.0		lt/100km driven

HDDV *Heavy-Duty Diesel Vehicles*
HDGV *Heavy-Duty Gasoline Vehicles*
LDDV *Light-Duty Diesel Vehicles*
LDGV *Light-Duty Gasoline Vehicles*

Hydrant Low Point (LP) flushing Vehicle

	HDDV	Units
Total Road length - all LP flushing vehicles	14.0	Km
Total Idle time - all LP flushing vehicles	20.0	min
Average consumption, lt/100km	15.0	lt/100km driven

Figure 4.6: Emission model - inputs

4.2.2 Environmental Impact of Airport Fueling Emissions

This section presents the environmental impact of airport fueling emissions that consists of four main emissions: 1) emissions of aircraft fueling and defueling operations, 2) emissions of aviation fuel tank farms, 3) emissions of vehicles traffic, and 4) emissions of hydrant operations.

4.2.2.1 Emissions of Aircraft Fueling and Defueling Operations

This section involves the calculation of emissions associated with fueling operations by both hydrant dispensers and refuelers, as well as defueling operations by refuelers. In the case of refuelers, the emissions from the loading of the tank truck as well as those during the redelivery of the defueled product to the aircraft have been taken into account. The operational data that is required for calculating aircraft fueling emissions, including emissions from tank trucks during loading operations, are: the amount of fuel refueled by fuel type, the amount of jet fuel defuelled, the percentage of fueling operations, the relative to total for the site, by hydrant systems, and the percentage of fueling operations, relative to total for the site, by the refueler. Using the above operational data and emissions factors, the annual VOC emissions can be calculated. Figure 4.7 shows an example of calculations performed with the emission model - aircraft and refueler vent emissions calculation.

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Calculation Sheet: Emissions from Aircraft and Refueller Vents

PMIA Airport

Emissions from aircraft fuel tank vents during aircraft refuelling and Emissions from tank truck vent during loading

Data below correspond to:	1	days	**Calculations correspond to**	365	days

Input

		Units
Jet Fuel delivered	50,000.0	lt
Jet fuel by Hydrant System	80.0%	%
Jet Fuel density	0.80	kg/lt
Jet fuel by Refueller	20.0%	%
Jet fuel defuelled into Refueller	1,000.0	lt
Avgas delivered by Refueller	0.0	lt
Avgas density	0.00	kg/lt

Emission Calculations

	per year	Units
Total emissions, Jet fuel	181.040	kg VOC
Total emissions, Avgas	0.000	kg VOC
A. Total emissions	**181.040**	kg VOC
A1. By Dispensers	116.800	kg VOC
A2. By Refuellers	64.240	kg VOC

Financial Impact

		Units
Unit cost for reducing VOC [2]	2,420.0	$/tn VOC reduced
Total cost for VOC emissions	0.438	k$

Factors [1]

Jet fuel Emission factor	0.01	gr VOC/kg fuel
Avgas Emission factor	1.27	gr VOC/kg fuel

Equations

Equation used for the above calculation

Emissions [g VOC] = Σfuel types ((fuelhydrant delivered [kg] + 2 × fueltanker delivered [kg]) × emission factor [g/kg]) + (2 × fueltanker defuelled [kg]) × emission factor [g/kg])

Figure 4.7: Emissions from aircraft and refueler vents calculation

4.2.2.2 Emissions of Aviation Fuel Tank Farms

The operational data required for calculating standing and working loss of fuel storage tanks are: the tank design data, the daily throughput information and the number of tanks in the tank farm.

Using the above operational data emissions factors, the annual VOC emissions can be calculated. Figure 4.8 shows an example of calculations performed using the research emission model - storage tanks emissions calculation.

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Calculation Sheet: Emissions from Storage Tanks

PMIA **Airport**

Emissions from handling aviation fuels into storage tanks

Data below correspond to: 1 days

Input

Basic Input Data	JET A1 Tanks	Avgas Tanks	Units
Vapor recovery system present?	No	No	Yes/No
Tank Data			
Diameter	22.5	0.0	m
Capacity	5,000,000.0		lt
(C)onical or (D)ome roof?	C	C	"C" or "D"
Shell height	13.5	0.0	m
Liquid Data			
Maximum daily throughput	1,320,000.0	0.0	lt/day/tank
Number of tanks in tankfarm	3.0	0.0	

Calculations correspond to 365 days

Emission Calculations

	per year	Units
Total emissions, Jet fuel	3,610.890	kg VOC
Total emissions, Avgas	0.000	kg VOC
Total emissions	3,610.890	kg VOC

Financial Impact

		Units
Unit cost for reducing VOC [2]	2,420.0	$/tn VOC reduced
Total cost for VOC emissions	8.738	k$

Equations [1],[3]

Equation used for the above calculation

Emissions [kg VOC] = SL + WL

Figure 4.8: Emissions from storage tanks calculation

4.2.2.3 Emissions of Vehicle Traffic

The operational data required for calculating vehicle exhaust emissions are: the total road length for all diesel-powered vehicles, the total road length for gasoline-powered vehicles, the total idle time for all diesel-powered vehicles, the total idle time for all gasoline-powered vehicles, the average consumption rate (liter/100km) for diesel-powered vehicles, and the average consumption rate (liter/100km) for gasoline-powered vehicles.

Using the above operational data and emission factors, the annual vehicle exhaust emissions can be calculated. Figure 4.9 shows an example of calculations performed using the research emission model - vehicle traffic emissions calculation.

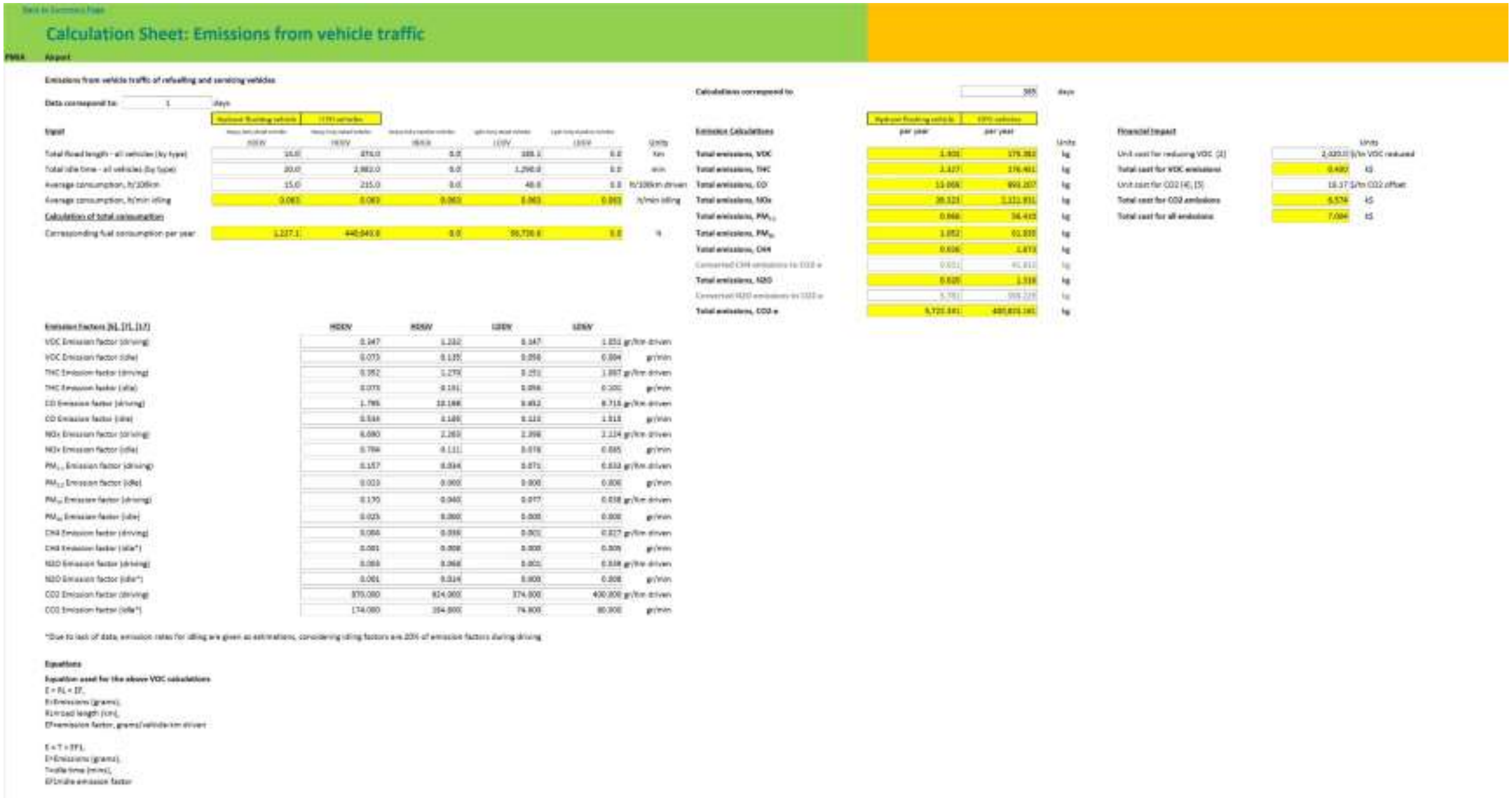


Figure 4.9: Emissions from vehicle traffic calculation

4.2.2.4 Emissions of Hydrant Operations

The operational data that is required for calculating vehicle exhaust emissions are: the number of low points flushed every day, the average quantity of fuel flushed from each low point (typically: 50-200 liters), and the total road length for the hydrant low point flushing vehicle (typically diesel-powered, heavy duty). Using the above operational data and emissions factors, the annual emissions attributed to hydrant low point flushing can be calculated. Figure 4.10 shows an example of calculations performed using the research emission model - hydrant operations emissions calculation.

Figure 4.11 shows an example of aggregating all related emissions calculations performed using the research emission model and presented as the total emissions environmental impact – environmental impact.

Figure 4.10: Emissions from hydrant operations calculation

Figure 4.11: Environmental impact

4.2.3 Economic Impact of Airport Fueling Emissions

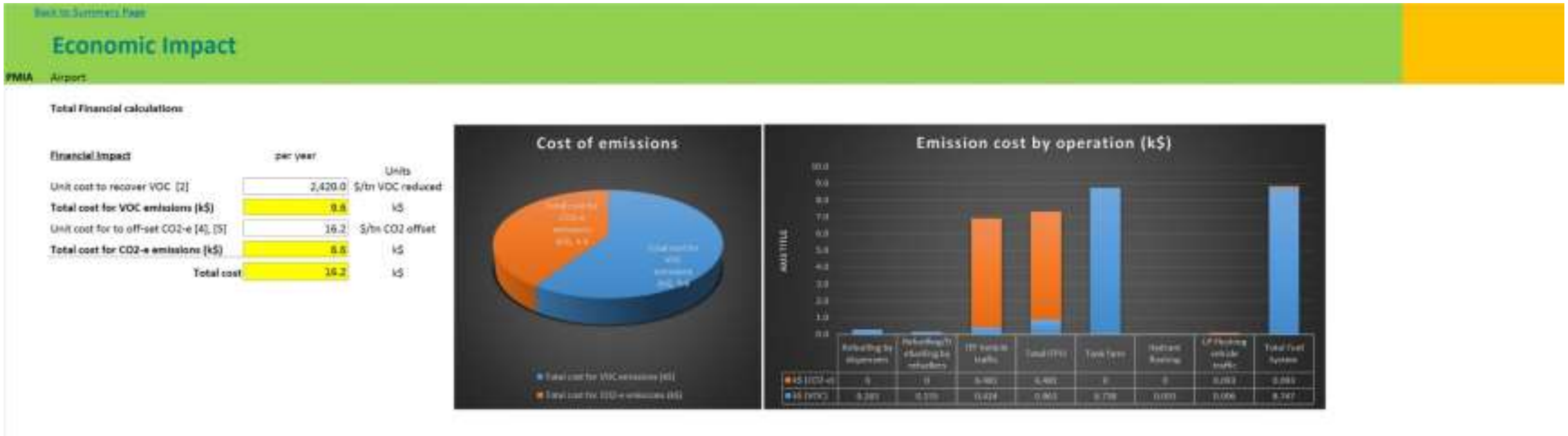
This research model compares project alternatives and the economic impact based on CO_2 emissions offsetting cost and VOC recovery cost.

4.2.3.1 CO_2 Offsetting Cost

This research estimates the costs associated with CO_2 emissions calculated for the various aircraft fueling activities (e.g., storage and handling of aviation fuels). It was estimated that the average cost of offsetting CO_2 emissions based on best practices and similar industry project costs is equivalent to $16.2 per ton of CO_2. As such, the cost for offsetting the total amount of CO_2 emissions (including emissions of other greenhouse gases, CH_4 and N_2O, converted to CO_2 – equivalent) was estimated on the basis of the above unit cost.

4.2.3.2 VOC Recovery Cost

The average cost of the operation of the vapor recovery unit – as a means to control VOC emissions- is 2.42 K$ per ton VOC. As such, the financial impact of VOC emissions was estimated on the basis of the above unit cost to control VOC emissions via vapor recovery systems. Figure 4.12 shows an example of aggregating all related emission calculations performed using the research emission model and presented as the total emissions economic impact – economic impact.



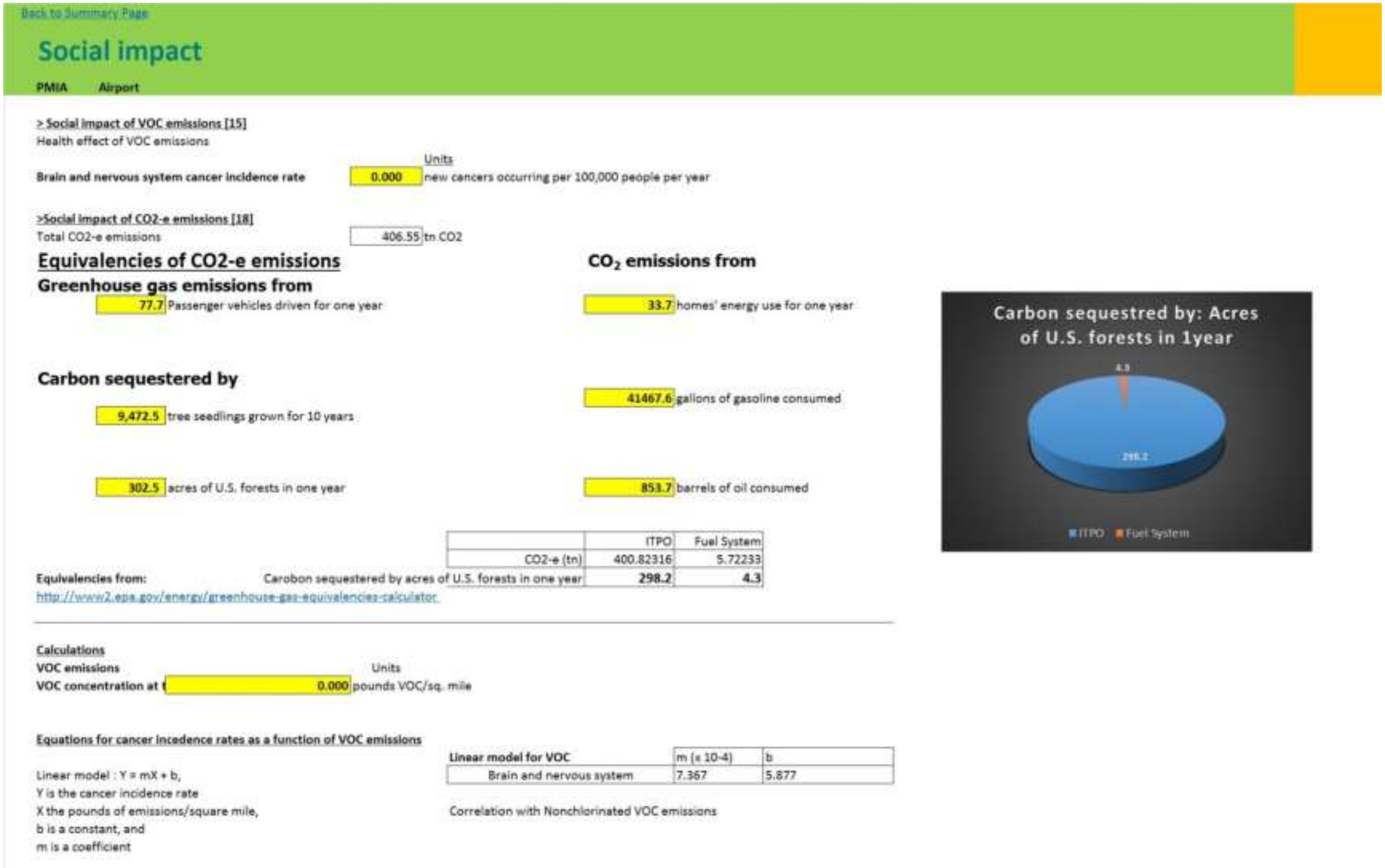
	ITPO				Fuel System				
	Refuelling by dispenser	Refuelling/Defuelling	ITP Vehicle traffic	Total ITPO	Tank farm	Hydrant flushing	LP Flushing vehicle tra	Total Fuel System	
k$ (VOC)	0.283	0.155	0.424	0.863	8.738	0.003	0.006	8.747	k$
k$ (CO2-e)	0	0	6.481	6.481	0	0	0.093	0.093	k$
				7.344				8.839	k$

Figure 4.12: Economic impact

4.2.4 Social Impact of Airport Fueling Emissions

This research assesses the social impact of calculated emissions for the main emission species based on: 1) the social impact of VOC emissions due to its link to higher cancer incident rates, and 2) the effect of CO_2 emissions in the community that was determined on the basis of estimating the equivalent of CO_2 emissions in everyday terms.

Based on the above approach, Figure 4.13 shows an example of aggregating all related emission calculations performed using the research emission model and presented as the total emissions social impact – social impact.



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Social impact

PMIA Airport

> Social impact of VOC emissions [15]

Health effect of VOC emissions

		Units
Brain and nervous system cancer incidence rate	0.000	new cancers occurring per 100,000 people per year

>Social impact of CO2-e emissions [18]

Total CO2-e emissions 406.55 tn CO2

Equivalencies of CO2-e emissions

Greenhouse gas emissions from

77.7 Passenger vehicles driven for one year

CO_2 emissions from

33.7 homes' energy use for one year

41467.6 gallons of gasoline consumed

853.7 barrels of oil consumed

Carbon sequestered by

9,472.5 tree seedlings grown for 10 years

302.5 acres of U.S. forests in one year

	ITPO	Fuel System
CO2-e (tn)	400.82316	5.72233
Carobon sequestered by acres of U.S. forests in one year	298.2	4.3

Equivalencies from:

http://www2.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Calculations

VOC emissions Units

VOC concentration at t 0.000 pounds VOC/sq. mile

Equations for cancer incedence rates as a function of VOC emissions

Linear model : Y = mX + b,

Y is the cancer incidence rate

X the pounds of emissions/square mile,

b is a constant, and

m is a coefficient

Linear model for VOC	m (x 10-4)	b
Brain and nervous system	7.367	5.877

Correlation with Nonchlorinated VOC emissions

Figure 4.13: Social impact

4.2.5 Discussion: Objective #2 Development of Emissions Analysis Model for Airport Fueling Projects

Currently, there are no initiatives for the emissions of airport fueling projects that consider predefined equations and functions to determine all related emissions (i.e., tank farm emissions, hydrant system emissions, mobile equipment fueling component emission, and aircraft fueling operation emissions) and to evaluate different design alternatives based on their economic, environmental and social impacts. Considering the current absence of models for analyzing the emissions of aircraft fueling projects at airports, this research provided a framework to develop a means for pursuing sustainability and maximizing the potential benefits of sustainability. This chapter answered the following research questions: 1) What are the types of emissions that are specific to airport fueling project?; 2) How to assess and calculate the different types of emissions related to airport fueling projects systematically?; and 3) How to analyze the emissions of different airport fueling project alternatives with respect to sustainability measures (environmental, economic, and social)?

The research presented the first detailed analysis for aircraft fueling project by identifying the sources of emissions through a deep analysis and review of relevant international standards and specifications. The detailed analysis covered the vehicles’ movement, handling aviation fuels in tank farms, and the operation and maintenance of hydrant systems. Detailed investigation, review and analysis of emission sources were conducted during: aircraft refueling operations, defueling operations, the movement of vehicles associated with aircraft fueling activities, the operation and maintenance of hydrant fuel systems and routine operations of aviation fuel tank farms.

Until this research, no equation in the literature considered the emissions of airport fueling services activities. The research introduced an in-depth extension of current emission-related equations in the literature to cover airport fueling project operation sub-elements. This extension facilitated the implementation of the equations in the airport fueling project field.

The model requires the user to enter different operational and design data related to general airport information, aircraft fueling operations, tank details and hydrant systems and vehicle movement. Using the research's predefined equations, the model calculates and presents the environmental impact (main emission species), the economic impact (cost of CO_2 offsetting and VOC recovery system), and the social impact (cancer incident rates related to VOC emissions and the equivalent of CO_2 emissions in every day terms). The model represents the emission impacts of each project alternative numerically and graphically with respect to the sustainability measures (economic, environmental and social). This representation aims at analyzing a project's sustainability by highlighting each project alternative with respect to different emissions' economic, environmental and social measures. In addition, it provides a tool to visualize the analysis results.

The model has been validated using a focus group and two case studies. The two case studies incorporated a variety of conditions and alternatives for two new international airport projects to illustrate the model and its practical application. The case studies used the proposed model to analyze the sustainability of different project alternatives for aircraft fueling activities (including tank farm, hydrant system, into-plane mobile equipment and buildings) based on emissions. The focus group included a number of domain experts who were interviewed and surveyed to evaluate the model. The airport domain experts included airport engineering firms and consultants in addition to fuel system operators. The survey assessed the implementation of the sub-model of both case studies based on applicability, flexibility, scalability, usability, and coverage.

4.3 Results and Discussion of Objective #3 - Development of Energy Consumption Analysis Model for Airport Fueling Projects

The model structure and use is presented in Figure 4.14 and will be explained in more detail in the subsequent sections.

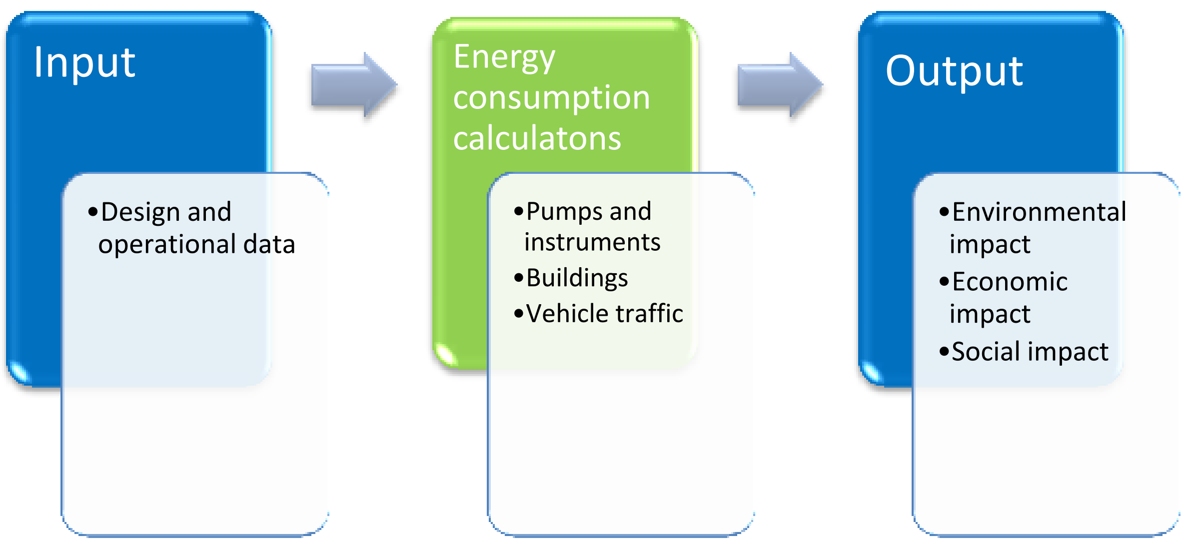


Figure 4.14: Energy model structure

4.3.1 Introduction

Figure 4.15 shows the instructions that give quick guidance and an explanation for the user in addition to quick links to other calculators for easy use.

Instructions
1. Fill in all applicable data required in the tabs " Pumps and Instruments", "Buildings" and "Vehicles"
The tabs above include an INPUT section (where input is to be provided) and an OUTPUT section (with calculations)
1.1 Ensure input is given in all white-coloured cells in the INPUT section of each tab
1.2 Ensure the values reported correspond to the units displayed next to each data box
2. Once all data have been provided, go to the Output tabs (in yellow) to see Impacts:
2.1 Environmental: calculated CO_2 emissions, based on calculated energy consumption for pumps/equipment, energy consumption for buildings and fuel consumption for vehicles
2.2 Financial: costs for electricity consumption of pumps/equipment and buildings, along with costs for motor vehicle fuel and cost to offset calculated CO_2 emissions
2.3 Social: Equivalency of CO_2 emissions and of power consumption into every days' (community) terms
3. References tab: Includes a list of references (for info)

Contents

Topic	Link
Pumps and Instruments	Link
Buildings	Link
Vehicles	Link
Environmental Impact	Link
Financial Impact	Link
Social Impact	Link
References	Link

Figure 4.15: Energy Model – Instructions

4.3.1.1 Energy Consumption of Pumps

Figure 4.16 shows an example of calculations performed using the research energy calculator tool for pumps.

Airport: PMIA, Madidnah

Input - Pumps

INPUT

Colour-coding:
White cells: Add Input, Grey Cells: Add input if site specific data are available, otherwise leave default values, Orange cells: indicate calculations (do not change)

INPUT ON GENERAL PARAMETERS			Units
Electricity Average Unit Price	:		$/kWh

Input for 1 day

INPUT for Pumps		Tankfarm										Hydrant
	Name pump>	Jet Pump	Slop	Tank transfer/recovery	Unloading	Other Depot	Other Depot	Other Depot	Other Depot	Other Depot	Foam	Fire water	Hydrant
# of pumps working concurrently	**Units**	1	0	1	1								
Concurrency factor*			0.3	0.7	1.0						0.0	0.3	
Operating Hrs per day	Hrs	20.0	1.0	3.0	42.0							1.0	20.0
Density**	kg/m³	800.0	800.0	800.0	800.0						1200.00	1000.00	800.0
Output	m³/h	275.0	30.0	120.0	90.0								
Delivery height	m		3.5	3.5	10.0								2.0
Efficiency of pump**		0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.80	0.80	0.75
Efficiency of motor**		0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.80	0.80	0.95
Overall efficiency		0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.64	0.64	0.71

*Concurrency factor: No operation: 0, Low Operation: 0.3, High operation:0.7, Full operation: 1
**If no site specific data are available, leave default values

Input for 1 day

INPUT for Instruments		Tankfarm				Hydrant			
		Number	Concurrency factor*	Estimated energy consumption (kW)**	Operating hrs (per day)	Number	Concurrency factor	Estimated energy consumption (kW)**	Operating hrs (per day)
Electrical actuators	#	60	0.3	1.2	1	25	0.3	1.2	0.5
Instruments	#	47	1	0.04	24	39	0.3	0.04	24
Outdoor spotlights on poles	#	120	0.7	0.4	12	0	0.7	0.4	0
Outdoor fluorescent light fittings	#	70	0.3	0.12	12	34	0.7	0.12	0
Cathodic protection	#	3	1	0.4	24	1	1	0.4	0

OUTPUT

Calculations for 1 year

Pumps		Pumps - Tankfarm											Pumps - hydrant
		Jet Pump	Slop	Tank transfer/recovery	Unloading	Other Depot	Other Depot	Other Depot	Other Depot	Other Depot	Foam	Fire water	Hydrant
Energy consumption	kWh	**0.0**	**10.6**	**985.0**	**42214.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Total					
Tankfarm	**43209.5**	kWh	Hydrant	**0.0**	kWh
CO_2 emissions:	**34567.6**	kgCO2	CO_2 emissions:	**0.0**	kgCO2

Calculations
Energy cons. = 365 (days) x Number of pumps working concurrently x Concurrency factor x Operating hrs per day x Pump Output flowrate (m3/hr) x Delivery height (m) x Density (kg/m3) x gravity (g=9.81m2/s) / (Overall efficiency x 3.6*10^6)
CO2 emissions = Energy consumption (kWh) x Emission factor (kgCO2/kWh)

Calculations for 1 year

Instruments	Tankfarm		Hydrant	
Energy consumption	kWhr	CO2 emissions (kg CO2)	kWhr	CO2 emissions (kg CO2)
Electrical actuators	7884	6307	1642.5	1314
Instruments	16468.8	13175	4099.68	3280
Outdoor spotlights on poles	147168	117734	0	0
Outdoor fluorescent light fittings	11037.6	8830	0	0
Cathodic protection	10512	8410	0	0
Total	**193070.4**	**154456.3**	**5742.2**	**4593.7**

Calculations
Energy consumption = 365 (days) x Number of instruments working concurrently x Concurrency factor x Operating hrs per day x Estimated energy consumption
CO2 emissions = Energy consumption (kWh) x Emission factor (kgCO2/kWh)

GENERAL PARAMETERS (Default values)			Ref:
Unit cost for CO_2 offset	16.17	\$/tn CO_2	("Carbon Portal," n.d.)
CO_2 Emission Factor (Electricity)	0.8	$kgCO_2/kWh$	("US Environmental Protection Agency | US EPA," n.d.)

Figure 4.16: Energy consumptions calculations for pumps and instrument

4.3.1.2 Energy Consumption of Buildings

Figure 4.17 shows an example of calculations performed using the research energy calculator tool for buildings.

4.3.1.3 Energy Consumption of Vehicles

Figure 4.18 shows an example of calculations performed using the research energy calculator for vehicles traffic.

Airport: **PMIA, Madidnah**

Input - Buildings

INPUT

Colour-coding:
White cells: Add Input, Grey Cells: Add input if site specific data are available, otherwise leave default values, Orange cells: indicate calculations (do not change)

Input for 1 day

INPUT for A/C		Tankfarm		ITPO		Hydrant	
		buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)
Quantity of A/C units	#	0	30	0	7	0	
Concurrency factor*			0.7		1.0		
Power rating**	kW	3.5	3.5	3.5	3.5	3.5	3.5
Hours used per day	hr						

*Concurrency factor: No operation: 0, Low Operation: 0.3, High operation:0.7, Full operation: 1
**If no site specific data are available, leave default values

INPUT for ALL sockets and lights		Tankfarm		ITPO		Hydrant	
		buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)
Lump of Sockets, lights	#		446.0		156.0		
Concurrency factor*		0.0	0.7	0.0	0.7		
Power ratng**	kW	25.0	25.0	25.0	25.0	25.0	25.0
Hours used per day	hr						

OUTPUT

Calculations for 1 year

Calculations		Tankfarm		ITPO		Hydrant		
		buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	
Energy consumption-A/C	kWh	0	0	0	0	0	0	0
Energy consumption-All sockets/ligh	kWh	0	0	0	0	0	0	0
CO2 emissions-A/C	kgCO2	0	0	0	0	0	0	0
CO2 emissions-All sockets/lights	kgCO2	0	0	0	0	0	0	0

Calculations
Energy consump. = 365 x Quantiry of units x Power rating (kWh) x Hours used per day (hr) x concurrency factor
Emissions = Energy consumption (kWh) x Emission factor (kgCO2/kWh)

Figure 4.17: Energy consumption calculations for building

Airport: **PMIA, Madidnah**

Input - Vehicle movement

INPUT

Colour-coding:
White cells: Add Input, Grey Cells: Add input if site specific data are available, otherwise leave default values, Orange cells: indicate calculations (do not change)

INPUT ON GENERAL PARAMETERS			Units
Diesel Fuel Price per lt	:		$/lt
Gasoline Fuel Price per lt	:		$/lt

Input for 1 day

INPUT for Vehicle Traffic		Hydrant LP flushing vehicles		ITPO Vehicles				
		Diesel Engines (HD)	Gasoline Engines (HD)	Diesel Engines (HD)	Gasoline Engines (HD)	Diesel Engines (LD)	Gasoline Engines (LD)	HD: Heavy Duty; LD: Light Duty
Total Road length - all vehicles (by type)	km	15		878		201		
Total Idle time - all vehicles (by type)	min	20		3163		1290		
Average consumption during driving	lt/100km	15.0		215.0		15.0		
Average consumption during idling**	lt/min idling	0.063	0.063	0.063	0.063	0.063	0.063	

**If no site specific data are available, leave default values

OUTPUT

Calculations for 1 year

Calculations		Hydrant LP flushing vehicles		ITPO Vehicles				
		Diesel Engines (HD)	Gasoline Engines (HD)	Diesel Engines (HD)	Gasoline Engines (HD)	Diesel Engines (LD)	Gasoline Engines (LD)	HD: Heavy Duty; LD: Light Duty
Fuel consumption	lt	1304	0	761836	0	40711	0	
CO2 emissions	kgCO2	3516.4	0.0	2054822.2	0.0	109804.9	0.0	2168143.5

Calculations
Fuel consumption = Σ all fuel types 365*[Distance driven per day (km) x consumption during driving (lt/100km) + time in idle per day (min) x consumption during idling (lt/min)]
CO2 Emissions = Consumption (Diesel) x Emission factor (Kg CO2/lt Diesel) + Consumption (Gasoline) x Emission factor (Kg CO2/lt Gasoline)

GENERAL PARAMETERS (Default values)		
CO2 emissions per lt consumed (Diesel)	2.7	kg CO2/lt cons.
CO2 emissions per lt consumed (Gasoline)	2.3	kg CO2/lt cons.

Ref: Emission Factors for Greenhouse Gas Inventories, http://www2.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf

Figure 4.18: Energy consumptions calculations for vehicle traffic

4.3.2 Environmental Impact of Airport Fueling Energy

Figure 4.19 shows an example of aggregating all related energy consumption calculations performed using the research energy calculator and presented as the total energy environmental impact.

Pumps and other instruments: the environmental impact of electricity consumption of pumps and other instruments utilized at tank farms and hydrant facilities has been calculated on the basis of CO_2 emissions equivalent to the total electricity consumption (kWh), using the EPA emission factor for electricity consumption.

E = Energy (kWh) x emission factor kg CO_2/kWh)

Emission factor = 0.8 kgCO_2/kWh

Buildings: the environmental impact of electricity consumption of buildings and offices utilized at tank farms, into-plane operations and hydrant facilities has been calculated on the basis of CO_2 emissions equivalent to the total electricity consumption (kWh), using the EPA emission factor for electricity consumption.

E = Energy (kWh) x emission factor (kg CO_2/kWh)

Emission factor = 0.8 kgCO_2/kWh

Vehicles: The environmental impact of fuel consumption of vehicles has been calculated on the basis of CO_2 emissions associated with diesel or gasoline fuel consumption, using EPA emission factors for diesel powered vehicles (Table 4.27).

E = Power (kWh) x emission factor (kg CO_2/kWh)

Emission factor (diesel) = 2.697 kgCO_2/liter diesel

Emission factor (gasoline) = 2.319 kgCO_2/liter gasoline

Table 4.27: CO_2 Emission factors for vehicles, linked to fuel consumption

Emission factors per unit fuel consumption	Diesel	Units
CO_2 Emission factor	10.21	kg/gallon
CO_2 Emission factor	2.697	kg/litre

Source: (EPA 2015)

Environmental Impact

Airport **PMIA, Madidnah**

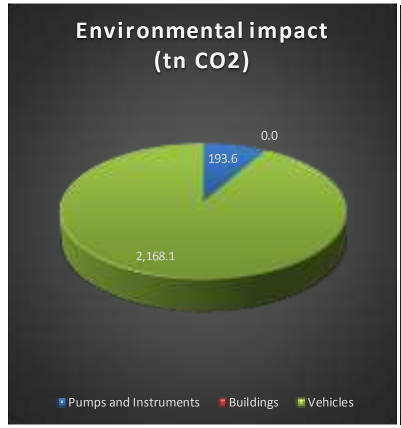
Energy Consumption and CO_2 Emission calculations

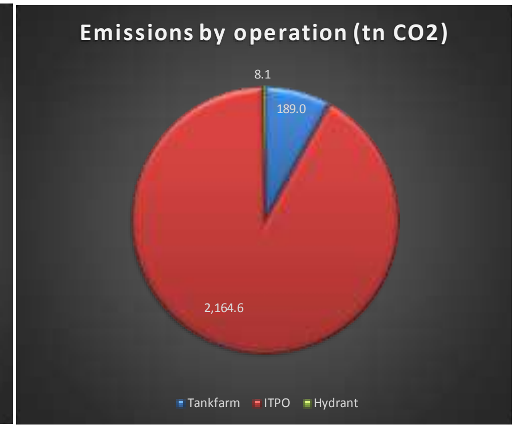
Pumps and Instruments	Energy Consumption	Units	CO_2 emissions	Units
Pumps-Tankfarm	**43,209.5**	kWh	**34.6**	tn CO_2
Instruments-Tankfarm	**193,070.4**	kWh	**154.5**	tn CO_2
Pumps-Hydrant	**0.0**	kWh	**0.0**	tn CO_2
Instruments-Hydrant	**5,742.2**	kWh	**4.6**	tn CO_2
Total	**242,022.1**	kWh	**193.6**	tn CO_2

Buildings	Energy Consumption		CO_2 emissions	
Tankfarm	**0.0**	kWh	**0.0**	tn CO_2
ITPO	**0.0**	kWh	**0.0**	tn CO_2
Hydrant	**0.0**	kWh	**0.0**	tn CO_2
Total	**0.0**	kWh	**0.0**	tn CO_2

Vehicles	Fuel consumption		CO_2 emissions	
ITPO vehicles (Diesel engines)	**802,547.1**	lt	**2,164.6**	tn CO_2
Hydrant Vehicles (Diesel engines)	**1,303.7**	lt	**3.5**	tn CO_2
ITPO vehicles (Gasoline engines)	**0.0**	lt	**0.0**	tn CO_2
Hydrant Vehicles (Gasoline engines)	**0.0**	lt	**0.0**	tn CO_2
Total		lt	**2,168.1**	tn CO_2

TOTAL	**242,022.1**	kWh	**2,361.8**	tn CO_2
	803,850.8	lt Diesel	**0.0**	lt Gasoline





	CO_2 emissions
Tankfarm	189.0
ITPO	2,164.6
Hydrant	8.1

Figure 4.19: Environmental impact sheet

4.3.3 Economic Impact of Airport Fueling Energy

Figure 4.20 shows an example of aggregating all related energy consumption calculations performed using the research energy calculator and presented as the total energy economic impact. This research calculator compares project alternatives and the economic impact of emissions based on CO_2 emissions offsetting cost and the estimated cost of electricity consumption.

There is a wide range of selection for carbon offsetting projects. This research estimates costs associated with CO_2 emissions calculated for the various aircraft fueling activities (e.g., storage and handling of aviation fuels). It was estimated that the average cost of offsetting CO_2 emissions based on the best practices and similar industry project costs were equivalent to $16.2 per ton of CO_2.

Pumps and other instruments: the economic impact of electricity consumption of pumps and other equipment utilized at tank farms and hydrant facilities has been calculated based on electricity consumption costs, using the local electricity consumption unit costs provided as input to the calculator:

Cost of electricity = Energy (kWh) x electricity unit cost ($/kWh)

CO_2 offset costs (cost to offset calculated amount of CO_2 emissions):

Cost of CO_2 offset = CO_2 emissions (ton) x CO_2 offset unit price ($/ton CO_2)

Unit price for CO_2 offset: 16.17 $/ton CO_2

Buildings: the economic impact of electricity consumption of buildings and offices utilized at tank farms and hydrant facilities has been calculated based on the electricity consumption costs, using the local electricity consumption unit costs provided as input to the calculator:

Cost of electricity = Energy (kWh) x electricity unit cost ($/kWh)

CO_2 offset costs (cost to offset calculated amount of CO_2 emissions):

Cost of CO_2 offset = CO_2 emissions (ton) x CO_2 offset unit price ($/ton CO_2)

Unit price for CO_2 offset: 16.17 $/ton CO_2 ("Carbon Portal" 2015)

Vehicles: the economic impact of motor vehicle fuel consumption of light-duty and heavy-duty vehicles, both gasoline-powered and diesel-powered engines, utilized for into-plane operations and hydrant operating activities have been calculated based on the following:

1) Fuel consumption costs, using the local fuel prices provided as input to the calculator:

   Cost of fuel = Consumption (liter) x fuel price ($/liter)

2) CO_2 offset costs (cost to offset calculated amount of CO_2 emissions):

   Cost of CO_2 offset = CO_2 emissions (ton) x CO_2 offset unit price ($/ton CO_2)

   Unit price for CO_2 offset: 16.17 $/ton CO_2

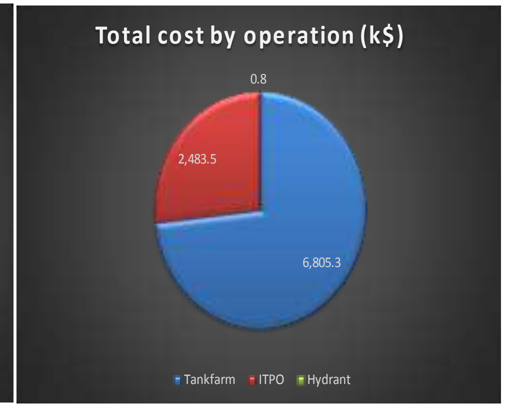
Economic impact calculations

Pumps and Instruments	Energy Consumption	Units	Cost of electricity	Units	Cost of CO_2 offset	Units
Pumps-Tankfarm	**43,209.5**	kWh	**3.69**	k$	**0.56**	k$
Instruments-Tankfarm	**193,070.4**	kWh	**16.48**	k$	**2.50**	k$
Pumps-Hydrant	**0.0**	kWh	**0.00**	k$	**0.00**	k$
Instruments-Hydrant	**5,742.2**	kWh	**0.49**	k$	**0.07**	k$
Total	**242,022.1**	kWh	**20.65**	k$	**3.13**	k$

Buildings	Energy Consumption		Cost of electricity		Cost of CO_2 offset	
Tankfarm	**69,015,660.0**	kWh	**5,889.31**	k$	**892.79**	k$
ITPO	**24,129,420.0**	kWh	**2,059.04**	k$	**312.14**	k$
Hydrant	**0.0**	kWh	**0.00**	k$	**0.00**	k$
Total	**93,145,080.0**	kWh	**7,948.35**	k$	**1,204.92**	k$

Vehicles	Fuel consumption		Cost of fuel		Cost of CO_2 offset	
ITPO vehicles (Diesel engines)	**686,835.0**	lt	**82.42**	k$	**29.96**	k$
Hydrant Vehicles (Diesel engines)	**1,687.6**	lt	**0.20**	k$	**0.07**	k$
ITPO vehicles (Gasoline engines)	**0.0**	lt	**0.00**	k$	**0.00**	k$
Hydrant Vehicles (Gasoline engines)	**0.0**	lt	**0.00**	k$	**0.00**	k$
Total		lt	**82.62**	k$	**30.03**	k$

Total Cost of Electricity	**7,969.00**	k$
Total Fuel cost	**82.62**	k$
Total cost to offset CO2 emissions	**1,238.08**	k$
TOTAL	**9,289.71**	k$



	Energy cost	Fuel cost	CO_2 offset	**Total**
Tankfarm	5,909.5	0.0	895.8	**6,805.3**
ITPO	2,059.0	82.4	342.1	**2,483.5**
Hydrant	0.5	0.2	0.1	**0.8**

Figure 4.20: Economic impact

4.3.4 Social Impact of Airport Fueling Energy

Figure 4.21 shows an example of aggregating all related energy consumption calculations performed using the research energy calculator and presented as the total energy social impact. The social impact of energy consumption and CO_2 emissions has been determined using the EPA Greenhouse Gas Equivalencies Calculator (EPA 2015). The calculator is used for translating power consumption into concrete terms, which relate to the society, where 1 ton of CO_2-e is equivalent to:

Table 4.28: EPA Greenhouse gas equivalencies

Greenhouse gas emissions from:	
0.0001	Passenger vehicles driven for one year
1.6	Miles driven by an average passenger vehicle
CO_2 emissions from:	
0.078	Gallons of gasoline consumed
0.741	Pounds of coal burned
0.0001	Home energy use for one year
0.0001	Home electricity use for one year
0.018	Incandescent lamps switched to CFLs
0.002	Barrels of oil consumed
Carbon sequestered by	
0.018	Tree seedlings grown for ten years

Social impact

Airport **PMIA, Madinah**

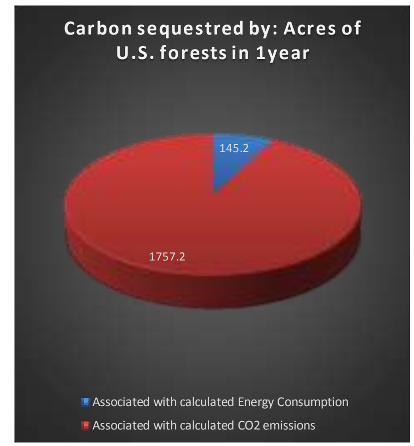
Social Impact of Energy consumption and Motor Vehicle fuel consumption

		Units
Energy Consumption	242,022.11	kWh
Fuel Consumption Vehicles (Total)	2,361.76	tn CO_2

Social Impact

Equivalencies of CO2-e emissions

	Associated with calculated Energy Consumption	Associated with calculated CO_2 emissions	Total
Greenhouse gas emissions from			
	24.2 Passenger vehicles driven for one year	**451.1** Passenger vehicles driven for one year	**475.3** Passenger vehicles driven for one year
Carbon sequestered by			
	4356.4 tree seedlings grown for 10 years	**55029.0** tree seedlings grown for 10 years	**59385.4** tree seedlings grown for 10 years
	145.2 acres of U.S. forests in one year	**1757.2** acres of U.S. forests in one year	**1902.4** acres of U.S. forests in one year
CO_2 emissions from			
	24.2 homes' energy use for one year	**196.0** homes' energy use for one year	**220.2** homes' energy use for one year
	18877.7 gallons of gasoline consumed	**240899.6** gallons of gasoline consumed	**259777.4** gallons of gasoline consumed
	484.0 barrels of oil consumed	**4959.7** barrels of oil consumed	**5443.7** barrels of oil consumed



Equivalencies from:
http://www2.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Figure 4.21: Social impact

4.3.5 Discussion: Objective #3 Development of Energy Consumption Analysis Model for Airport Fueling Projects

Currently, there is a lack of systematic models for analyzing energy consumption of aircraft fueling projects at airports. Therefore, there is a need for a framework to develop a means for pursuing sustainability and maximizing its potential benefits. This research presented the first detailed energy consumption analysis for aircraft fueling projects. This research objective answered the following research questions: 1) What are the types of energy consumption that are specific to airport fueling projects?; 2) How to assess and calculate the different types of energy consumption related to airport fueling projects systematically?; and 3) How to analyze energy consumption of different airport fueling project alternatives with respect to sustainability measures (environmental, economic, and social)? This chapter identified the energy consumption elements that are specific to airport fueling projects (i.e., buildings, fuel system, and vehicles) and the method to assess and calculate the different types of energy related to airport fueling projects systematically.

Until this research, no previous equations in the literature considered energy consumption of airport fueling service activities. The research introduced a compilation of current energy-related equations in the literature to cover airport fueling project operation sub-elements. This compilation facilitated the implementation of the current generic equations in the airport fueling project domain. The model requires the user to enter different operational and design data related to buildings, pumps, and vehicle movements. Using the research's predefined equations, the model calculated and defined the environmental impacts (CO_2 emissions), economic impact (cost of electricity consumption costs), and the social impact (equivalent of CO_2 emissions in every day terms). The model represents the energy consumption impacts of each project alternative numerically and graphically with respect to the sustainability measures (economic, environmental and social). This representation attempts to provide the visual support tool to illustrate the analysis results for project decision-makers.

The model has been validated using focus group and two case studies for two new international airport projects to illustrate the model and its practical application. The same validation process explained previously in section 4.2.5 for objective #2 was implemented for objective #3.

4.4 Results and Discussion of Objective #4 - Model Evaluation - Case Studies

This section presents the results of the research models evaluation by a focus group using two case studies from the GCC. It discusses the two case study results, the related focus group session and the questionnaire results.

4.4.1 Results of Case Study 1: Prince Mohammed Bin Abdulaziz International Airport (PMIA) Project

Case study 1 considered the new PMIA into-plane operation and location alternatives in addition to tank farm design and location alternatives with a total of eight alternatives (as described in section 3.4.3.1). The three research models have been implemented for all eight alternatives. The first model was used to assess the sustainability and determine the sustainability index (SI) of each alternative. The sustainability assessment model assessed each alternative based on the environmental, economic, and social criteria presented in appendices D, E, and F. The model calculated SI (0 to 1 scale) for all alternatives and then provided graphical presentations for comparison (Figure 4.22). In addition, the second and third research models were used for the emissions and energy analyses of all eight alternatives and to present the comparisons graphically (Figure 4.23 to Figure 4.28). The detailed models' calculations of the three research models for the eight alternatives were conducted. One full sample of these calculations is presented in Appendix P due to the size of the files.

Alternative 2 had the highest SI (0.379) among other project alternatives with the utilities of (0.114) for environmental, (0.480) for economy, and (0.517) for social. Alternative 2 considered a new tank farm design at a new location in addition to a joint operation at the new ITP building location. The models showed the detailed differences with regards to the three sustainability criteria and sub-criteria. In addition, the research models determined all energy and emissions sources for each alternative, which provide an easy tool to compare the alternatives in more details for all sources of energy and emissions. Based on the models' assessment, this alternative requires lower capital expenses as it will save the demolishing of current tank farm and relocation expenses of current facility. In addition, alternative 2 will have less operating expenses due to the fact of having joint operation for the ITP, which will optimize operation resource with lower operating capital and expenses (less number of mobile fueling equipment and less number of manpower). Alternative 2 has location near the aircraft parking (apron) so the driving distance to the aircraft will be less. Consequently, the emission and energy models show that alternative 2 has less environmental, economic, and social impacts.

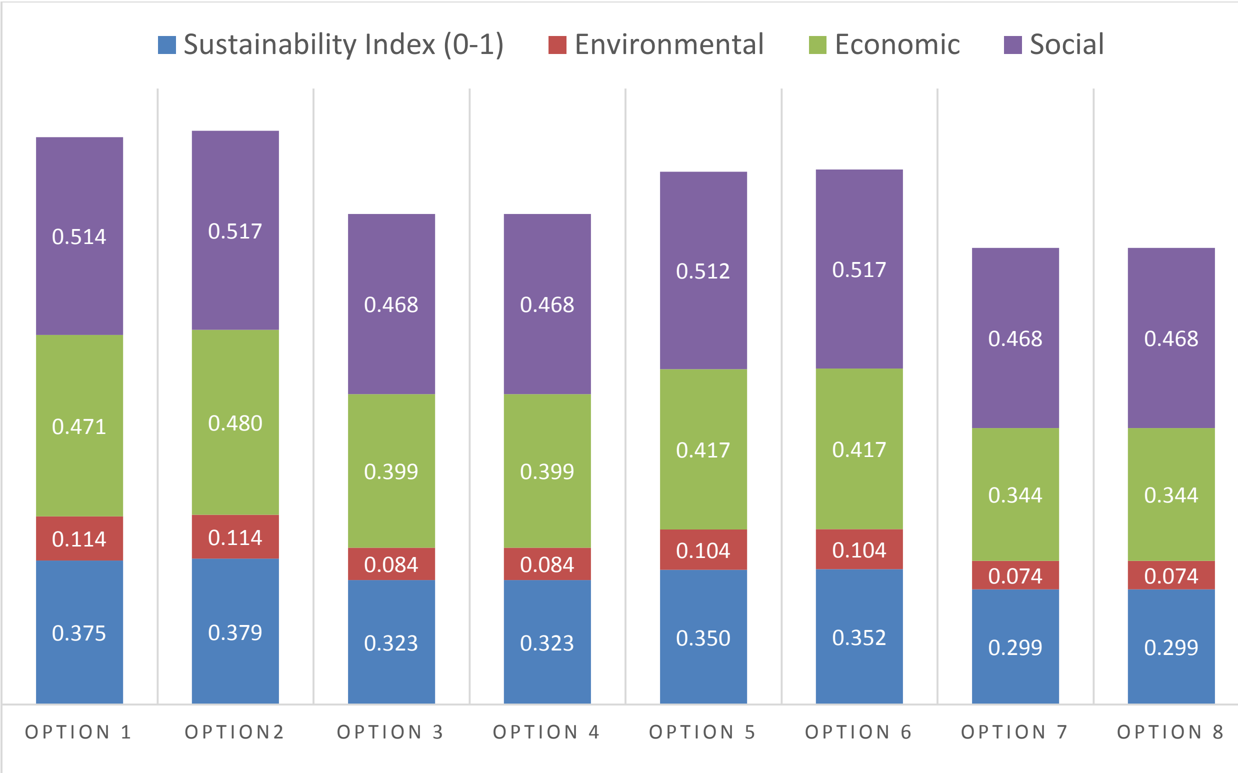


Figure 4.22: Project Alternative Comparison - SI and Sustainability Factors (Environmental, Economic, and Social)

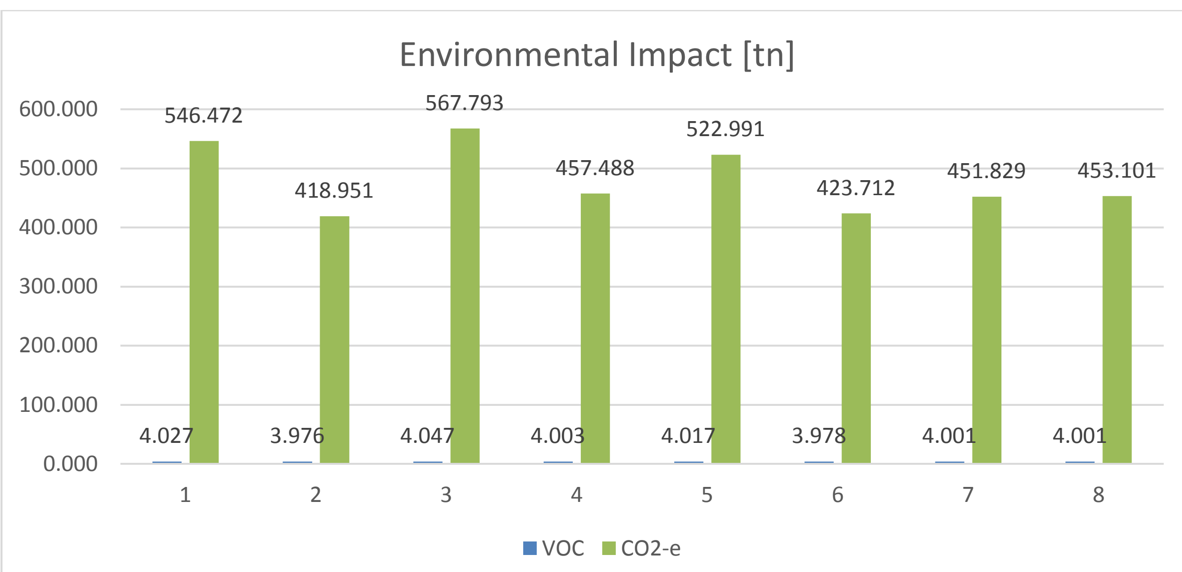


Figure 4.23 : Project Alternatives Comparison – Emissions' Environmental Impact (Tons of VOC and CO_2)

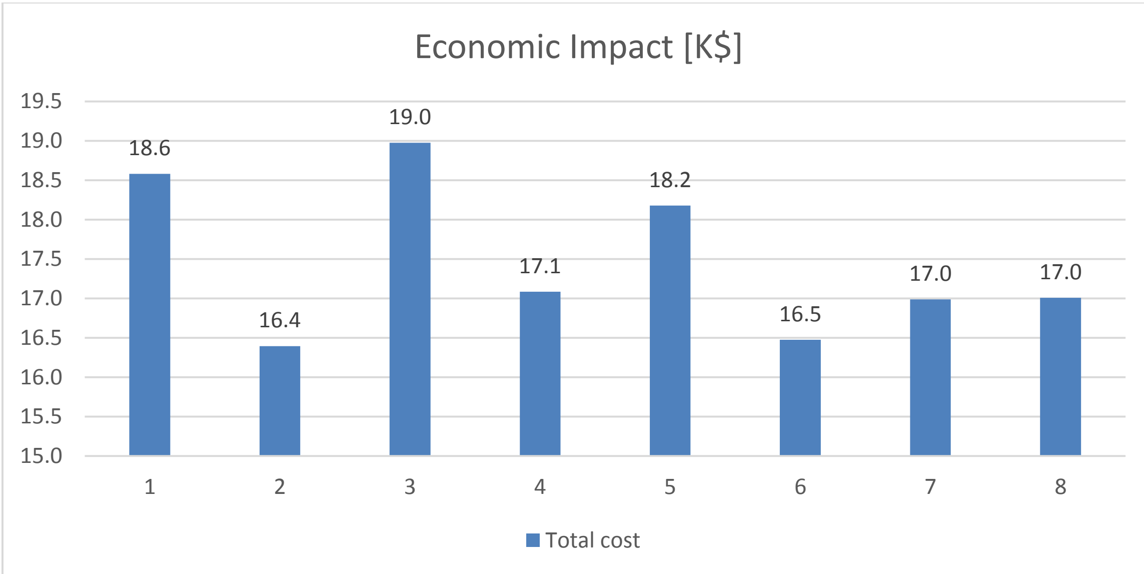
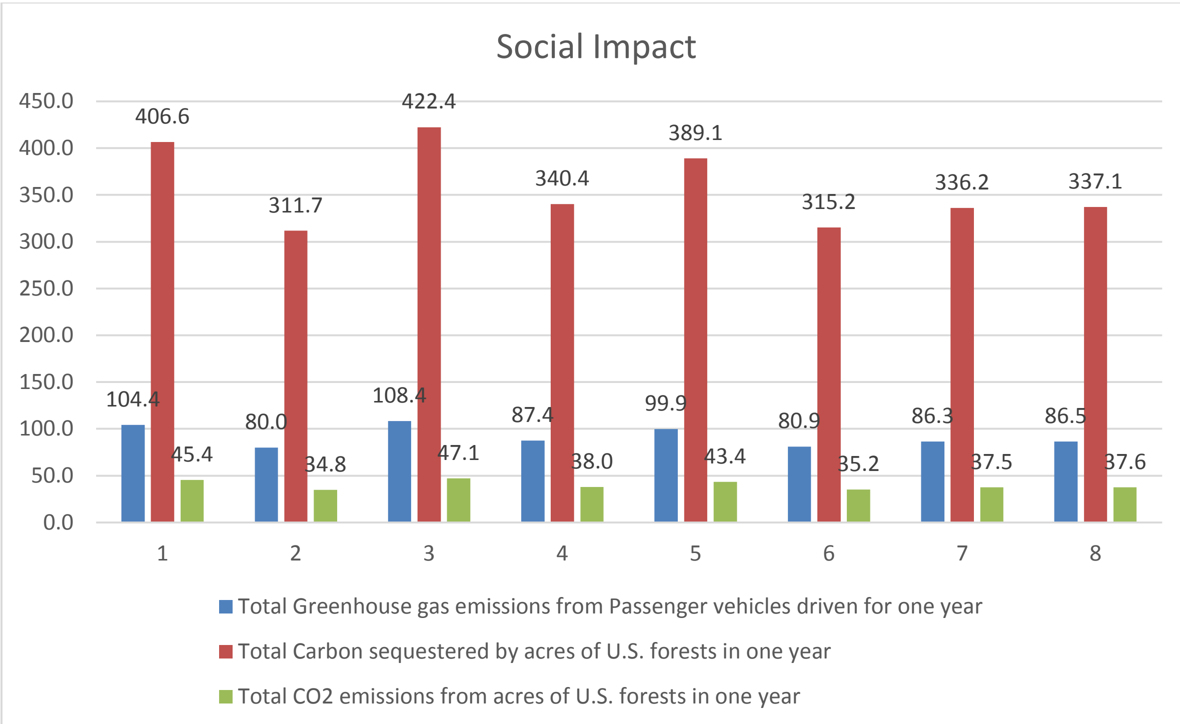


Figure 4.24: Project Alternatives Comparison – Emissions' Economic Impact (K$)



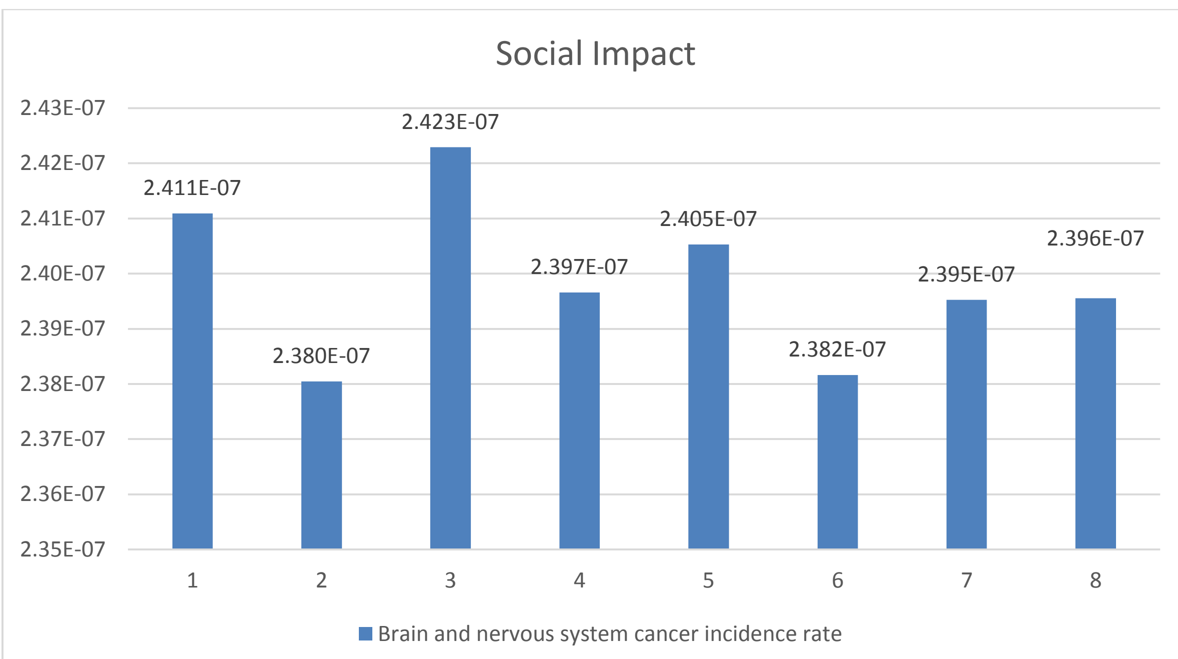


Figure 4.25: Project Alternatives Comparison – Emissions' Social Impact

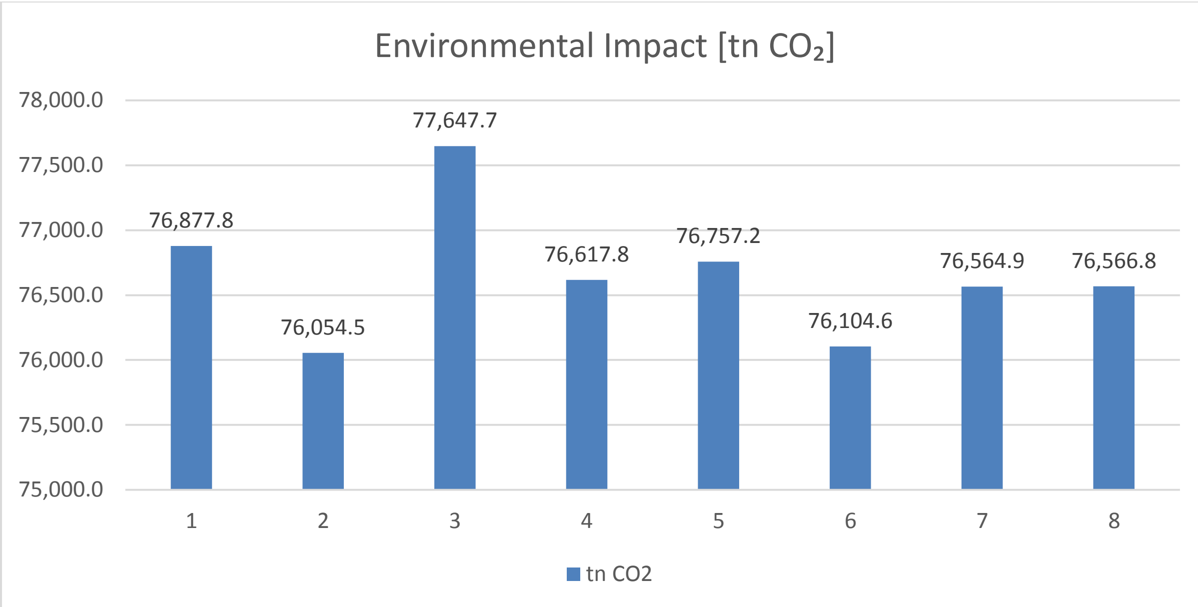


Figure 4.26: Project Alternatives Comparison – Energy's Environmental Impact (Tons of CO_2)

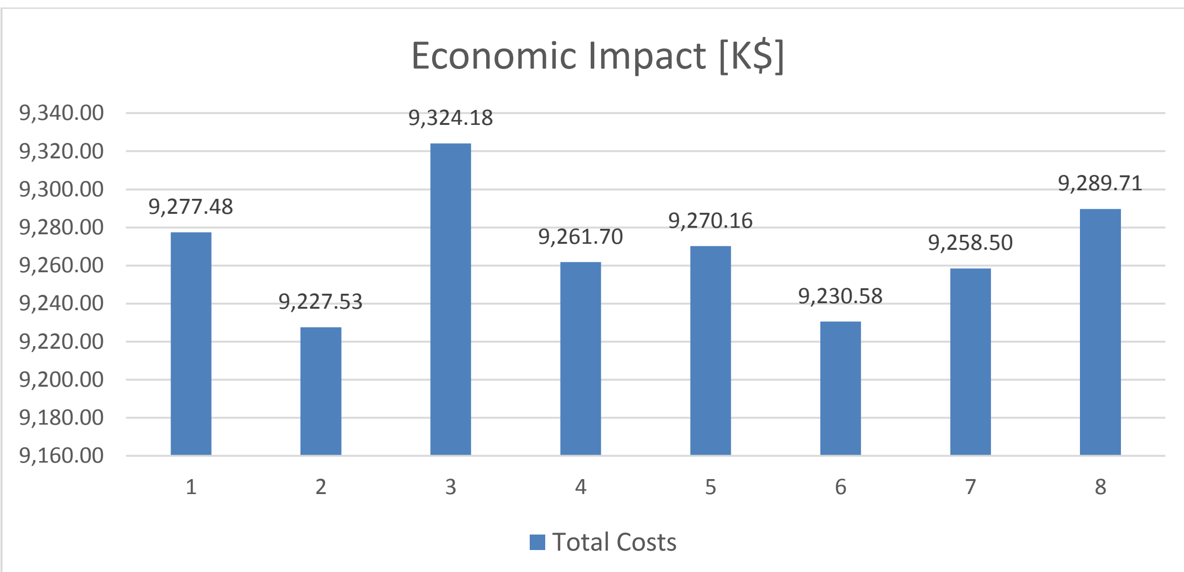


Figure 4.27: Project Alternatives Comparison – Energy's Economic Impact (K$)

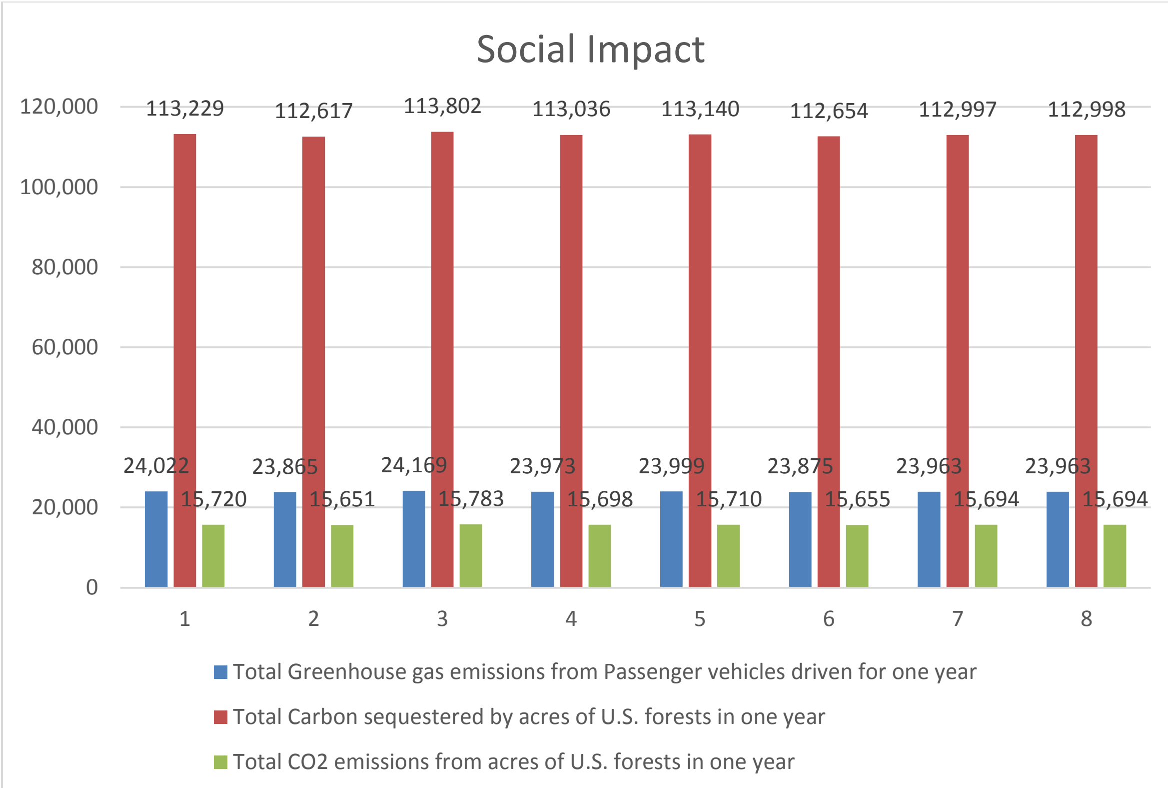


Figure 4.28: Project Alternatives Comparison – Energy's Social Impact

4.4.2 Results of Case Study 2: King Abdulaziz International Airport (KAIA) Project

Case study 2 considered the new KAIA into-plane building design and location alternatives in addition to one tank farm design and location alternative with a total of four alternatives (as described in section 3.4.3.2). Similar to case study 1, the three research models have been implemented for all four alternatives. The sustainability assessment model was implemented to determine the sustainability index (SI) of each alternative and to compare the sustainability of all project alternatives based on the environmental, economic, and social criteria presented in appendices D, E, and F. The resulted SI (0 to 1 scale) for all four alternatives was presented graphically in Figure 4.29. The emissions and energy research models were used to analyze all four alternatives and for graphical comparisons (Figure 4.29 to Figure 4.35). The detailed models' calculations of the three research models for the four alternatives were conducted. One full sample of these calculations is presented in Appendix Q due to the size of the files.

Alternative 2 had the highest SI (0.333) among other project alternatives with the utilities of (0.088) for environmental, (0.421) for economy, and (0.468) for social. The research models assessed all alternatives with respect to the three sustainability criteria and sub-criteria, and determined all energy and emissions sources. Alternative 2 considered a new ITP building design and a new ITP building location. This alternative ITP building location is near the aircraft parking (apron) so the driving distance to the aircraft will be less. The design of alternative 2 considers a loading rack for jet fuel loading and mobile equipment testing. This will save the ITP equipment a driving distance to load the jet fuel and test the equipment at other loading and testing facilities. Therefore, the emission and energy models show that alternative 2 has less environmental, economic, and social impacts.

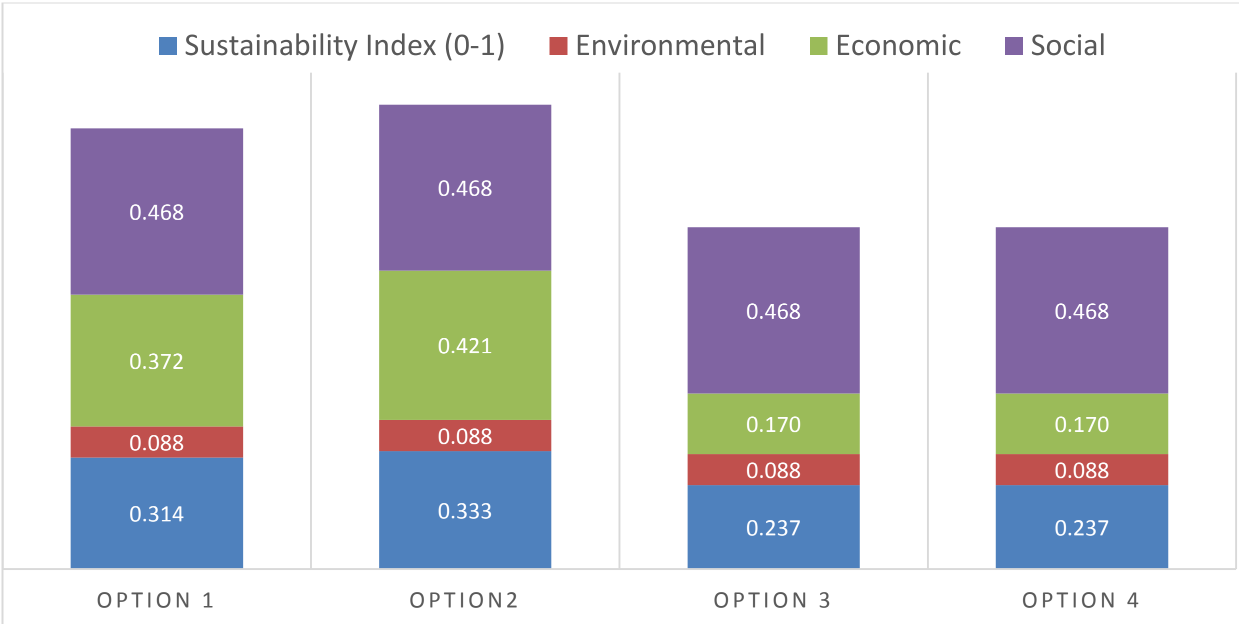


Figure 4.29: Project Alternatives Comparison – SI and Sustainability Factors (Environmental, Economic, and Social)

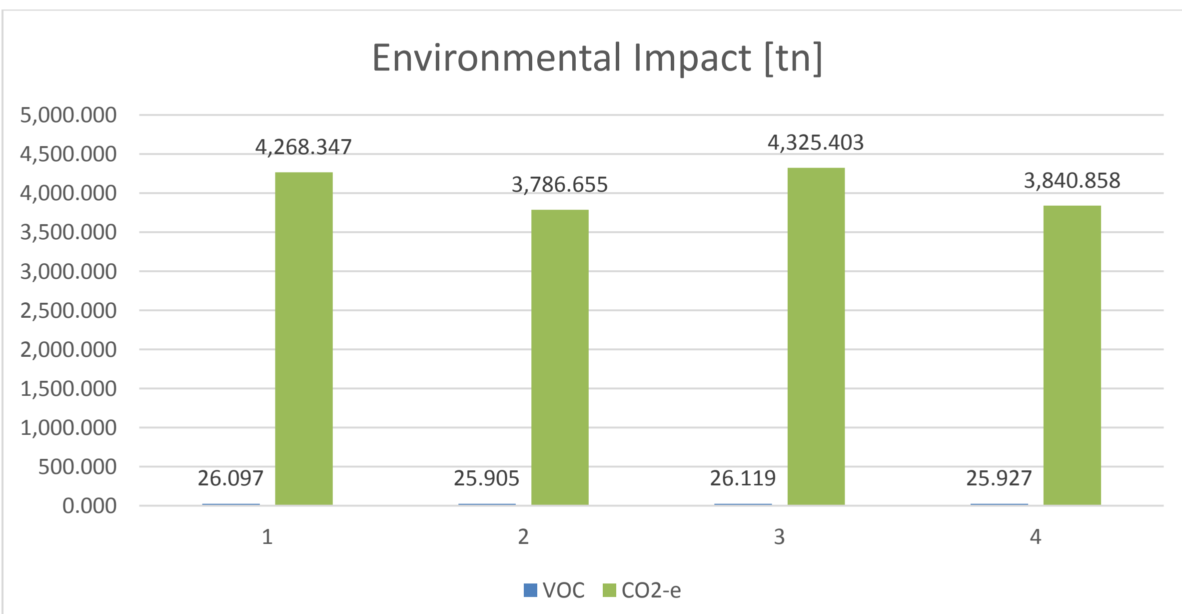


Figure 4.30: Project Alternatives Comparison – Emissions' Environmental Impact (Tons of VOC and CO_2)

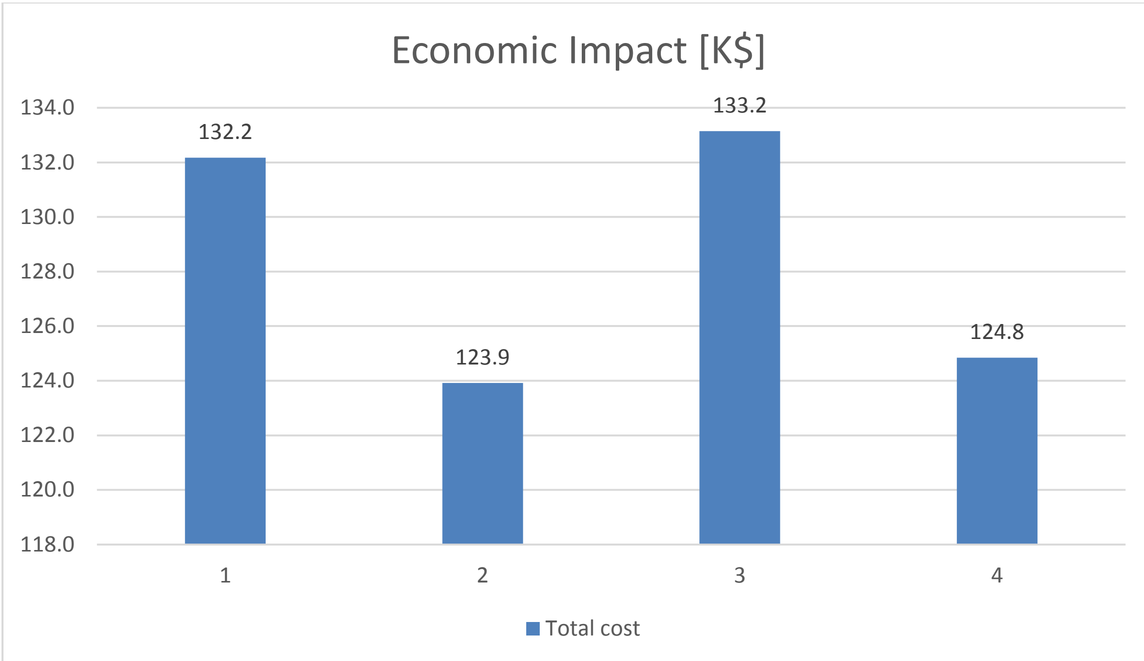
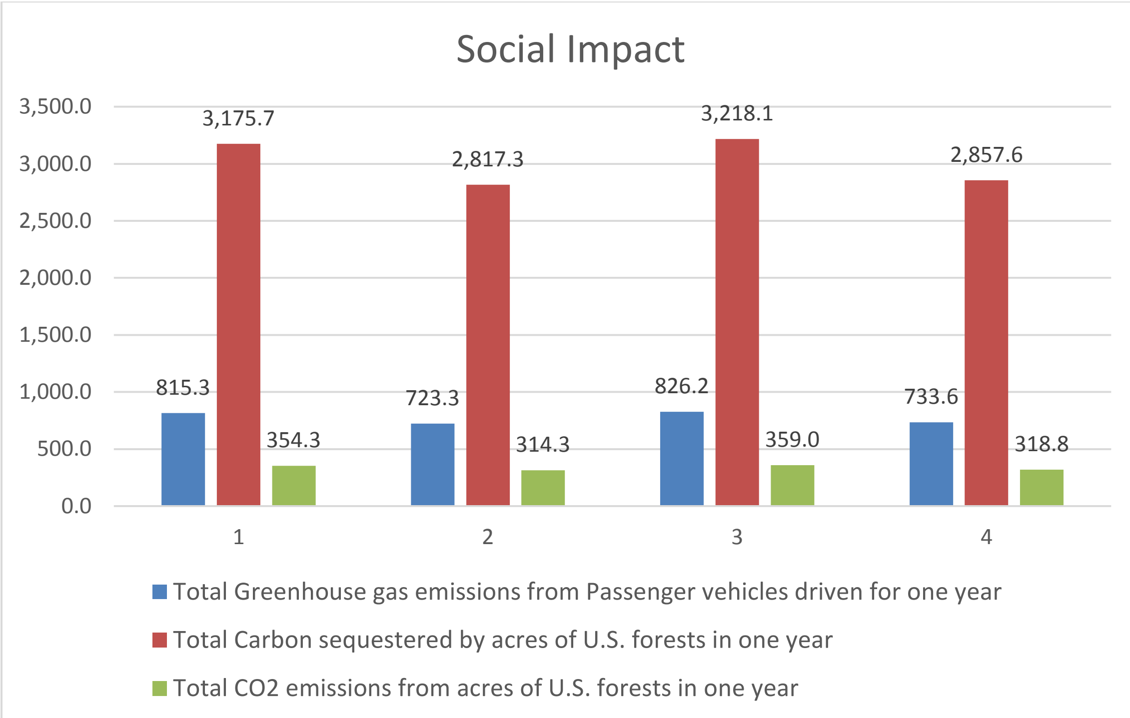


Figure 4.31: Project Alternatives Comparison – Emissions' Economic Impact (K$)



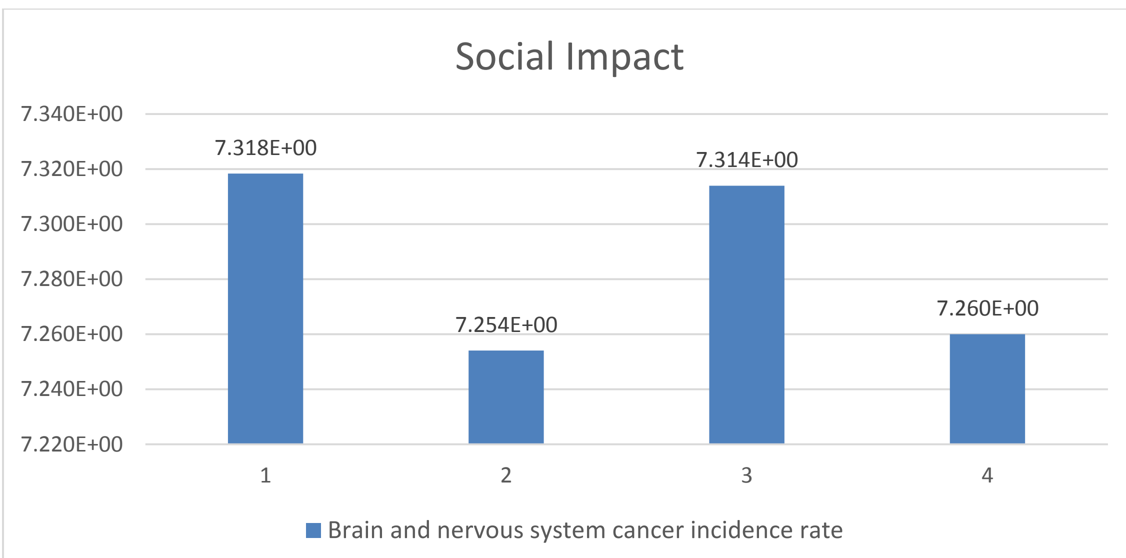


Figure 4.32: Project Alternatives Comparison – Emissions' Social Impact

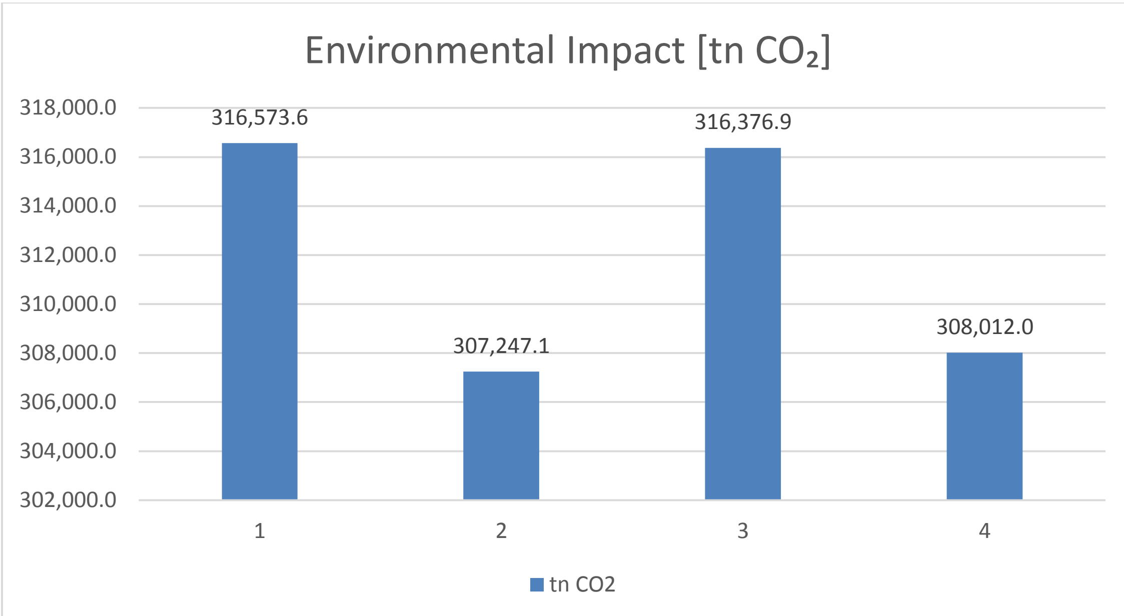


Figure 4.33: Project Alternatives Comparison – Energy's Environmental Impact (Tons of CO_2)

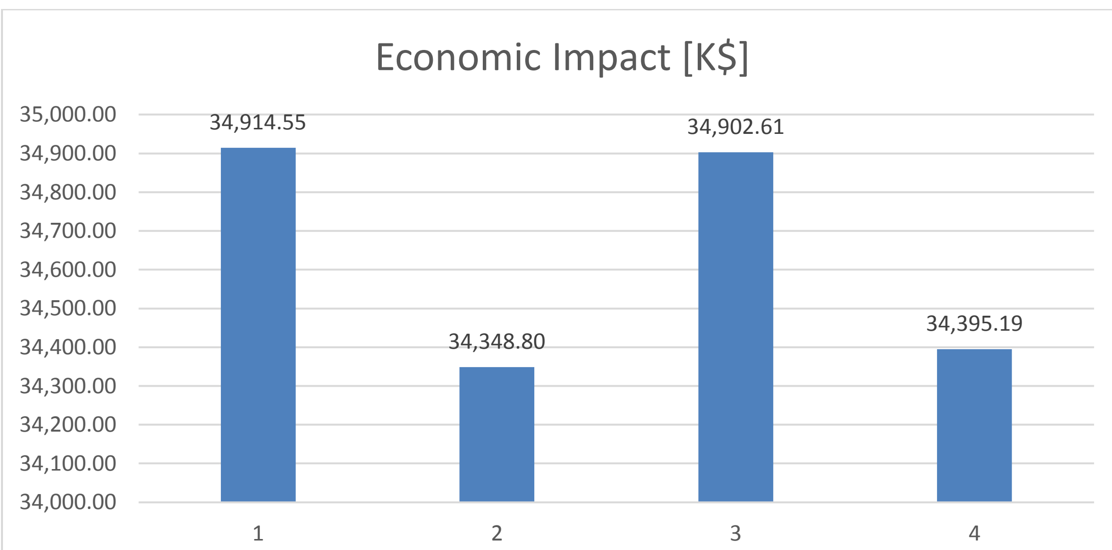


Figure 4.34: Project Alternatives Comparison – Energy's Economic Impact (K$)

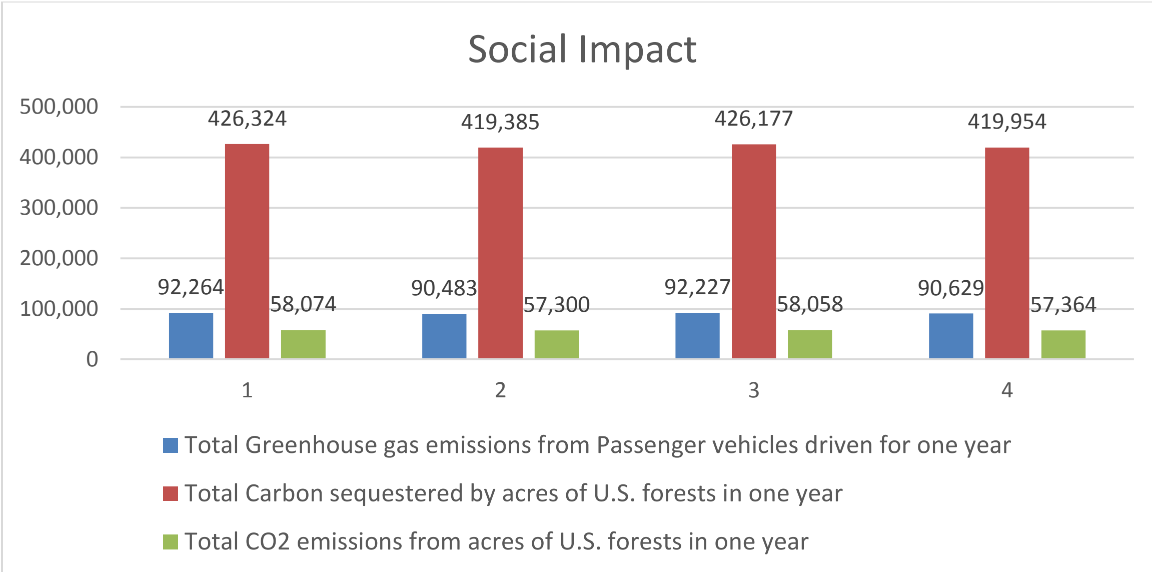


Figure 4.35: Project Alternatives Comparison – Energy's Social Impact

4.4.3 Results of the Focus Group Session

All participants' questions raised during the discussion sessions were answered to their satisfaction. Several examples were given and discussed to answer these questions. The discussions covered several subjects such as the expandability and categorization of the models and their applicability to other project domains. Several possible extensions to the models were discussed and the researcher provided options to add more sustainability dimensions, criteria and sub-criteria. These were inserted into the models. The participants found the models to be flexible and expandable. In addition, the researcher initiated several trials during the session to categorize any design or operational criteria under the three sustainability dimensions (environmental, economic and social). The participants were given the opportunity to identify potential technical criteria. They appreciated the detailed assessment provided by the models and found that the models covered all aircraft fueling projects' design and operational criteria. Participants also appreciated the benefits of the models with respect to calculating and analyzing emissions and energy consumption for potential airport fueling projects. Furthermore, some participants suggested these models could be implemented on other airport-related projects besides aircraft fueling projects. All participants agreed with the suggestion and several examples were discussed.

4.4.4 Results of the Focus Group Questionnaire

Considering the three ways of handling Likert scales (i.e., continuous, ordinal and nominal), the central tendency of the data is indicated by the mean, standard deviation (SD), median and mode. Yet, the overall interpretation of the result presented below is based on the median, as most statisticians consider data obtained through a Likert scale to be ordinal (El-Gohary et al. 2010). This research considers all responses with median values less than 3.0 (i.e., 1: Strongly Agree; 2: Agree) to represent an acceptable level of agreement by the group. Median values of 3.0 or more (i.e., 3: Neither Agree nor Disagree; 4: Disagree; 5: Strongly Disagree) should be considered as reflecting a level of agreement below moderate, which would trigger some consideration to adjusting the model. Questions were included to obtain a positive or negative answer from each respondent, as to whether they agreed or disagreed (yes or no) with each statement and then determine the level of their agreement or disagreement based on a 1-5 scale. The results from the eight respondents are summarized in Tables 34-36 below. The median values were translated into a statement representing the level of agreement in the scale used, with the results presented in the last column of the tables. The results were divided into three sub-sections to gather feedback for each model.

4.4.5 Discussion: Objective #4 Model Evaluation - Case Studies

This section discusses the evaluation results of the three research models considering the two cases studies and focus group sessions and questionnaire.

4.4.5.1 Airport Fueling Sustainability Assessment Model

Based on the summarized results for evaluating the airport fueling sustainability assessment model (Table 4.29), the respondents confirmed they agreed with all statements related to the model. They “Agree” that the proposed assessment model contains a sufficient number of criteria so it can adequately represent the domain of sustainable airport fueling projects. The criteria covered the environmental, economic, and social criteria of airport fueling project elements (i.e., fuel system (tank farm and hydrant system) and into-plane refueling services) across the project's life cycle (i.e., planning and design, construction, operation and maintenance). They “Agree” or “Strongly Agree” that the proposed assessment model contains no redundancy among its criteria, indicators or standard of measures. This may be due to the fact that experts reviewed the proposed assessment model to avoid redundancy, as they had the option to remove a number of criteria, indicators and standard of measures during the expert interview sessions. They “Agree’ or “Strongly Agree” it is easy to locate certain sustainability criteria, as user can easily navigate the criteria by dimension (environmental, economic, and social), relevance scope or phases. The participants “Agree” or “Strongly Agree” it is easy to use the assessment model (reading instructions and entering data). They also “Strongly Agree” that the classification of the sustainable criteria is flexible to expand and include additional airport-specific sustainability criteria, as the model’s hierarchy (dimensions and sub-dimensions) supports the required flexibility to adopt any criteria related to airport sustainability. The participants “Agree” or “Strongly Agree” with the categorization of the sustainability criteria as the model’s criteria, indicators and standard of measures have been reviewed by experts during the expert interview sessions to confirm that the categorization is based on related the industry's standards, manuals, and best practices. Furthermore, they "Agree" the proposed assessment model will be useful for airport fueling projects and "Strongly Agree" the proposed assessment model will be beneficial for assessing airport fueling project sustainability. The model evaluates airport fueling projects through predefined equations and functions that support systematic calculations and analyses of sustainability for airport fueling projects. The participants also "Agree" or "Strongly Agree" that the model output provides a sufficient indicator for project sustainability.

Table 4.29: Evaluation of the airport fueling sustainability assessment model

#	*Airport fuel sustainability assessment model*		*R1*	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*	Average Rating	SD	Mode	Median	*Interpretation Median*
A1.1	Representation	The proposed assessment model contains sufficient number of criteria so it can adequately represent the domain of sustainable airport fueling projects.	3.0	2.0	1.0	1.0	2.0	1.0	2.0	2.0	1.8	0.7	2.0	2.0	Agree
A1.2	Representation	The proposed assessment model contains no redundancy among its criteria, indicators or standard of measures.	2.0	3.0	1.0	1.0	2.0	1.0	1.0	2.0	1.6	0.7	1.0	1.5	Agree to Strongly Agree
A2.1	Ease of use	It is easy to locate certain sustainability criteria.	1.0	1.0	3.0	2.0	2.0	1.0	2.0	1.0	1.6	0.7	1.0	1.5	Agree to Strongly Agree
A2.2	Ease of use	It is easy to use the assessment model (reading instructions and entering data).	3.0	3.0	2.0	1.0	1.0	1.0	2.0	1.0	1.8	0.8	1.0	1.5	Agree to Strongly Agree
A3.1	Flexibility/ Expandability	The classification of the sustainable criteria is flexible to expand and to include additional airport-specific sustainability criteria.	2.0	3.0	1.0	1.0	2.0	1.0	1.0	1.0	1.5	0.7	1.0	1.0	Strongly Agree
A4.1	Categorization	Do you agree with the categorization of the sustainability criteria?	1.0	1.0	2.0	2.0	2.0	2.0	1.0	1.0	1.5	0.5	1.0	1.5	Agree to Strongly Agree
A5.1	Usability	The proposed assessment model will be useful for airport fueling projects.	2.0	2.0	1.0	1.0	1.0	2.0	2.0	2.0	1.6	0.5	2.0	2.0	Agree
A5.2	Usability	The proposed assessment model will be beneficial for assessing airport fueling project sustainability.	1.0	2.0	2.0	1.0	2.0	1.0	1.0	1.0	1.4	0.5	1.0	1.0	Strongly Agree
A6.1	Relevancy	The model output provides a sufficient relevance indicator for project sustainability.	2.0	2.0	1.0	1.0	2.0	2.0	1.0	1.0	1.5	0.5	2.0	1.5	Agree to Strongly Agree

4.4.5.2 Aircraft Fueling Emissions-Oriented Sustainability Analysis Model

Based on the summarized results for evaluating the aircraft fueling emission-oriented sustainability analysis model (Table 4.30), the respondents confirmed they agreed with all the statements related to the model. They “Agree” that the proposed model is capable of being applied to GCC airport fueling facilities, as the model incorporates local emissions regulation and standards related to airport fueling project’s elements. They “Agree” or “Strongly Agree” the proposed model is flexible and can thus include airport fueling facilities with different design elements and operational requirements. The model has the ability to determine emissions of different operational requirements such as into-plane, fixed fuel system and hydrant system and different design elements such as mobile equipment (dispenser and refueller). They also “Agree” the proposed model has the ability to be implemented at different airport fueling facilities with different sizes and capacities, as it considers emissions of different fuel system capacities including tanks (vertical or horizontal), pumps, filters, and service buildings. In addition, the participants “Agree” it is easy to use the assessment model (reading instructions and entering data) and “Strongly Agree” there are potential benefits to using the proposed model. The model calculates emissions of different project alternatives in order to select the alternative with the lowest emissions based on predefined equations. It provides a management tool that helps save time, efforts, and resources for stakeholders’ decision-making during planning and design phase. They “Agree” or “Strongly Agree” that the proposed model adequately covers the main sources of airport fueling facilities emission. The model determines emissions sources of mobile equipment, service vehicles, fuel farm, hydrant system, and buildings. It has the flexibility to adopt future technologies that minimize emissions such as electrical mobile equipment, electrical service vehicles, and other related renewable technologies.

Table 4.30: Evaluation of aircraft fueling emission-oriented sustainability analysis model

#	*Emissions model*		*R1*	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*	Average Rating	SD	Mode	Median	*Interpretation Median*
B1.1	Applicability	The proposed model is capable of being applied to GCC airport fueling facilities.	2	1	3	1	2	3	3	2	2.1	0.8	2	2	Agree
B2.1	Flexibility/Expandability	The proposed model is flexible to include airport fueling facilities with different design elements and operational requirements.	2	1	2	1	1	2	1	2	1.5	0.5	2	1.5	Agree to Strongly Agree
B3.1	Scalability	The proposed model has the ability to be implemented at different airport fueling facilities with different sizes and capacities.	3	1	1	2	2	2	2	1	1.8	0.7	2	2	Agree
B4.1	Ease of use	It is easy to use the assessment model (reading instructions and entering data).	1	3	2	1	2	2	2	1	1.8	0.7	2	2	Agree
B5.1	Usability	Do you agree there are potential benefits of using the proposed model?	2	1	1	1	1	2	2	1	1.4	0.5	1	1	Strongly Agree
B6.1	Coverage	The proposed model adequately covers the main sources of airport fueling facilities emissions.	1	1	2	2	2	3	1	1	1.6	0.7	1	1.5	Agree to Strongly Agree

4.4.5.3 Aircraft Fueling Energy-Oriented Sustainability Analysis Model

Based on the summarized results for evaluating the aircraft fueling energy-oriented sustainability analysis model (Table 4.31), the respondents confirmed they agreed with all statements related to the model. They “Agree” or “Strongly Agree” the proposed model is capable of being applied to GCC airport fueling facilities, as the model caters for all local energy consumption rules, regulations and applied standards. They “Agree” the proposed model is flexible and can thus include airport fueling facilities with different design elements and operational requirements. The model covers energy consumption for into-plane, fixed fuel system and hydrant system, different kind of mobile equipment (dispenser and refueller), and considering all related safety, health, security and environmental aspects. They also “Agree” the proposed model has the ability to be implemented at different airport fueling facilities with different sizes and capacities. The model considers energy consumptions of both small and large airports with different capacities of tanks (vertical or horizontal), pumps, filters, and service buildings based on airport traffic forecast. Furthermore, the participants “Agree” or “Strongly Agree” it is easy to use the assessment tool (reading instructions and entering data) and “Strongly Agree” there are potential benefits to using the proposed model, as the model provide predefined detailed equations that determine energy consumptions of all project’s elements. The model calculates energy consumptions of different project alternatives in order to select the alternative with the lowest energy consumption. They “Strongly Agree” that the proposed model adequately covers the main sources of airport fueling facilities energy consumption, as the model identifies all related sources of mobile equipment, service vehicles, fuel farm, hydrant system, and buildings. In addition, the model has the flexibility to covers futures sources of energy consumptions.

Table 4.31: Ratings and analysis for the assessment of the aircraft fueling energy-oriented sustainability analysis model

#	*Energy model*		*R1*	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*	Average Rating	SD	Mode	Median	*Interpretation Median*
C1.1	Applicability	The proposed model is capable of being applied to GCC airport fueling facilities.	1	1	3	1	2	2	2	1	1.6	0.7	1	1.5	Agree to Strongly Agree
C2.1	Flexibility/Expandability	The proposed model is flexible to include airport fueling facilities with different design elements and operational requirements.	1	1	2	2	2	2	2	1	1.6	0.5	2	2	Agree
C3.1	Scalability	The proposed model has the ability to be implemented at different airport fueling facilities with different sizes and capacities.	2	1	2	2	1	2	2	2	1.8	0.4	2	2	Agree
C4.1	Usability	It is easy to use the assessment tool (reading instructions and entering data).	2	1	1	2	1	1	3	2	1.6	0.7	1	1.5	Agree to Strongly Agree
C5.1	Usability	Do you agree there are potential benefits of using the proposed model?	1	3	1	1	2	1	1	1	1.4	0.7	1	1	Strongly Agree
C6.1	Coverage	The proposed model adequately covers the main sources of airport fueling facilities energy consumption.	2	2	1	1	1	2	1	1	1.4	0.5	1	1	Strongly Agree

CHAPTER 5 : Conclusion

This chapter provides a summary of the findings of this research, its contributions, limitations, and recommendations.

5.1 Summary of Results

This thesis has four objectives that aimed to facilitate decision-making among stakeholders of airport fueling projects by highlighting the most sustainable project alternatives. The first research objective was to develop a mathematical sustainability assessment model for supporting sustainable development of airport fueling projects. This development incorporated systematic methods for identifying and aggregating sustainability criteria. To achieve this objective, the research first identified relevant sets of sustainability assessment criteria through quantitative and qualitative indicators that are compared against standard of measures. This was developed using a "Top-Down-Bottom-Up" methodology. TDBU methodology started by defining the sustainability dimensions among stakeholders, the assessment framework, and the initial potential set of main criteria, indicators and standard of measures that characterize the sustainability of airport fuelling projects. Then, the proposed set of sustainability criteria (economic, environmental and social) was validated through interviews and questionnaire surveys with experts. A final set of sustainability criteria and indicators for the airport fueling project has been revised based on the experts' validation. Their feedback has been analyzed in order to remove, add, and validate the criteria, indicators and standard of measures through a quantitative and qualitative analysis of the questionnaire surveys. The second task to achieve the first research objective was to develop the mathematical model using Multi-Criteria Analysis (MCA) to evaluate project alternatives. The model used the set of economic, environmental, and social sustainability criteria and indicators that have been identified previously as part of the first task. The Multi-Attribute Utility Theory (MAUT) was used to aggregate the different indicators and calculate the sustainability index of each project alternative. The index has been defined as the overall sustainability index resulting from aggregating all sustainability criterion utilities of a project alternative along with its sustainability dimensions (economic, environmental and social). The project alternative with the highest value of the sustainability index will be the preferred sustainable project alternative. Using MAUT, the model presented the aggregation and calculations of the sustainability index as an output for each project alternative. The results of the analysis are displayed both numerically and graphically in the model output. This will provide the opportunity to present and compare the sustainability index of different project alternatives graphically.

In addition, the research's second and third objectives aim to develop two models that focus on analyzing the sustainability of airport fueling project alternatives from the emission and energy consumption perspectives. The models were presented as domain-specific measures that identify all sources and calculate all types of emissions and energy consumption for airport fueling projects. The models' systematic assessment approach presented the emission and energy impacts of each project alternative numerically and graphically with respect to the sustainability measures (economic, environmental and social).

All three research models were evaluated on their merit by a focus group composed of different stakeholders of airport operations. Based on the implementation of the research's three models into two different case studies and the analysis of the results, the respondents confirmed they agreed with all the statements presented in the questionnaire for the assessment of the three different models. The feedback from the respondents was that they "Agree" or "Strongly Agree" with all statements selected to evaluate the models (median values in the range of “1” to “2”, which represent “Agree” or “Strongly Agree” in the scale used). The overall outcome of the survey supports the view that the proposed models can serve the objectives they were created for and can be used with a significant level of confidence to conduct sustainability assessments of airport fueling projects.

5.2 Contribution and Implications

This research aimed to address the limited scientific research on frameworks for assessing the sustainability of aircraft fueling projects. The research provides the first models to assess the sustainability, emissions and energy consumption of airport fueling projects. This should help develop a body of knowledge that would improve the culture of sustainable development within the airport ground services industry in general and the airport fueling industry in particular. The implementation of these models should motivate other airport ground services to adopt their own sustainable development initiatives.

The research identified and assessed relevant sets of sustainability assessment criteria through quantitative and qualitative indicators that are compared against standard of measures. The research developed the first mathematical sustainability assessment model for supporting the sustainable development of airport fueling projects. The comprehensive domain-specific model incorporates systematic methods for identifying and aggregating sustainability criteria for these projects. This model should help assess and manage the sustainability of airport fuelling projects across the project's life cycle. The model should also help stakeholders select the best airport fuelling project alternative during the planning and design phases of these projects. It should also enable them to assess these projects’ sustainability throughout other life cycle phases (i.e., construction, operation).

The research also developed and validated two models for analyzing the sustainability of these airports from the emission and energy consumption perspectives. The first model provides a detailed analysis of the emissions of aircraft fuelling projects. This model builds upon existing emission-related equations in the literature to cover airport fuelling project operation elements. The research presented the first detailed analysis of aircraft fuelling projects by identifying existing sources of emissions. This was conducted through a thorough review of relevant international standards and specifications. The second model aimed to address the lack of similar models that would consider the energy consumption of airport fueling services activities. This model is the first to also cover airport fuelling project operation sub-elements (i.e., buildings, fuel system, and vehicles) building upon existing relevant equations in the literature to assess and calculate energy consumption for these elements. These models have been validated using focus groups and case studies and were developed to be used in different countries. Nevertheless, stakeholders using them should consider the applicability of the models' criteria, and the regulations and standards specific to each country before applying them.

5.3 Limitations and Recommendations for Future Work

Expert interviews were conducted to review and validate the initial proposed set of criteria, indicators and standard of measures for the whole project life cycle for airport fuelling. Questionnaire surveys have been filled out by 20 experts and their feedbacks have been analyzed to validate the proposed primary hierarchy, including a series of criteria for the sustainability assessment of airport fueling projects. These experts included airport authorities, contractors, consultants and fueling service providers with different roles (operations, engineering, maintenance, quality, health, safety, security, and environment (HSSE)). In addition, the participants of the focus group were invited to the session based on the selected criteria highlighted in the research method. The eight individuals were part of the experts involved in the validation process for the sustainability assessment criteria.

This limitation in the number of participation was due the specialized nature of the industry and to the limited number of experts available worldwide, making their recruitment a difficult task. Their unavailability was also another issue. Yet, the sample involved represented more than 10% of airport fueling project stakeholders and provided thus a significantly representative sample. Future research should include more experts in the validation process. Additionally, the focus group session should consider having different participants than the participants in the expert interview session to validate the sustainability criteria, indicators, and standard of measures. A limitation of the focus groups used in this research is that the evaluation questionnaires used as part of them concentrated on the general usefulness of the models, specifically as it relates to their flexibility, usability, and ease of use. Future evaluation questionnaires should consider other technical aspects of the models such as their equations, calculations, and formulas. In addition, future research should enable participants to apply the models on their own projects or case studies rather than the researcher’s case studies. This will allow participants to use the models to make decisions related to their own projects, providing further evidence about the models’ validity.

Another limitation in this research is the economic measure of the reforestation that has been considered for carbon offsetting in order to generate reductions in greenhouse gas emissions. This proposed economic measure considers the tree-planting cost in Canada for emission offsetting for fuelling service emissions at airport fueling project developments. However, future research should consider the actual cost of tree planting in different countries for comparison.

The aviation fueling industry has continuous developments and new innovations, such as electrical cars, mobile equipment, vanadium batteries, new control systems, other electrical technologies. Future research should consider updating all models and equations to cover these new developments in aviation fueling technologies. It should also attempt to expand on the sustainability factors involved in the field of airport fuelling projects (e.g., cultural and technical). Moreover, future research should compare the results derived from the use of the models developed in this research with the results derived from the use of other multi objective aggregation models. This is because different methods for deriving the overall sustainability index can lead to different results.

Future research should implement the research models in different countries or regions to compare the results of these implementations. It should consider altering the models before implementing them. Project stakeholders in these different regions and countries need to agree on the applicability and priority of the assessment criteria. This may lead to changes in the models' criteria and sub-criteria, the removal of some or the addition of others. The model's indicators and standard of measures should to be reviewed based on the country or region in which the models are applied. This revision will include updating all specific rules, regulations and standards that are applicable for each country or region. For the emission and energy consumption models, the measuring units should be reviewed based on the country or region of application. In addition, economic measures for the emission analysis model should also be updated based on each country or region (i.e., the average cost of offsetting CO_2 emissions and the average cost of the operation of the vapor recovery unit).

5.4 Concluding Remarks

Airport projects are a complex field due to the involvement of different stakeholders and the number of standards and regulations that must be met during the project life cycle. The sustainable development of airports has become a concern in the development of civil aviation. Yet, there is limited academic research on developing a systematic framework for airport sustainability assessment. The main goal of this research is to support sustainable airport development by developing sustainability assessment models for aircraft fueling projects. The domain-specific comprehensive assessment models will help assess and manage the sustainability of airport fuelling projects across the project's life cycle. The research has provided a solid platform to identify and systemically assess sustainability assessment criteria, quantitative and qualitative indicators, and standard of measures. In addition, the research has investigated emissions and energy factors for the aircraft fueling project domain. The research models are the first detailed emissions and energy analysis for aircraft fuelling project. The research validated the models by case studies, which will pave the ways to support stakeholders in selecting the best airport fuelling project alternative during the project's life cycle starting from the planning and design phases.

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Appendix A: Summary of General Sustainability Criteria (Karol and Brunner 2009)

	UN	SEEDA	Cascadia Scorecard	OPL	MPCAT
Environment	Atmosphere	Climate change and energy	Energy use	Carbon emission	Energy minimization
	Land	Transport and movement	Wildlife restoration	Sustainable transport	Water minimization
	Oceans, seas, coasts	Ecology	Urban sprawl	Sustainable water use	Transport integration
	Freshwater	Resources protection	Pollution level	Natural habitat and wildlife support	Biodiversity protection
	Biodiversity	Building efficiency		Waste minimization	Atmosphere protection
	Natural hazards			Sustainable material use	Waste minimization
					Sustainable material selection
Economic	Economic development	Business support	Economic well-being	Equity, fair and local economy support	Housing affordability
	Global economic partnership				Commercial success
	Consumption and production patterns				
Social	Poverty	Community support	Health	Cultural and heritage support	Community well-being
	Health	Place making	Population growth	Health and happiness support	Design excellence
	Education			Local and sustainable food production	
	Governance				
	Demographics				

Appendix B: Summary of Transportation Sustainability Assessment Tools (Mihyeon Jeon and Amekudzi 2005)

Tool/Initiative	Overview
United States Department of Transportation USDOT (2003).	USDOT has defined five strategic goal areas covering safety, mobility, economic growth and trade, human and natural environment, and national security. For each goal a set of strategic outcome goals and a number of more specific performance measures are defined for use in the annual performance planning.
United States Environmental Protection Agency USEPA (1999)	USEPA's report attempts to provide a comprehensive overview of the full range of environmental impacts (including impacts on air, water, climate, natural habitats, and other endpoints) from transportation modes (including road, rail, air and sea).
Transport Canada TC (2001)	TC reports are structured around a set of seven challenges, 29 sub-commitments, sub-targets and performance indicators. Three levels of indicators, reflecting different spheres of influence, include state level indicators (describing the state of the transportation systems in terms of sustainability), behavioral indicators (describing the behavior or activities of the actors and stakeholders whose actions matter for the state of the system), and operational indicators (describing indicators for operations and actions of TC itself).
Environment Canada EC (1991) and (2003)	This report presents 43 preliminary indicators in 18 issue areas with widespread stakeholder and media interest. This includes a fourth category related to the nature of human activity. The structure thus encompasses four sets of issues: ecological life support systems; natural

Tool/Initiative	Overview
	resources sustainability; human health and well-being; and pervasive influencing factors.
National Round Table on the Environment and the Economy NRTEE (2003)	The NRTEE has developed a set of sustainable transportation principles that concern access, equity, individual and community responsibility, health and safety, education and public participation, integrated planning, land and resource use, pollution prevention, and economic well-being.
Ontario Round Table on the Environment and the Economy. ORTEE (1995).	ORTEE report develops and assesses indicators for evaluating the impacts of possible actions or measures on the sustainability of the transportation system in Ontario.
Transportation Association of Canada TAC (1999)	TAC presents 13 principles pointing to sustainable transportation systems and related urban land use in Canada. A survey to monitor trends towards attainment of the principles can be considered as framing indicators or potential indicators to the extent that they provide appropriate quantitative responses.
Victoria Transport Policy Institute VTPI (2003)	VTPI presents a literature review on its approach and selection criteria for sustainable transportation indicators. It offers an alternative perspective on the selection of transport indicators by focusing on access (the ability to reach goods, services or destinations) rather than on the transportation system's ability to "move vehicles" (by measuring traffic congestion, for example).
Centre for Sustainable Transportation CST (2003)	CST adopted four criteria to select the indicators: the indicators must be relevant to the definition, a time series, represents all of Canada, and comes from a reliable source. The direction of the graph representing time series numbers for each indicator shows whether progress has been

Tool/Initiative	Overview
	made towards sustainable transportation.
Organization for Economic Cooperation and Development OECD (1999a)	The document pertains to the integration of environmental concerns into transport policies through the development and use of indicators. The indicators are structured according to three themes: sectoral trends of environmental significance; environmental impacts of the transport sector; and economic linkages between transport and the environment
Procedures for Recommending Optimal Sustainable Planning of European City Transport Systems PROSPECTS (2003)	The purpose of the report is to: 1. present a coherent but flexible general approach to planning for a sustainable urban land use/transport system, building on the logical structure 2. offer innovative methods of carrying out the steps of that logical structure, especially regarding appraisal of land use/transport strategies with respect to sustainability, and optimization with respect to sustainability 3. provide detailed advice on a number of issues in the planning process.
European Environment Agency EEA (2002)	The report describes the progress the EU is making towards the integration of environmental concerns into its transport policies. The aim is to monitor progress in three areas: the degree of environmental integration in the EU transport sector, progress towards transport systems that are more compatible with sustainable development, and the effectiveness of the adopted policy measures

Tool/Initiative	Overview
Department of Sustainable Development DSD (2003)	The United Kingdom presents ten guiding principles: 1. putting people at the centre 2. taking a long-term perspective 3. taking account of costs and benefits 4. creating an open and supportive economic system 5. combating poverty and social exclusion 6. respecting environmental limits 7. the precautionary principle 8. using scientific knowledge 9. transparency, information, participation, and access to justice 10. making the polluter pay.
New Zealand Ministry of the Environment NZME (1999)	The main purpose of the document is to provide the basis for agreement on the use of a core set of indicators to measure the environmental effects of transport. The components of the framework are: 1. root causes of transport activity 2. indirect pressures 3. direct pressures 4. state or effects indicators

Appendix C: Summary of Transportation Sustainability Assessment Tools Criteria (Mihyeon Jeon and Amekudzi 2005)

	US DOT	US EPA	TC	EC	NRTEE	ORTEE	TAC	VTPI	CST	OECD	PROS-PECTS	EEA	DSD	NZME
Economic														
Population density (persons/ha)						✓	✓							✓
Economic efficiency						✓					✓			
Employment						✓	✓							
Accessibility measures											✓			
Public expenditure											✓			
Growth potential											✓			
Green GDP						✓								
Tax revenues						✓								
Implementation of internalization instruments												✓		
Employment-to-population ratio in central area							✓							
Environmental														
C02 emissions (by mode)		✓	✓	✓		✓	✓			✓		✓		
Greenhouse gas emissions	✓			✓	✓				✓			✓	✓	
Fossil fuel consumption				✓			✓		✓	✓		✓		
Per capita use of transportation energy	✓				✓		✓	✓	✓					
Emissions of air pollutants (from transportation vehicle and equipment Manufacturing)	✓	✓						✓		✓		✓		
NO_x emissions (by mode)		✓							✓	✓		✓	✓	
VOCs emissions		✓							✓			✓		
Main land use/urban land use		✓				✓					✓			

	US DOT	US EPA	TC	EC	NRTEE	ORTEE	TAC	VTPI	CST	OECD	PROS-PECTS	EEA	DSD	NZME
Fossil fuel use by auto		✓		✓						✓				
Waste/recycling		✓	✓									✓		
CO emissions		✓							✓				✓	
Emission intensity									✓			✓		
Noise level/cost		✓									✓			
Green area								✓			✓			
Toxic substances in urban air: benzene/ozone		✓		✓										
Fuel efficiency of new auto				✓						✓				
E-index (per capita energy consumption)				✓		✓								
Non-fossil fuel use (alternative fuel)						✓						✓		
Wetland losses and creation	✓	✓												
Hazardous materials incidents	✓	✓												
Maritime oil spills	✓	✓										✓		
Overall energy efficiency for passenger and freight transport				✓								✓		
C02 cost [9]											✓			
S02 emissions		✓							✓					
CH_4 emissions		✓												
Black smoke emissions													✓	
Lead emissions		✓											✓	
Air pollution cost											✓			
Chlorofluorocarbons and stratospheric ozone depletion		✓		✓										
Urban sprawl											✓			
Fragmentation/particles/ volatile organic compounds		✓		✓										
Vulnerable areas											✓			
Worldwide major natural disasters					✓									
Ecological footprint						✓								

	US DOT	US EPA	TC	EC	NRTEE	ORTEE	TAC	VTPI	CST	OECD	PROS-PECTS	EEA	DSD	NZME
Demo technic index						✓								
Number of motor vehicles scrapped annually, disposal of scrap tires		✓												
Lead acid batteries in municipal solid waste Streams		✓												
Percentage of arterial roads and state highways with appropriate levels of storm water treatment														✓
Sediment loads in streams (pressure indicator)														✓
Change in criteria pollutant emissions compared to vehicle travel 1940-1997		✓												
No. of animal/wildlife collisions		✓												
Water quality		✓												
Fuel tank leakage		✓												
Percentage of tanks in compliance with guidelines			✓											
Mobile source contribution to hazardous air pollution inventories		✓												
Toxic chemicals released from ship and boat building and repair facilities		✓												
Fisheries protection compliance rate with federal fisheries regulations	✓													
Environmental costs and liabilities as reported to Treasury Board			✓											
Number of contaminated sites undergoing remediation or risk management			✓											
Fragmentation of ecosystems and habitats		✓										✓		

	US DOT	US EPA	TC	EC	NRTEE	ORTEE	TAC	VTPI	CST	OECD	PROS-PECTS	EEA	DSD	NZME
Percentage of strictly protected area				✓										
Change in emissions of toxic substances variable				✓										
Change in sulphur dioxide emissions (acid rain)		✓		✓										
Per capita water use				✓										
Municipal wastewater treatment improvement				✓										
Percentage of eco zone with strictly protected forest area				✓										
Reduction in number of bare-soil days on agricultural land				✓										
Per capita non-hazardous solid waste generation				✓										
Dredging and impacts to aquatic resources		✓												
Introduction of non-native species		✓												
Impervious surfaces		✓												
Releases of de-icing chemicals, cleaning fluids and wastewater		✓												
Solid waste (e.g. motor vehicle scrappage, motor oil, tires)		✓												
Social														
Residential population exposed to outside airport noise	✓	✓										✓		✓
Accessibility for those without a car								✓			✓	✓		
Residential population exposed to outside road traffic noise		✓										✓		✓
Average number of major services within walking distance of residents								✓		✓				

	US DOT	US EPA	TC	EC	NRTEE	ORTEE	TAC	VTPI	CST	OECD	PROS-PECTS	EEA	DSD	NZME
and average walking distance between residences and public services														
Percentage increase in environmental awareness, as measured by surveys or testing			✓									✓		
Local activity											✓			
Quality of transit with respect to mobility impaired											✓			
Income inequality											✓			
Equity impact tables											✓			
User benefit inequality											✓			
Benefits by zone											✓			
Taxpayer money											✓			
Crime						✓								
Community disruption						✓								
Distribution Inequality Index						✓								
Vehicle access						✓								
Quality of pedestrian and bicycle environment								✓						
Affordability of public transit service by lower income residents								✓						
Proportion of residents with public transit service within 500 metres	✓													
Residents' participation in transportation and land-use decision-making								✓						
Consumer perception of satisfaction with air quality		✓												
Environmental justice - environmental justice cases that	✓													

	US DOT	US EPA	TC	EC	NRTEE	ORTEE	TAC	VTPI	CST	OECD	PROS-PECTS	EEA	DSD	NZME
remain unresolved over one year														
Percentage of environmental emergency plans in place (percentage of plans up to date)			✓											
Population exposed to excess of EU air quality standards for PM_{10}, NO2, benzene, ozone, lead and CO												✓		
Proximity of transport infrastructure to designated areas												✓		
Regional access to markets: the case of reaching economically important assets by various modes												✓		
Extent of performing transport/ environment integration management												✓		
Percentage of bus fleets/key rail station with ADA compliance	✓													
Access to basic service										✓				

Appendix D: Environmental Sustainability Assessment

B: Buildings | TF: Tank Farm | FE: Fueling Equipment | V: Vehicles | O&P: Operation & Procedure | P&D: Planning & Design | C: Construction | O&M: Operation & Maintenance

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
A	Environmental							
A1	Administrative procedures							
A1.1	Cooperative sustainability policy	O&P	P&D C O&M	Adoption of a corporate policy on sustainable standards.	Extent of the corporate sustainability policy.	0.00 0.25 0.50 0.75 1.00	No process, program or policy in place Limited process, program or policy in place to address issues Process, program or policy is well developed and reflects good practice from the industry Process, program or policy embedded in airport operations and reflects best practice from the industry Industry leading process, program or policy. Long term planning horizon	CDA, Sustainable Airport Manual, 2013
A1.2	Sustainable procurement policy	O&P	P&D C O&M	Adoption of a sustainable procurement policy.	Extent of the sustainable procurement policy.	0.00 0.25 0.50 0.75 1.00	No process, program or policy in place Limited process, program or policy in place to address issues Process, program or policy is well developed and reflects good practice from the industry Process, program or policy embedded in airport operations and reflects best practice from the industry Industry leading process, program or policy. Long term planning horizon	CDA, Sustainable Airport Manual, 2013

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
A1.3	Green product procurement policy	O&P	P&D C O&M	Adoption of a green purchasing program. Points for this credit will be awarded based on the number of green products, as defined in Appendix AP-A (refer to SAM), procured for general day-to-day office use.	Number of green products and their minimum required content levels.	0.00 0.25 0.50 0.75 1.00	0 1 – 2 3 – 5 6 – 11 +12	CDA, Sustainable Airport Manual, 2013 (pp. AP-13)
A1.4	Program for the use of renewable materials	O&P, TF, B	P&D C O&M	Promoting the use of renewable input materials.	Existence of a program to monitor the percentage of renewable input materials used.	0.00 0.25 0.50 0.75 1.00	Risks have not been assessed and performance is/will not be monitored Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	CDA, Sustainable Airport Manual, 2013 (pp. AP-16) Sustainable Airport Manual, Chicago Airport

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
					Percentage of renewable input materials used ((Total renewable input materials used/Input materials used) x 100).	0.00 0.25 0.50 0.75 1.00	Less than 10% 10%-20% 20%-30% 30%-40% More than 40%	
A1.5	Program for the recycle used materials	O&P, TF, B	P&D C O&M	Promoting the recycle of used materials.	Existence of a program to monitor the percentage of recyclable materials.	0.00 0.25 0.50 0.75 1.00	Risks have not been assessed and performance is/will not be monitored Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	Sustainability Reporting Guidelines & Airport Operators Sector Supplement Sustainable Airport Manual, Chicago Airport
					Percentage of recyclable	0.00 0.25	Less than 10% 10%-20%	

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
					materials recycled ((Total used materials recycled /Total used recyclable materials) x 100).	0.50 0.75 1.00	20%-30% 30%-40% More than 40%	
A1.6	Environmental Impact Assessment (EIA) study	O&P	P&D C O&M	Application of EIA to ensure commitment to environmental regulations and standards stated in the General Environmental law of GCC.	Existence of an Environmental Impact Assessment (EIA) study for the whole project.	0.00 1.00	No EIA study EIA study in place	CDA, Sustainable Airport Manual (2013), General Environmental Law and Rules for Implementatio n (15 October 2001)
A1.7	Environmental certificate	O&P	P&D C O&M	Commitment to environmental laws and standards of local or international organizations. The law of PME requires an environmental license for organizations in the petroleum sector.	Number of environmental certificates from local (i.e. PME) or international organizations (i.e. LEED, ISO 14001)	0.00 0.25 0.50 0.75 1.00	0 1 local certificate 1 local and 1 international certificate 1 local and 2 international certificates More than 1 local and more than 2 international certificates	Best Practice
A1.8	Sustainability Training	O&P	P&D O&M	Adoption of sustainability training program for staff.	Existence of sustainability training program for staff.	0.00 0.25 0.50 0.75	No sustainability training program in place Training provided for 25% of staff Training provided for 50% of staff Training provided for 75% of	Airport cooperative Research Program, Airport Sustainability Practices

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
							staff	
A1.9	Sustainability function within the organization	O&P	P&D C O&M	Creating of sustainability positions/office within the organization	Existence of "sustainability manager" position or "sustainability office" within the organization.	1.00 0.00 1.00	Sustainability training program in place No sustainability position/office in place Sustainability position/office incorporated within the organization	Airport cooperative Research Program, Airport Sustainability Practices
A2	Water efficiency							
A2.1	Wastewater generation	TF, B	P&D C O&M	Generation of waste water using potable water resources.	Level of initiatives to minimize the amount of pollutants and chemicals entering waste water (e.g., vehicle washing monitoring programs).	0.00 0.25 0.50 0.75 1.00	No process, program or policy in place Limited process, program or policy in place to address issues Process, program or policy is well developed and reflects good practice from the industry Process, program or policy embedded in airport operations and reflects best practice from the industry Industry leading process, program or policy. Long term planning horizon	CDA, Sustainable Airport Manual, 2013
					Percentage of wastewater generation ((total amount of current wastewater / total amount of previous wastewater) × 100).	0.00 0.25 0.50 0.75 1.00	Less than 10% 10% 50% 75% 100%	CDA, Sustainable Airport Manual, 2013 Best practice
A2.2	Water withdrawal	TF, B	P&D C	Monitoring and improving the efficient	Efficiency of water use	0.00	Risks have not been assessed and performance is/will not be	Sustainability Reporting

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
			O&M	use of water.	reduction programs and annual reduction achieved.		monitored	Guidelines & Airport Operators Sector Supplement
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
					Percentage of water withdrawal production ((the total amount of current water use / total amount of previous water use) × 100).	0.00	Less than 10%	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	10%	
						0.50	50%	
						0.75	75%	
						1.00	100%	
A2.3	Storm water management system	TF, B	P&D O&M	Effectiveness of drainage system to minimize the effects of	Efficiency of storm water management	0.00	Risks have not been assessed and performance is/will not be monitored	Sustainability Reporting Guidelines &

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator		Standards of Measure Utility (0-1)	Reference
				storm water on the environment.	programs.	0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	Airport Operators Sector Supplement
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
					Existence of petroleum products at the storm water system.	0.00	existence of petroleum products	
						1.00	Free of petroleum products	PME, General Environmental law, 2001
A2.4	Water recycling and reusing	TF, B	P&D O&M	Monitoring and improving the water reuse/recycle.	Extent of reuse/recycled water programs and the annual reduction achieved.	0.00	Risks have not been assessed and performance is/will not be monitored	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
					Percentage of total volume of water recycled/reused by the operation per year.	0.00	Less than 10%	Sustainable Airport Manual, Chicago Airport
						0.25	10%-20%	
						0.50	20%-30%	
						0.75	30%-40%	
						1.00	More than 40%	
A2.5	Landscaping water use	B	P&D O&M	Level of water sources significantly affected by water withdrawal by the operation.	Efficiency of landscaping water use on water sources.	0.00	Risks have not been assessed and performance is/will not be monitored	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to	

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
							be reported either internal or external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
A2.6	Water use reduction	TF, B	P&D C O&M	Efficiency to reduce the use of potable water and waste water.	Percentage of water saving.	0.00	0	Sustainable Airport Manual, Chicago Airport
						0.25	1% - 15%	
						0.50	15% - 30%	
						0.75	30% - 45%	
						1.00	more than 45%	
A3	Indoor environmental quality							
A3.1	Indoor ventilation and air quality	B	P&D C O&M	Improvement of indoor air quality.	Extent of ventilation systems designed using the ventilation rate procedure or the applicable local code; whichever is more stringent.	0.00	Issue not on radar screen, relevancy to the organization undetermined. No budget allocation for activity	Sustainable Airport Manual, Chicago Airport
						0.25	Problems identified. Stakeholders take the lead in raising issue. Limited budget allocation for managing issue	
						0.50	Some awareness of issue inside organization. Policy or program is communicated and enforced. Funding allocation to manage	

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)	Reference
						issue established on annual basis 0.75 Strong internal awareness, recognition and understanding of issues. Investment deemed a priority 1.00 Feedback loops in place, continuous surveying of stakeholders. Performance goals incentivized.	
					Level of indoor air ventilation rates for all air-handling units serving occupied spaces as required by ASHRAE Standard 62.1-2007.	0.00 Less than 30% 0.25 30% 0.50 50% 0.75 60% 1.00 70% and more	Sustainable Airport Manual, Chicago Airport
					Implementation of one or the two options mentioned below: A. Modify or maintain each outside air intake, supply air fan, and/or ventilation distribution system to supply at least the outdoor air ventilation rate required by ASHRAE 62.1—2010	0.00 Neither option A nor B has been implemented 1.00 Either Option A or B has been implemented	Sustainable Airport Manual, Chicago Airport

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
					under all normal operating conditions. OR B. Modify or maintain the system to supply at least ten cubic feet per minute of outdoor air per person under all normal operating conditions.			
A3.2	Low or free-VOC indoor finishing materials	B	P&D C O&M	Reporting the use of zero or low-VOC paints/coating, or the installation of VOC free natural flooring/ceramic tiles.	The use of zero or low-VOC indoor finishing components/ materials.	0.00	No low or free- VOC materials in place	
						1.00	low or free- VOC materials in place	
A3.3	Carbon dioxide (CO_2) monitoring (O&P)	O&P	P&D C O&M	Reporting of Carbon dioxide (CO_2) monitoring system.	Adoption of carbon dioxide (CO_2) monitoring system.	0.00	No Carbon dioxide (CO_2) monitoring system is in place	

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
						1.00	Carbon dioxide (CO_2) monitoring system is in place	
A4	Energy							
A4.1	Energy savings from operation of pumps	TF	P&D O&M	Reduction of energy consumption associated with the operation of pumps.	Level of initiatives for energy savings due to conservation and efficiency improvements.	0.00	Risks have not been assessed and performance is/will not be monitored	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
					Percentage of electricity	0.00	Less than 15%	Sustainable Airport
						0.25	15%-20%	

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator		Standards of Measure Utility (0-1)	Reference
					consumption savings as a result of the energy saving initiatives.	0.50 0.75 1.00	20%-25% 25%-30% More than 30%	Manual, Chicago Airport
A4.2	Energy savings from operation of buildings	B	P&D O&M	Initiatives for energy savings due to conservation and efficiency improvements.	Level of reduction in energy consumption associated with the operation of offices and buildings.	0.00	Risks have not been assessed and performance is/will not be monitored	Sustainability Reporting Guidelines & Airport Operators Sector Supplement; CDA, Sustainable Airport Manual, 2013
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
					Percentage of electricity consumption savings as a result of the energy saving initiatives.	0.00 0.25 0.50 0.75 1.00	Less than 15% 15%-20% 20%-25% 25%-30% More than 30%	Sustainable Airport Manual, Chicago Airport

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
A4.3	Use of renewable energy	TF, B	P&D C O&M	Encouragement of on-site and off-site renewable energy to reduce environmental impacts associated with fossil fuel energy use.	Percentage of renewable energy utilization for on-site activities.	0.00 0.25 0.50 0.75 1.00	Less than 4.5% 4.5%-6% 6%-7.5% 7.5%-9% More than 9%	Sustainable Airport Manual, Chicago Airport
					Percentage of renewable energy utilization for off-site activities.	0.00 0.25 0.50 0.75 1.00	Less than 37.5% 37.5%-50% 50%-62.5% 62.5%-75% More than 75%	Sustainable Airport Manual, Chicago Airport
A4.4	Vehicles and mobile equipment fuel savings	V, FE	P&D C O&M	Reduction of fuel consumption for refueling, hydrant flushing and passenger due to vehicle movement/idling.	Extent of initiatives for motor vehicle fuel savings due to utilization of green (LNG/Electric) vehicles and implementation of alternative driving routes.	0.00 0.25 0.50 0.75 1.00	Risks have not been assessed and performance is/will not be monitored Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to	Sustainability Reporting Guidelines & Airport Operators Sector Supplement; International Civil Aviation Organization, 2011

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
							stakeholders and general public.	
A5	Emissions				Percentage of fuel consumption savings as a result of the fuel saving initiatives.	0.00 0.25 0.50 0.75 1.00	Less than 10% 10%-20% 20%-30% 30%-40% More than 40%	Sustainable Airport Manual, Chicago Airport
A5.1	Reduction of VOC emissions	FE	P&D O&M	Reduction of VOC emissions from 1) aircraft vents during fueling operations; 2) refueler vents during filling operations, 3) hydrant LP flushing vehicle vents during LP flushing operations 4) tank vents during routine operation and receipt of product into storage tanks.	Extent of initiatives to monitor VOC emissions by weight.	0.00 0.25 0.50 0.75 1.00	Risks have not been assessed and performance is/will not be monitored Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	International Civil Aviation Organization, 2011

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)	Reference
					Percentage of the VOC reduction as a result of the VOC monitoring and reduction initiatives.	0.00 Less than 10% 0.25 10%-20% 0.50 20%-30% 0.75 30%-40% 1.00 More than 40%	UNECE, Decision 2012/2 Amendment of the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, Annexes X and XI, Emission reduction commitments for Volatile Organic Compounds for 2020 and beyond
A5.2	Vehicles and mobile equipment exhaust emissions	V, FE	P&D C O&M	Reduction of VOCs and greenhouse gases emissions from the exhausts of refueling, hydrant flushing and passenger vehicles, during vehicle movement/idling.	Extent of initiatives to monitor VOCs and greenhouse gases emissions by weight and whether the location has considered a plan to optimize routes and idling times.	0.00 Risks have not been assessed and performance is/will not be monitored 0.25 Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance 0.50 Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization 0.75 Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported	International Civil Aviation Organization, 2011

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
							internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
					Percentage of CO_2 reduction as a result of the CO_2 monitoring and reduction initiatives.	0.00 0.25 0.50 0.75 1.00	Less than 15% 15%-20% 20%-25% 25%-30% More than 30%	United Nations Framework Convention on Climate Change 2011
A5.3	Utilization of environmentally friendly vehicles	V, FE	P&D C O&M	Initiatives to utilize 'green' or 'clean' vehicles and/or mobile fueling equipment (liquefied petroleum gas or electric) as a means to reduce VOCs and greenhouse gases emissions from vehicles' exhausts.	Efficiency of initiative to utilize 'green' or 'clean' vehicles and/or mobile fueling equipment as a means to reduce VOCs and greenhouse gases emissions from vehicles' exhausts.	0.00 0.25 0.50 0.75 1.00	No process, program or policy in place Limited process, program or policy in place to address issues Process, program or policy is well developed and reflects good practice from the industry Process, program or policy embedded in airport operations and reflects best practice from the industry Industry leading process, program or policy. Long term planning horizon	Airport cooperative Research Program, Airport Sustainability Practices
A5.4	GHG emissions associated with energy consumption	TF, B, V, FE	P&D C O&M	Initiatives to monitor greenhouse gases emissions by weight by kw/hr of electricity consumption.	Extent of initiatives to monitor and reduce greenhouse gases (GHG) emissions associated with	0.00 0.25	Risks have not been assessed and performance is/will not be monitored Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	International Civil Aviation Organization, 2011 US Environmental Protection

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
					energy savings.	0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	Agency
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
					Percentage of CO_2 reduction as a result of the CO_2 monitoring and reduction initiatives.	0.00	Less than 15%	United Nations Framework Convention on Climate Change 2011
						0.25	15%-20%	
						0.50	20%-25%	
						0.75	25%-30%	
						1.00	More than 30%	
A6	Waste							
A6.1	Hazardous wastes produced from ad-hoc activities (e.g., commissioning procedures) and spills	TF, FE	P&D C O&M	Reduction of hazardous wastes produced during ad-hoc activities and spills (e.g., commissioning operations of equipment and	Extent of initiatives to monitor and reduce hazardous wastes produced by type and by weight.	0.00	Risks have not been assessed and performance is/will not be monitored	JIG 1,2,4 and EI/JIG 1530 US Environmental Protection Agency
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)	Reference
				facilities, soaked fuel after soak tests for new storage tanks or refueling vehicles, wastewater after initial pressure strength test of new hydrant systems, etc.).		0.50 Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization 0.75 Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization 1.00 Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
					Percentage of hazardous wastes reduced by implementing specific initiatives.	0.00 Less than 10% 0.25 10%-20% 0.50 20%-30% 0.75 30%-40% 1.00 More than 40%	Sustainable Airport Manual, Chicago Airport
A6.2	Hazardous wastes produced from routine operation and maintenance	V, FE, TF	P&D O&M	Reduction of hazardous wastes produced over the course of normal/routine operations (tank farm, hydrant and ITP) (e.g., fuel slops, used filter elements, used hoses, vehicle tires, etc.).	Level of initiatives to monitor and reduce hazardous wastes produced by type and by weight.	0.00 Risks have not been assessed and performance is/will not be monitored 0.25 Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance 0.50 Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	JIG 1,2,4 and EI/JIG 1530 US Environmental Protection Agency

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
					Percentage of hazardous wastes reduced by implementing specific initiatives.	0.00	Less than 10%	Sustainable Airport Manual, Chicago Airport
						0.25	10%-20%	
						0.50	20%-30%	
						0.75	30%-40%	
						1.00	More than 40%	
A6.3	Non-hazardous wastes produced from routine operation and maintenance	B, TF, V,	P&D O&M	Reduction of non-hazardous wastes produced over the course of routine operations (tank farm, hydrant, ITP and household type of wastes from buildings and offices).	Level of initiatives to monitor and reduce non-hazardous wastes produced by type and by weight.	0.00	Risks have not been assessed and performance is/will not be monitored	CDA, Sustainable Airport Manual, 2013
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported	

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
							internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
					Percentage of non-hazardous wastes reduced by implementing specific initiatives.	0.00 0.25 0.50 0.75 1.00	Less than 10% 10%-20% 20%-30% 30%-40% More than 40%	Sustainable Airport Manual, Chicago Airport
A6.4	Pollution of land / waterways	TF, FE	P&D O&M	Reduction of uncontained spills into the ground / waterways.	Efficiency of initiatives to monitor uncontained spills into the ground / waterways.	0.00	Risks have not been assessed and performance is/will not be monitored	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance	

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator		Standards of Measure Utility (0-1)	Reference
							goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
A7	Land use & biodiversity							
A7.1	Efficiency of land use	B, TF	P&D	Optimizing site location, land acquisition, future expansion, and visual harmony.	The availability of unoccupied land adjacent to the tank farm facilities.	0.00	Issue not on radar screen, relevancy to the organization undetermined. No budget allocation for activity	CDA, Sustainable Airport Manual, 2013
						0.25	Problems identified. Stakeholders take the lead in raising issue. Limited budget allocation for managing issue	
						0.50	Some awareness of issue inside organization. Policy or program is communicated and enforced. Funding allocation to manage issue established on annual basis	
						0.75	Strong internal awareness, recognition and understanding of issues. Investment deemed a priority	
						1.00	Feedback loops in place, continuous surveying of stakeholders. Performance goals incentivized.	
A7.2	Impact of location and size of land used for operations in biodiversity	B, TF	P&D O&M	Impacts of land that lies within, contains, or is adjacent to legally protected areas on biodiversity in these areas.	Level of initiatives to monitor significant direct and indirect positive and negative impacts of land (location and size) with	0.00	Issue not on radar screen, relevancy to the organization undetermined. No budget allocation for activity	CDA, Sustainable Airport Manual, 2013
						0.25	Problems identified. Stakeholders take the lead in raising issue. Limited budget allocation for managing issue	

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
					reference to the following: species affected; extent of areas impacted; duration of impacts; and reversibility or irreversibility of the impacts.	0.50	Some awareness of issue inside organization. Policy or program is communicated and enforced. Funding allocation to manage issue established on annual basis	
						0.75	Strong internal awareness, recognition and understanding of issues. Investment deemed a priority	
						1.00	Feedback loops in place, continuous surveying of stakeholders. Performance goals incentivized.	
A7.3	Impact of activities in biodiversity	B, TF	P&D O&M	Impacts of activities, products, and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas.	Extent of initiatives to monitor significant direct and indirect positive and negative impacts of activities with reference to the following: species affected; extent of areas impacted; duration of impacts; and reversibility or irreversibility of the impacts.	0.00	Issue not on radar screen, relevancy to the organization undetermined. No budget allocation for activity	CDA, Sustainable Airport Manual, 2013
						0.25	Problems identified. Stakeholders take the lead in raising issue. Limited budget allocation for managing issue	
						0.50	Some awareness of issue inside organization. Policy or program is communicated and enforced. Funding allocation to manage issue established on annual basis	
						0.75	Strong internal awareness, recognition and understanding of issues. Investment deemed a priority	
						1.00	Feedback loops in place, continuous surveying of stakeholders. Performance goals incentivized.	
A8	Noise							

#	Environmental Criteria	Relevance Scope	Phase	Description	Indicator	Standards of Measure Utility (0-1)		Reference
A8.1	Noise pollution	B, TF, V, FE	P&D C O&M	Maintaining noise levels from machinery and fuel pumps and equipment at permissible levels.	Level of initiatives to monitor noise levels from machinery and equipment used at airport fuel operation facilities (e.g., power generators, air-powered tools, firefighting pumps, etc.) against noise targets or limits applicable to the airport.	0.00	Risks have not been assessed and performance is/will not be monitored	Sustainability Reporting Guidelines & Airport Operators Sector Supplement; ICAO Annex 16, ACI Noise Rating Index
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	

Appendix E: Economic Sustainability Assessment

#	Economic Criteria	Relevance Scope	Phase	Description	Indicator	Standard of Measures Utility (0-1)	Reference
B	Economic						
B1	Economic performance analysis						
B1.1	Life cycle cost	B, TF, V, FE	P&D C O&M	Assessing the total cost of facility, vehicles, and equipment ownership over the life cycle of the project	Level of cost-effective option among different competing alternatives to purchase, own, operate and maintain.	0.00 Risks have not been assessed and performance is/will not be monitored 0.25 Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance 0.50 Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization 0.75 Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization 1.00 Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	Airport cooperative Research Program, Airport Sustainability Practices
B1.2	Projects Capital	B, TF, FE, V	P&D C O&M	Measuring the components of capital investment	Existence of capital projects analysis to predict current and future	0.00 No process, program or policy in place 0.25 Limited process, program or policy in place to address issues	Airport cooperative Research Program,

#	Economic Criteria	Relevance Scope	Phase	Description	Indicator	Standard of Measures Utility (0-1)		Reference
					expenditure	0.50	Process, program or policy is well developed and reflects good practice from the industry	Airport Sustainability Practices
						0.75	Process, program or policy embedded in airport operations and reflects best practice from the industry	
						1.00	Industry leading process, program or policy. Long term planning horizon	
B1.3	Environmental mitigation and protection expenditures	B, TF	P&D C O&M	Measuring environmental mitigation and protection expenditures to allow the efficiency assessment of the environmental initiatives at tank farm facilities.	Level of process to establish targets and monitor the monetary value of waste disposal, emissions treatment, and remediation costs related to the following items: • Treatment and disposal of waste; •Treatment of emissions (e.g., expenditures for filters, agents); • Expenditures for the purchase and use of emissions certificates; •Depreciation of related equipment, maintenance, and operating material and services, and	0.00	Risks have not been assessed and performance is/will not be monitored	
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	

#	Economic Criteria	Relevance Scope	Phase	Description	Indicator	Standard of Measures Utility (0-1)		Reference
					related personnel costs; Insurance for environmental liability; and • Clean-up costs, including costs for remediation of spills.			
B1.4	Land and property value	B, TF	P&D	Measuring the best viable option for the land and property value in real estate domain.	Assessment of land and property value to provide the best sustainable value and return to the project	0.00	No process, program or policy in place	Airport cooperative Research Program, Airport Sustainability Practices
						0.25	Limited process, program or policy in place to address issues	
						0.50	Process, program or policy is well developed and reflects good practice from the industry	
						0.75	Process, program or policy embedded in airport operations and reflects best practice from the industry	
						1.00	Industry leading process, program or policy. Long term planning horizon	
B1.5	Capital to sales ratio	B, TF, V, FE	P&D C O&M	Measuring how effectively Capital investment utilized to generate sales revenue.	Utilization level of capital investment in generating sales revenue capex to sales ratio (%).	0.00	Capex to sales ratio is below average industry benchmark	Industry best practice
						0.25	Capex to sales ratio is below average industry benchmark by up to 0.25%	
						0.50	Capex to sales ratio is below average industry benchmark by up to 0.5%	
						0.75	Capex to sales ratio is below average industry benchmark by up to 0.75%	
						1.00	Capex to sales ratio is below average industry benchmark by more than 0.75%	

#	Economic Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures Utility (0-1)	Reference
B1.6	Operating expenses to sales	B, TF, FE, V, O&P	P&D O&M	Measuring the operational efficiency and performance of controlling expenses.	Average expenses as a percentage of sales compared against oil and energy sector average expenses.	0.00	Opex to sales ratio is below average industry benchmark	
						0.25	Opex to sales ratio is below average industry benchmark by up to 0.25%	
						0.50	Opex to sales ratio is below average industry benchmark by up to 0.5%	
						0.75	Opex to sales ratio is below average industry benchmark by up to 0.75%	
						1.00	Opex to sales ratio is below average industry benchmark by more than 0.75%	
B1.7	Operating Expenses Efficiency	B, TF, FE, V, O&P	P&D O&M	Measuring the ability to control operation expenses compared to be level of inflation.	Efficiency of controlling operation expenses level compared to annual monetary agency inflation.	0.00	Annual increase in Opex is above the average declared inflation rate	Saudi Arabian Monetary Agency (SAMA)
						0.25	Annual increase in Opex is below the average declared inflation rate by 0.5%	
						0.50	Annual increase in Opex is below the average declared inflation rate by 0.75%	
						0.75	Annual increase in Opex is below the average declared inflation rate by 0.75%	
						1.00	Annual increase in Opex is below the average declared inflation rate by 1%	
B1.8	Maintenance to assets cost	B, TF, V, FE	P&D O&M	Measuring the performance of assets safeguards and the implementation of preventative maintenance polices	Performance of assets safeguards measures against maintenance functional benchmark of	0.00	Maintenance to asset cost is above the benchmark by 2% and more	http://cleanbayarea.com/recycling-environment/maintenance-cost-vs-asset-
						0.25	Maintenance to asset cost is above the benchmark by 1 .5%	

#	Economic Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures Utility (0-1)	Reference
					(3%) for oil and energy sector.	0.50	Maintenance to asset cost is above the benchmark by 1%	replacement-value-rav/
						0.75	Maintenance to asset cost is above the benchmark by 0.5%	
						1.00	Maintenance to asset cost is 3% or below	
B1.9	Working capital to sales	B, TF, FE, V	P&D O&M	Measuring the ability to finance additional sales without incurring additional debt. .	Effectiveness of using project working capital measured against the industry average ratio benchmark (Working capital ÷ sales revenue).	0.00	Working capital is less than 30% to sales revenue	http://www.tadawul.com.sa/Resources/fsPdf/644_2015-07-07_08-10-57_Arabic.pdf
						0.25	Working capital is between 30% -32% to sales revenue	
						0.50	Working capital is between 32% -34% to sales revenue	
						0.75	Working capital is between 34% - 36% to sales revenue	
						1.00	Working capital is above 36% to sales revenue	
B2	Economic value retained							
B2.1	Direct economic value generated	TF, FE, B, V	P&D O&M	Measuring the direct economic value created. It is calculated by net sales plus revenues from financial investments and sales of assets.	Existence of programs to monitor direct economic value generated including revenues vs. financial targets.	0.00	No process, program or policy in place	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	Limited process, program or policy in place to address issues	
						0.50	Process, program or policy is well developed and reflects good practice from the industry	
						0.75	Process, program or policy embedded in airport operations and reflects best practice from the industry	

#	Economic Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures Utility (0-1)	Reference
B2.2	Economic value retained	B, TF, FE, V, O&P	P&D O&M	Measuring firm's economic value created in excess of the required return of the company's shareholders.	Level of programs to monitor economic value generated and retained (investments, equity release etc.) vs. financial targets.	1.00	Industry leading process, program or policy. Long term planning horizon	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.00	Risks have not been assessed and performance is/will not be monitored	
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
B2.3	Net present value (NPV) of discounted cash flow	B, TF, FE, V, O&P	P&D O&M	Measuring the project's profitability and the amount of value added to the firm. It based on difference between the present value of cash	NPV value	0.00	NPV <0	http://capitalbudgeting.tripod.com/id24.html http://www.gulfbase.com/ScheduleReports/2
						0.25	NPV >0 and NPV above Equity risk premium by 2%	

#	Economic Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures Utility (0-1)	Reference
				inflows and the present value of cash outflows of the project.		0.50	NPV >0 and NPV above discount rate by 3%	50364a2_GCC EquityRiskPremium-October2012.pdf
						0.75	NPV >0 and NPV above equity risk premium by 4%	
						1.00	NPV >0 and NPV above equity risk premium by 5%	
B2.4	Payback period	B, TF, FE, V, O&P	P&D O&M	Measuring the length of time required to recover the cost of project. Accepted if payback period < maximum acceptable payback period. (7 years)	Average payback period	0.00	Payback period is > 10 years	ICAO , Emission reduction measure payback period http://www.icao.int/Meetings/Environmental Workshops/Documents/2014-Malaysia/9-1_Financing.pdf
						0.25	Payback period is 9 to 10 years	
						0.50	Payback period is 8 to 9 years	
						0.75	Payback period is 7 to 8 years	
						1.00	Pay pack period is 7 years or less	
B2.5	Return on assets (ROA)	B, TF, FE, V	P&D O&M	Measuring how profitable a project is relative to its total assets that are used to evaluate the efficiency of an investment. A profitability ratio calculated as net income divided by total assets.	ROA value	0.00	ROA is below five years average of oil & gas industry sectors	https://www.stock-analysis-on.net/NYSE/Company/Exxon-Mobil-Corp/Ratios/Profitability
						0.25	ROA is above five years average of oil & gas industry sectors by 0.25%	
						0.50	ROA is above five years average of oil & gas industry sectors by 0.5%	
						0.75	ROA is above five years average of oil & gas industry sectors by 0.75%	

#	Economic Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures Utility (0-1)	Reference
						1.00	ROA is above five years average of oil & gas industry sectors by 1%	
B2.6	Financial implications of emissions and climate change	B, TF, FE, V, O&P	P&D C O&M	Measuring the effect of financial implications due to emissions and climate change.	Existence of programs for the quantitatively estimations of the financial implications of climate change for the organization (e.g., cost of offsetting CO_2 emissions or VOC emissions).	0.00	Risks have not been assessed and performance is/will not be monitored	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
B3	Market presence							
B3.1	Service and product marketability	B, TF, FE, V, O&P	P&D O&M	Measuring the ability to attract and increase sales volume and the elasticity of demand as result of the	The Annual growth in Gross Domestic Product (GDP).	0.00	Growth in Annual sales volume is below annual GDP Growth	Netherlands Airport Consultants B.V., NACO, Kingdom's
						0.25	Growth in Annual sales volume is above annual GDP Growth by 0.5%	

#	Economic Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures Utility (0-1)	Reference
				implementation of effective marketing tools.		0.50	Growth in Annual sales volume is above annual GDP Growth by 1%	Airport Aviation and Logistics. Saudi Arabia, May 2012
						0.75	Growth in Annual sales volume is above annual GDP Growth by 1.5%	
						1.00	Growth in Annual sales volume is more than Annual GDP by 2% and above	
B3.2	Standard entry level wage ratio	O&P	P&D O&M	Measuring the variance in the range of ratios of standard entry level wage compared to local minimum wage at significant locations of operation. Economic well-being is one of the ways in which an organization invests in its employees.	Existence of the entry wage ratio to the local minimum entry wage.	0.00	No process, program or policy in place	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	Limited process, program or policy in place to address issues	
						0.50	Process, program or policy is well developed and reflects good practice from the industry	
						0.75	Process, program or policy embedded in airport operations and reflects best practice from the industry	
						1.00	Industry leading process, program or policy. Long term planning horizon	
B3.3	Employment opportunity	O&P	P&D O&M	Measuring the effect of creation employment opportunities	Existence of plans to generate employment opportunities.	0.00	No process, program or policy in place	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	Limited process, program or policy in place to address issues	
						0.50	Process, program or policy is well developed and reflects good practice from the industry	
						0.75	Process, program or policy embedded in airport operations and reflects best practice from	

#	Economic Criteria	Relevance Scope	Phase	Description	Indicator	Standard of Measures Utility (0-1)		Reference
							the industry	
						1.00	Industry leading process, program or policy. Long term planning horizon	
B3.4	Service and product affordability	B, TF, FE, V, O&P	P&D O&M	Measuring the use of sustainability tools to assess mid- and long-term affordability	Level of process to assess affordability.	0.00	No process, program or policy in place	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	Limited process, program or policy in place to address issues	
						0.50	Process, program or policy is well developed and reflects good practice from the industry	
						0.75	Process, program or policy embedded in airport operations and reflects best practice from the industry	
						1.00	Industry leading process, program or policy. Long term planning horizon	
B3.5	Long-term plan	B, TF, FE, V, O&P	P&D C O&M	Assessing the 25-years airport master plan for factoring long-term project components.	Extent of the long-term airport master plan	0.00	No process, program or policy in place	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	Limited process, program or policy in place to address issues	
						0.50	Process, program or policy is well developed and reflects good practice from the industry	
						0.75	Process, program or policy embedded in airport operations and reflects best practice from the industry	
						1.00	Industry leading process, program or policy. Long term planning horizon	
B4	Indirect economic impacts							

#	Economic Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures Utility (0-1)	Reference
						0.00	Risks have not been assessed and performance is/will not be monitored	
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	
B4.1	Indirect economic impacts	B, TF, FE, V, O&P	P&D O&M	Measuring the multiplier effect of economic activity and the total additional activity generated by the project.	Level of indirect economic impacts and their significance in the context of external benchmarks and stakeholder priorities.	0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
B4.2	Non-monetary benefits	B, TF, FE, V, O&P	P&D O&M	Measuring the annual objectives and targets that should include quantification of non-monetary benefits.	Existence of annual objectives and targets including quantification of non-monetary	0.00	Risks have not been assessed and performance is/will not be monitored	Airport cooperative Research Program, Airport Sustainability
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of	

#	Economic Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures Utility (0-1)	Reference
					benefits.		performance	Practices
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
B4.3	Finance leverage	B, TF, FE, V, O&P	P&D C O&M	Measuring the extent to which a project is financed by the borrowed fund. The main measure is debt to equity (DOE) ratio that indicates how much debt is used to finance assets relative to the amount of value represented in	Debt to equity ratio (DOE).	0.00	Debt to equity is above the energy sector benchmark by 0.4%	https://www.stock-analysis-on.net/NYSE/Company/Exxon-Mobil-Corp/Long-Term-Trends/Debt-to-Equity#Comparison-to-Industry
						0.25	Debt to equity is higher than energy sector benchmark by 0.3%	
						0.50	Debt to equity is higher than energy sector benchmark by 0.2%	

#	Economic Criteria	Relevance Scope	Phase	Description	Indicator	Standard of Measures Utility (0-1)	Reference
				shareholders’ equity. E = Total Liabilities / (Total Assets - Total Liabilities).		0.75 Debt to equity is higher than energy sector benchmark by 0.1%	
						1.00 Debt to equity ratio is lower or equal to energy sector benchmark	

Appendix F: Social Sustainability Assessment

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
C	Social							
C1	Occupational health and safety							
C1.1	Representation in Health, Safety, Security and Environment (HSSE) committees	O&P	P&D C O&M	Representation in formal joint management worker health and safety committees that help monitor and advise on occupational health and safety programs.	Level of representation of workforce in formal joint management-worker health and safety committees.	0.00	No process, program or policy in place	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	Limited process, program or policy in place to address issues	
						0.50	Process, program or policy is well developed and reflects good practice from the industry	
						0.75	Process, program or policy embedded in airport operations and reflects best practice from the industry	
						1.00	Industry leading process, program or policy. Long term planning horizon	
					Percentage of commitment to HSSE programs: Internal HSSE Audit: 1 per year External HSSE Audit: 1 per 3 years Safety walk by management: 2 per year Safety Meetings: 12 per year Safety bulletin: 4 per year KPI (HSSE) - Compilation 4 per	0.00	Less than 85%	Best industry practice
						0.25	85% to 90%	
						0.50	90% to 95%	
						0.75	95% to 99%	
						1.00	100%	

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
					year Minimum acceptable limit: 85% of actual vs planned.			
C1.2	Work-related injuries and fatalities	O&P	P&D C O&M	Protective and preventive measures applied to protect personnel from occupational health hazards associated with hazardous materials,	Level of programs for monitoring rates of injury and total number of work-related fatalities.	0.00	Risks have not been assessed and performance is/will not be monitored	JIG HSSE statistics
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
					Number of incident (goal is zero).	0.00	> 3	Best industry practice
						0.25	3 minor Incidents	
						0.50	2 minor Incidents	
						0.75	1 minor Incident	

#	Social Criteria	Relevance Scope	Phase	Description	Indicator	Standard of Measures		Reference
						1.00	Zero incidents	
C1.3	Reduction of work-related injuries and fatalities	O&P	P&D C O&M	Reduce rates of injury and total number of work-related fatalities.	Percentage of reduction in work-related injuries and fatalities	0.00	Reduction in incident rates less than 20%	JIG HSSE statistics
						0.25	Reduction in incident rates 20%-40%	
						0.50	Reduction in incident rates 40%-60%	
						0.75	Reduction in incident rates 60%-80%	
						1.00	No incidents or reduction in incident rates > 80%	
					Number of potential incidents reported, Annual HSSE Plan activities, Annual HSSE Plan investments, implementation of HSSE audit recommendations and implementation of HSSE Remedial Action Plan.	0.00	> 3 Injuries	Best industry practice
						0.25	3 Injuries	
						0.50	2 Injuries	
						0.75	1 Injury	
						1.00	Zero Injuries	
C1.4	Occupational diseases, lost days and absenteeism	O&P	P&D C O&M	Rates of occupational diseases, lost days and absenteeism.	Level of programs for monitoring and reducing rates of occupational diseases, lost days and absenteeism.	0.00	Risks have not been assessed and performance is/will not be monitored	JIG HSSE statistics
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or	

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
							external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
					Percentage of absenteeism due to occupational diseases Absenteeism = 5 days/ year/ employee. Sick leave= 8 days/year/employe e.	0.00	Absenteeism more than 10%	JIG HSSE statistics
						0.25	Absenteeism 7%-10%	
						0.50	Absenteeism 5%-7%	
						0.75	Absenteeism 3%-5%	
						1.00	Absenteeism less than 3%	
C1.5	Health and safety awareness and prevention	O&P	P&D C O&M	Introduction of education, training, counseling, prevention and risk-control programs to assist workforce members, their families or community members regarding serious	Extent of the programs related to assisting workforce members, their families or community members regarding serious	0.00	No process, program or policy in place	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	Limited process, program or policy in place to address issues	
						0.50	Process, program or policy is well developed and reflects good practice from the industry	
						0.75	Process, program or policy embedded in airport operations	

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
				diseases.	diseases.		and reflects best practice from the industry	
						1.00	Industry leading process, program or policy. Long term planning horizon	
C1.6	Education enhancement on HSSE awareness	O&P	P&D C O&M	Enhancement of education, risk assessment, work control permit, safety meeting, fundamental of safety, Defense Driving, law, and workplace health and safety policies and procedures, use PPE as required.	Percentage of commitment and implementation for: Education enhancement; Trainings; HSSE Policies; Defense Driving; Use PPE as required	0.00 0.25 0.50 0.75 1.00	Less than 80% 80% to 90% 90% to 95% 95% to 99% 100%	Best industry practice
C1.7	Health and safety coverage with trade unions	O&P	P&D O&M	Formal agreements can promote the acceptance of responsibilities by both parties and the development of a positive health and safety culture.	Level of program (either local or global) with trade unions cover health and safety.	0.00 0.25 0.50 0.75 1.00	No process, program or policy in place Limited process, program or policy in place to address issues Process, program or policy is well developed and reflects good practice from the industry Process, program or policy embedded in airport operations and reflects best practice from the industry Industry leading process, program or policy. Long term planning horizon	Sustainability Reporting Guidelines & Airport Operators Sector Supplement Business Ethics
C1.8	Fueling vehicles safety devices	O&P	P&D O&M	Performance and functionality of fueling equipment safety devices.	Existence of weekly checks of devices critical to safe operations and health of personnel (e.g.,	0.00 1.00	Not in place or not recorded All Weekly checks and records in place	AAFQCO Manual

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
					Interlock function, Bonding wire, Elevating platform lowering, Elevating platform wand sensors).			
					Existence of monthly checks of devices critical to safe operations and health of personnel (e.g., refueler high level cut-off devices, engine emergency stop switches).	0.00 1.00	Not in place or not recorded All Monthly checks and records in place	
					Existence of quarterly checks of devices critical to safe operations and health of personnel.	0.00 1.00	Not in place or not recorded All Quarterly checks and records in place	
					Existence of semi-annual, annual and less frequent checks of devices critical to safe operations and health of personnel.	0.00 1.00	Not in place or not recorded All Semi-annual/annual/less freq. checks and records in place	AAFQCO Manual
C1.9	Fueling vehicles safety equipment	FE	P&D O&M	Minimum required safety equipment considered is in place.	Existence of the minimum required safety equipment such as: Fire extinguishers: 2 /mobile equipment	0.00 1.00	Requirements not met Minimum equipment in place	AAFQCO Manual

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
					Spill kit: 50 Liter/ mobile equipment Cones: 3/ mobile equipment First aid box: 1 box/ mobile equipment.			
					Existence of the weekly checks of devices critical to safe operations and health of personnel (e.g., bonding wires).	0.00 1.00	Not in place or not recorded All Weekly checks and records in place	AAFQCO Manual
					Existence of the monthly checks of devices critical to safe operations and health of personnel (e.g., hydrant emergency shut-down buttons).	0.00 1.00	Not in place or not recorded All Monthly checks and records in place	AAFQCO Manual
C1.10	Fuel storage safety devices	O&P	P&D O&M	Performance and functionality of fuel storage safety devices.	Existence of the quarterly checks of devices critical to safe operations and health of personnel (e.g., safe procedures for entry in valve chambers).	0.00 1.00	Not in place or not recorded All Quarterly checks and records in place	AAFQCO Manual
					Existence of the semi-annual, annual and less frequent checks of devices critical to	0.00 1.00	Not in place or not recorded All Semi-annual/annual/less freq. checks and records in place	AAFQCO Manual

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
					safe operations and health of personnel (e.g., tank cleaning every 3-5 years, cathodic protection yearly.			
C1.11	Fuel storage safety equipment	TF	P&D O&M	Minim required safety equipment considered are in place.	Availability of the min required safety equipment: Fire extinguishers: Every 20m/ 10kg; Spill kit: 2 X 120 liter; Sprinkler system: every 1.5 m /1 nozzle; Fire Alarm syst. each 45 m/per unit; First aid box: 1 box / 3 - 4 min.	0.00 1.00	Requirements not met Minimum equipment in place	AAFQCO Manual
C1.12	Personal protective equipment (PPE)	O&P	P&D C O&M	Ensuring the greatest possible protection for employees at workplace.	Meeting the minimum standards/specifications of PPEs: Eye Protection; Fire Resistant & Antistatic Shirts/ Trousers; Fire Resistant & Antistatic Work wear Overalls; QC hand Gloves; High Visibility Vest; Safety Helmets; Safety boots; Anti-slip; Shock Absorbent.	0.00 1.00	Requirements not met All requirements met	NFPA, OSHA, AAFQCO Manual

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
C2	Security							
C2.1	Initiatives to improve security	O&P, B, TF	P&D C O&M	Initiatives to improve rates of security-related incidents.	Efficiency of programs for monitoring rates of security-related incidents.	0.00	Risks have not been assessed and performance is/will not be monitored	JIG HSSE statistics
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
					Fence height (2 to 3 m)	0.00	Less than 2 meters	Security Recommended Practice of industry & Best industry practice.
						0.25	2.2 meters	
						0.50	2.5 meters	
						0.75	3.7 meters	
						1.00	3 meters	
					Number of gates	0.00	0 Gate	Security

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
					(2 – Entry & Exit – 1 Crash Gate)	0.25 0.50 0.75 1.00	Gates are Under construction 1 Gate 2 Gates 3 Gates	Recommended Practice of industry & Best industry practice.
					Day/night CCTV camera vision (100 meter / 1 camera)	0.00 0.25 0.50 0.75 1.00	More than 250meters 250 meters 200 meters 150 meters 100 meters	Security Recommended Practice of industry & Best industry practice.
					Number of security guards (Minimum 4 / Shift – 24 Hours Operations)	0.00 0.25 0.50 0.75 1.00	None 1 2 3 4	Security Recommended Practice of industry & Best industry practice.
					Number hours for patrolling (2 hours/1 Vehicle)	0.00 0.25 0.50 0.75 1.00	More than 4 hours 4 hours 3.5 hours 3 hours 2 hours	Security Recommended Practice of industry & Best industry practice.
C2.2	Security breach	O&P	P&D C O&M	Rates of security-related incidents.	Percentage of reduction in security incident rates, based on initiatives taken.	0.00 0.25 0.50 0.75 1.00	Reduction in security incident rates less than 20% Reduction in security incident rates 20%-40% Reduction in security incident rates 40%-60% Reduction in security incident rates 60%-80% No security incidents or reduction in incident rates > 80%	Report reduction in security incident rates, based on initiatives taken
C3	Community well-being and engagement							

#	Social Criteria	Relevance Scope	Phase	Description	Indicator	Standard of Measures		Reference
C3.1	Community awareness program for sustainability	O&P	P&D O&M	Identify opportunities to raise awareness of employees and stakeholders on sustainability (e.g., development of leaflets to inform stakeholders about good environmental practices, websites, social media, etc.).	Level of plans implementation to raise community awareness on sustainability.	0.00 0.25 0.50 0.75 1.00	No process, program or policy in place Limited process, program or policy in place to address issues Process, program or policy is well developed and reflects good practice from the industry Process, program or policy embedded in airport operations and reflects best practice from the industry Industry leading process, program or policy. Long term planning horizon	Airport cooperative Research Program, Airport Sustainability Practices
C3.2	Community complaints	O&P	C O&M	Target to have zero community complains related to sustainability issues (such as noise, pollution, spills, etc.).	Number of community complaints per year related to sustainability issues	0.00 0.50 1.00	2 or more 1 0	Industry best practices
C3.3	Community engagement program	O&P	P&D C O&M	Local community engagement, impact assessments and development programs.	Level of implementation for local community engagement, impact assessments and development programs (e.g., environmental impact assessments and ongoing monitoring; public disclosure of results of environmental and	0.00 0.25 0.50 0.75 1.00	No process, program or policy in place Limited process, program or policy in place to address issues Process, program or policy is well developed and reflects good practice from the industry Process, program or policy embedded in airport operations and reflects best practice from the industry Industry leading process, program or policy. Long term planning horizon	Sustainability Reporting Guidelines & Airport Operators Sector Supplement

#	Social Criteria	Relevance Scope	Phase	Description	Indicator	Standard of Measures		Reference
					social impact assessments; local community development programs based on local communities' needs; work councils, occupational health and safety committees and other employee representation bodies to deal with impacts).			
C3.4	Impacts of operations on local communities	O&P	C O&M	Any negative or potential impacts of operations on local communities.	Number of audit report gaps from environmental authorities as per (EPA).	0.00 0.25 0.50 0.75 1.00	More than 3 3 2 1 Zero	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
C3.5	Sustainability orientation of contractors	O&P	P&D C O&M	Engagement of contractors who use environmentally friendly practices and are sustainability-oriented.	Efficiency of contractor selection and placement process to include sustainability practices and initiatives among the selection/assessment criteria.	0.00 0.25 0.50 0.75 1.00	No process, program or policy in place Limited process, program or policy in place to address issues Process, program or policy is well developed and reflects good practice from the industry Process, program or policy embedded in airport operations and reflects best practice from the industry Industry leading process, program or policy. Long term planning horizon	Airport Cooperative Research Program, Airport Sustainability Practices
C3.6	Community Diversity	O&P	P&D	Identify areas to	Extent of staff	0.00	No process, program or policy	Airport

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
			C O&M	improve equal opportunities for all community.	selection and placement process to consider diversity among the criteria.		in place	cooperative Research Program, Airport Sustainability Practices
						0.25	Limited process, program or policy in place to address issues	
						0.50	Process, program or policy is well developed and reflects good practice from the industry	
						0.75	Process, program or policy embedded in airport operations and reflects best practice from the industry	
						1.00	Industry leading process, program or policy. Long term planning horizon	
C3.7	Employee well-being	O&P	P&D C O&M	The opportunities to improve the well-being of employee working at the facility.	Level of employee well-being initiatives and programs (e.g., sport facilities for staff, intercompany day nursery, all airport services can be used by employees, every staff member has internet access, planters and open green space, etc.).	0.00	No process, program or policy in place	Airport cooperative Research Program, Airport Sustainability Practices
						0.25	Limited process, program or policy in place to address issues	
						0.50	Process, program or policy is well developed and reflects good practice from the industry	
						0.75	Process, program or policy embedded in airport operations and reflects best practice from the industry	
						1.00	Industry leading process, program or policy. Long term planning horizon	
C3.8	Business continuity plan	O&P	P&D O&M	The minimum fuel storage requirements for the quantity of fuel that needs to be stored in airport tanks to cover any interruptions of supply chain.	Fulfillment of industry measures of having five peak days for jet fuel stored in the tanks.	0.00	Minimum storage quantity is less than 5 peak days	IATA Guidelines for Minimum Fuel storage requirements https://www.iata.org/policy/Documents/guidance-fuel-
						1.00	Minimum storage quantity is above 5 peak days	

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
								storage-may08.pdf
C3.9	Local materials	B, TF, O&P	P&D C O&M	The demand of local materials (manufactured, extracted, or recovered locally).	Percentage of local materials use.	0.00 0.25 0.50 0.75 1.00	0 Less than 15% 15% - 30% 30% - 50% 50% and more	Sustainable Airport Manual, Chicago Airport
C4	Employment							
C4.1	Employee hiring and turnover	O&P	P&D O&M	Rate of new employee hiring and employee turnover results in changes to the human and intellectual capital of the organization.	Extent of programs to monitor the rate of new employees hired and employees leaving employment during the reporting period.	0.00 0.25 0.50 0.75 1.00	No process, program or policy in place Limited process, program or policy in place to address issues Process, program or policy is well developed and reflects good practice from the industry Process, program or policy embedded in airport operations and reflects best practice from the industry Industry leading process, program or policy. Long term planning horizon	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
					Percentage of staff turnover per year	0.00 0.25 0.50 0.75 1.00	19% or above 18% 15% 12% 10% or less	US Survey 2013 & Industry Best Practice
C4.2	Staff localization	O&P	P&D C O&M	Measured against labor law minimum requirements to hire staff from local community.	Percentage of staff localization hired from local community.	0.00 0.25 0.50	Local staff is less than 30% of total staff Local staff is 30% - 40 of total staff Local staff is 40% -50 of total staff	http://www.emol.gov.sa/nitaqat/nitaqat.pdf

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
						0.75	Local staff is 50% -60 of total staff	
						1.00	Local staff is above 60% of total staff	
C5	Labor / management relations							
C5.1	Notices of changes in operations	O&P	P&D O&M	Minimum notice period(s) regarding significant operational changes, including whether it is specified in collective agreements.	Efficiency of programs to ensure minimum number of weeks notice provided to employees and their elected representatives prior to the implementation of significant operational changes that could substantially affect them.	0.00	No process, program or policy in place	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	Limited process, program or policy in place to address issues	
						0.50	Process, program or policy is well developed and reflects good practice from the industry	
						0.75	Process, program or policy embedded in airport operations and reflects best practice from the industry	
						1.00	Industry leading process, program or policy. Long term planning horizon	
C5.2	Hygiene standards	O&P	P&D O&M	Hygiene standards such providing milk to staff can have positive anti-tumor effect and reducing lung cancer.	Amount of provided milk for staff (ml/day)	0.00	Less than 250 ml	http://www.acsu.buffalo.edu/~andersh/research/milkcancer.asp
						0.25	250 to 500 ml	
						0.50	500 to 750 ml	
						0.75	750 ml to one liter	
						1.00	One liter or above	
C6	Education and training							
C6.1	Employee empowerment	O&P	P&D O&M	Maintaining and improving human capital through training that expands the knowledge base of employees.	Extent of programs to monitor the average number of hours of training per year per employee, by employee category.	0.00	No process, program or policy in place	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	Limited process, program or policy in place to address issues	
						0.50	Process, program or policy is well developed and reflects good practice from the industry	
						0.75	Process, program or policy embedded in airport operations and reflects best practice from	

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
							the industry	
						1.00	Industry leading process, program or policy. Long term planning horizon	
					Percentage of training plans implementation (planned vs. actual).	0.00	Less than 75%	Industry Best Practice
						0.25	75%	
						0.50	80%	
						0.75	85%	
						1.00	90%	
C6.2	Skill management of employees	O&P	P&D O&M	Programs for skill management and lifelong learning that support the continued employability of employees and assist them in managing career endings.	Existence of employee training or assistance programs to upgrade skills.	0.00	No process, program or policy in place	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	Limited process, program or policy in place to address issues	
						0.50	Process, program or policy is well developed and reflects good practice from the industry	
						0.75	Process, program or policy embedded in airport operations and reflects best practice from the industry	
						1.00	Industry leading process, program or policy. Long term planning horizon	
					Percentage of plans implementation to upgrade employee skills (planned vs. actual).	0.00	Less than 65%	Industry Best Practice
						0.25	65%	
						0.50	70%	
						0.75	75%	
						1.00	80% and more	
C6.3	Employees performance appraisal	O&P	P&D O&M	Employees' performance appraisal implementation and effectiveness toward achieving organization	Extent of programs in place for employees to receive a formal performance	0.00	No process, program or policy in place	Sustainability Reporting Guidelines & Airport Operators
						0.25	Limited process, program or policy in place to address issues	
						0.50	Process, program or policy is	

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
				targets.	appraisal and review.		well developed and reflects good practice from the industry	Sector Supplement
						0.75	Process, program or policy embedded in airport operations and reflects best practice from the industry	
						1.00	Industry leading process, program or policy. Long term planning horizon	
					Percentage of achieving agreed targets.	0.00	Less than 70%	Industry Best Practice
						0.25	70%	
						0.50	80%	
						0.75	90%	
						1.00	100%	
C6.4	On-job training	O&P	P&D O&M	Implementation and efficiency of on-job training programs for teaching employees to complete the key activities needed for their job after hiring.	Percentage of on-job training programs of the total manpower.	0.00	On job training is below 12%	http://portal.mol.gov.sa/Sites/defauliter.aspx
						0.25	On job training is between 12 and 13%	
						0.50	On job training is between 13 and 14%	
						0.75	On job training is between 14 and 15%	
						1.00	On job training is above 15%	
C6.5	Sustainability research and development	O&P	P&D O&M	Initiatives for sustainability researches and development to improve existing environmental, social and economic practices.	Existence of program implementation for sustainability research and development.	0.00	No process, program or policy in place	Airport cooperative Research Program, Airport Sustainability Practices
						0.25	Limited process, program or policy in place to address issues	
						0.50	Process, program or policy is well developed and reflects good practice from the industry	
						0.75	Process, program or policy embedded in airport operations and reflects best practice from the industry	

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
						1.00	Industry leading process, program or policy. Long term planning horizon	
C7	Quality of services							
C7.1	Improve customer satisfaction	O&P	P&D O&M	Adoption of initiatives related to customer satisfaction, including results of surveys measuring customer satisfaction.	Level of program implementation to monitor the customer's satisfaction results or key conclusions of surveys (based on statistically relevant sample sizes).	0.00	Risks have not been assessed and performance is/will not be monitored	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
						0.25	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	
						0.50	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	
						0.75	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization.	
						1.00	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	
					Number of customer appreciations	0.00	0	Sustainability Reporting Guidelines & Airport Operators Sector
						0.50	1	
						1.00	2 or more	

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
								Supplement
C7.2	Sustainable employee transportation	O&P	P&D O&M	Implementation and efficiency of practices related to sustainable transportation (i.e. support public transports for employees, enhance cyclist access and facilities for employees, side roads).	Efficiency of airport initiatives for supporting sustainable transportation.	0.00 0.25 0.50 0.75 1.00	Issue not on radar screen, relevancy to the organization undetermined. No budget allocation for activity Problems identified. Stakeholders take the lead in raising issue. Limited budget allocation for managing issue Some awareness of issue inside organization. Policy or program is communicated and enforced. Funding allocation to manage issue established on annual basis Strong internal awareness, recognition and understanding of issues. Investment deemed a priority Feedback loops in place, continuous surveying of stakeholders. Performance goals incentivized.	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
C7.3	Employee satisfaction	O&P	P&D O&M	Adoption of employee satisfaction practices.	Quality of initiatives to improve employee satisfaction by the quality of services.	0.00 0.25 0.50	Issue not on radar screen, relevancy to the organization undetermined. No budget allocation for activity. Problems identified. Stakeholders take the lead in raising issue. Limited budget allocation for managing issue. Some awareness of issue inside organization. Policy or program is communicated and enforced. Funding allocation to manage issue established on annual basis.	Sustainability Reporting Guidelines & Airport Operators Sector Supplement

#	Social Criteria	Relevance Scope	Phase	Description	Indicator	Standard of Measures		Reference
						0.75	Strong internal awareness, recognition and understanding of issues. Investment deemed a priority.	
						1.00	Feedback loops in place, continuous surveying of stakeholders. Performance goals incentivized.	
					Percentage of employee satisfaction by the quality of services based on HR surveys.	0.00 0.25 0.50 0.75 1.00	Less than 10% 10%-25% 25%-40% 40%-55% More than 55%	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
C8	Regulatory compliance							
C8.1	Anti-competitive behavior	O&P	P&D O&M	Assessing the commitment toward anti-competitive behavior, anti-trust, and monopoly practices.	Number of occurrences of legal actions for anticompetitive behavior, anti-trust, and/or monopoly practices.	0.00 1.00	Has occurred at least once No occurrences	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
				Adoption of anti-corruption policies and procedures trainings for employees within the organization.	Existence of anti-corruption policies and procedures trainings for employees.	0.00 1.00	No training in place Training in place	Sustainability Reporting Guidelines & Airport Operators Sector Supplement
C9	Cultural heritage							
C9.1	Financial contributions to cultural institutions	O&P	P&D O&M	Participation in initiatives for financial support contributions (donations,	Level of program for financial support contributions	0.00 0.25	No process, program or policy in place Limited process, program or policy in place to address issues	Sustainability Reporting Guidelines & Airport

#	Social Criteria	Relevance Scope	Phase	Description	Indicator		Standard of Measures	Reference
				sponsorships, etc.) to cultural-related institutions.	(donations, sponsorships, etc.) to cultural-related institutions.	0.50	Process, program or policy is well developed and reflects good practice from the industry	Operators Sector Supplement
						0.75	Process, program or policy embedded in airport operations and reflects best practice from the industry	
						1.00	Industry leading process, program or policy. Long term planning horizon	

Appendix G: Ethics Approvals

UNIVERSITY OF MANITOBA | Research Ethics and Compliance
Office of the Vice-President (Research and International)

Human Ethics
208-194 Dafoe Road
Winnipeg, MB
Canada R3T 2N2
Phone +204-474-7122
Fax +204-269-7173

APPROVAL CERTIFICATE

May 19, 2016

TO:	**Azzam Qari** Principal Investigator	**(Supervisor: Nora El Gohary)**
FROM:	**Zana Lutfiyya, Chair** Education/Nursing Research Ethics Board (ENREB)	
Re:	**Protocol #E2016:055 (HS19700)** **"Stakeholder-Centered Sustainability Assessment of Airport Project in the GCC Countries"**	

Please be advised that your above-referenced protocol has received human ethics approval by the **Education/Nursing Research Ethics Board**, which is organized and operates according to the Tri-Council Policy Statement (2). **This approval is valid for one year only and will expire on May 19, 2017.**

Any significant changes of the protocol and/or informed consent form should be reported to the Human Ethics Secretariat in advance of implementation of such changes.

Please note:

- **If you have funds pending human ethics approval, please mail/e-mail/fax (261-0325) a copy of this Approval (identifying the related UM Project Number) to the Research Grants Officer in ORS in order to initiate fund setup. (How to find your UM Project Number: http://umanitoba.ca/research/ors/mrt-faq.html#pr0)**

- **If you have received multi-year funding for this research, responsibility lies with you to apply for and obtain Renewal Approval at the expiry of the initial one-year approval; otherwise the account will be locked.**

The Research Quality Management Office may request to review research documentation from this project to demonstrate compliance with this approved protocol and the University of Manitoba *Ethics of Research Involving Humans.*

The Research Ethics Board requests a final report for your study (available at: http://umanitoba.ca/research/orec/ethics/human_ethics_REB_forms_guidelines.html) **in order to be in compliance with Tri-Council Guidelines.**

umanitoba.ca/research

UNIVERSITY OF MANITOBA | Research Ethics and Compliance

Human Ethics
208-194 Dafoe Road
Winnipeg, MB
Canada R3T 2N2
Phone +204-474-7122
Email: humanethics@umanitoba.ca

RENEWAL APPROVAL

Date: May 15, 2017

New Expiry: May 19, 2018

TO: **Azzam Qari** (Advisor: N. El Gohary)
Principal Investigator

FROM: **Zana Lutfiyya, Chair**
Education/Nursing Research Ethics Board (ENREB)

Re: **Protocol #E2016:055 (HS19700)**
"Stakeholder-Centered Sustainability Assessment of Airport Project in the GCC Countries"

Education/Nursing Research Ethics Board (ENREB) has reviewed and renewed the above research. ENREB is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans.*

This approval is subject to the following conditions:

1. Any modification to the research must be submitted to ENREB for approval before implementation.
2. Any deviations to the research or adverse events must be submitted to ENREB as soon as possible.
3. This renewal is valid for one year only and a Renewal Request must be submitted and approved by the above expiry date.
4. A Study Closure form must be submitted to ENREB when the research is complete or terminated.

Funded Protocols:

- **Please mail/e-mail a copy of this Renewal Approval, identifying the related UM Project Number, to the Research Grants Officer in ORS.**

Research Ethics and Compliance is a part of the Office of the Vice-President (Research and International)
umanitoba.ca/research

Appendix H: Email Draft for Participation for Expert Interview

Subject: Participation at research project – Expert Interview

Dear ……

As a part of my PhD research, your participation at an expert interview session would be greatly appreciated. The session will be around one hour. I will present an overview of the project (around 20 minutes) and then a questionnaire will be requested to be filled (it will take you an approximate of 40 minutes).

The main objective of this research project is to develop a sustainability assessment model for airport fuelling system projects. The assessment model consists of different main criteria and sub-criteria to assess the sustainability of any potential airport fueling system project. You will review lists of sustainability assessment criteria, rank and rate them based on your best knowledge. The ranking and rating shall consider the whole life of the project (i.e., design, construction, operation and maintenance, etc.). A detailed introduction and instructions will be provided to the participant in a separate sheet. The researcher will analyze the participants' feedback in order to develop the final set of sustainability assessment criteria. The proposed final model will benefit all potential stakeholders in selecting the most sustainable airport fuel system project.

You have been selected as a participant based on your background and knowledge. Participation is completely voluntary. You will have the right to withdraw from the participation at any time without any negative consequences by telling me directly or sending an email. Your personal details and contact information will not be shared with public. Your feedback will be stored with the researcher only and will be used for statistical analyses by the researcher only. It will be used to improve the selection of the final sustainability assessment criteria and the way of measuring them.

Appreciate your kind feedback if you are interested to get more details about the participation and to provide you with more details about the project.

Looking forward to hearing back from you.

Best Regards,

Azzam Qari

Appendix J: Consent Form for Expert Interview

UNIVERSITY OF MANITOBA

Faculty of Engineering
Department of Civil Engineering

Engineering Building
15 Gillson Street
Winnipeg, Manitoba
Canada R3T 5V6
Tel (204) 474-8212/9220
Fax (204) 474-7513

Research Project Title: Stakeholder-Centred Sustainability Assessment of Airport Fuelling Projects

Principal Investigator and contact information: Azzam Qari, umqari@myumanitoba.ca

Research Supervisor and contact information: Dr. N. El-Gohary, gohary@illinois.edu

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The main objective of this research is to develop a sustainability assessment model for airport fuelling system projects. The assessment model consists of different main criteria and sub-criteria to assess the sustainability of any potential airport fuelling system project. The researcher has selected you as a participant based on your background and knowledge, mainly as part of potential airport fuelling system stakeholders (fuel operator, contractor, consultant, airport authority, airline representative, etc.).

You will review lists of sustainability assessment criteria, and rank and rate them based on your best knowledge. The ranking and rating shall consider the whole life of the project (design, construction, operation and maintenance, etc.). In addition, you will have the chance to recommend deleting, adding, or modifying any of the mentioned criteria and/or the method of measuring them (a detailed introduction and instructions will be provided to the participant in a separate sheet). The participant will need an average of 40 minutes to fill out the required hard copy form.

The researcher will analyze the participants' feedback to develop the final set of sustainability assessment criteria. The proposed final model will benefit all potential stakeholders in selecting the most sustainable airport fuel system project.

1/2

Your personal details and contact information will not be shared with the public and will be stored separately in locked drawer. All personal data and contact information will be destroyed by shredding by January 2017. Your feedback will be stored with the researcher used for statistical analyses only by the researcher. The analyses will be used to improve the selection of the final sustainability assessment criteria and the way of measuring the data as part of a PhD thesis and in potential publications.

You have the right to withdraw from the participation at any time without any negative consequences by contacting the researcher directly or sending an email. The researcher will provide the participant with a brief summary of the survey results by October 2016 by email (based on your preference).

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.

This research has been approved by the Education/Nursing Research Ethics Board. If you have any concerns or complaints about this project you may contact any of the above-named persons or the Human Ethics Coordinator at 204-474-7122 email: humanethics@umanitoba.ca. A copy of this consent form has been given to you to keep for your records and reference.

Participant's Name : ________________ Signature: ____________ Date: _________

☐ I would like to receive a summary of the results of this study by ☐ email ☐ other, by _______

Researcher's Signature _______________________________________ Date ___________

Appendix K: Evaluation Interview Survey

Introduction

1. Purpose of the Survey

This survey is intended to validate an assessment tool for supporting sustainable development of airport projects. Expert feedback is important for the validation of the assessment tool.

2. Instructions

A. Provide your information

The participants' feedback and personal information will be used for research purposes and will be kept with the researcher only. No personal information will be used or shared with other parties.

The researcher will use the personal information to communicate with the participants in case of any additional clarifications or feedback only.

B. Rank the 3 sustainability factors

Step 1 Define which sustainability factors you feel are the most important to consider throughout the whole life of the airport.

In the "SustFactors" tab, Rank the three sustainability factors (i.e. Environmental, Economic, Social) in the order of importance, with rank position one denoting the most important to consider and last place (3rd) denoting the least important.

C. Rank and Rate Sustainability criteria for Environmental - Economic - Social Sustainability

Step 1 For the 4 tables included in each of the three tabs: "Environmental", "Economic", and "Social", fill in the information as explained below.

The objective is to validate the proposed set of environmental, economic and social primary and secondary criteria, along with the proposed standards of measure (for secondary criteria)

Step 2 THE FOLLOWING SEQUENCE SHALL BE FOLLOWED IN ORDER TO COMPLETE THIS PART:

1. Read the description of the primary criteria, 2. Then, read carefully the description of the associated secondary criteria AND the proposed standard of measure

The above steps are essential in order to understand the scope and the objective of the criteria, BEFORE you rank and rate them as described below.

Seek additional information or clarifications, if need to before you start.

THE SEQUENCE SHOULD BE: READ-UNDERSTAND-CLARIFY (if needed)-RANK-RATE

Step 3 In Table 1, Rank the proposed primary criteria in the order of importance, with rank position 1 denoting the most important and last rank position the least important to characterize assessing the environmental or economic or social factor for airport projects.

Rank each criterion with a unique rank number, e.g. if the proposed list includes 9 criteria in total, assign a unique number in the (1-9) range to each criterion

Step 4 In Table 2, add any additional primary criteria - if you consider important for assessing the sustainability of airports - list them in the order of increased importance

Step 5 In Table 3: For each of the primary and secondary criteria listed, define whether to keep, remove or modify them (in the latter case, suggest modification). You may also select "Do not know" if needed

Step 6 Then, for those to keep, rate them individually on the 1-5 Likert scale shown below:

1: Very Important; 2: Important; 3: Moderately Important; 4: Slightly Important; 5: Not Important

Step 7 In Table 3: Assess the displayed "standard of measure" for each secondary criterion, and define whether to keep, remove or modify them (in the latter case, suggest modification)

Step 8 In Table 4, add any additional secondary criteria - if you consider important for assessing the sustainability of airports - list them in the order of increased importance.

Quote the primary criterion number (e.g. A1), with which the additional secondary criteria are associated with

D. Answer overall evaluation questions

Answer the evaluation questions that cover the overall categorization

Participant Information

Please provide the following information:

Name:	
Title/Position:	
Field:	
Years of Experience:	
Phone:	
E-mail:	

Survey date: / /

Ranking of sustainability factors

	Sustainability factors	Rank (1-3)
1	Environmental	
2	Economic	
3	Social	

Use each ranking number only once

Ranking scale:

1: Most important to consider throughout the whole life of the project

3: Least important to consider throughout the whole life of the project

ENVIRONMENTAL SUSTAINABILITY

Validate the proposed set of criteria

1. Rank the primary criteria in the order of importance

2. Propose additional primary criteria which you may consider important to include for the sustainability assessment

Rank the proposed primary criteria in the order of importance		Rank primary criteria (1-9)	Propose additional primary criteria - If you consider important for sustainability - in the order of increased importance	
#	Primary criterion		#	Additional Primary criterion
A1	Administrative procedures		A10	
A2	Water efficiency		A11	
A3	Indoor environmental quality		A12	
A4	Energy		A13	
A5	Emissions		A14	
A6	Waste		A15	
A7	Land Use & Biodiversity		A16	
A8	Expenditures		A17	
A9	Noise		A18	

Use each rank number only once

3. (i) Rate all proposed criteria using the 1-5 Likert scale and (ii) Validate the standard of measure of secondary criteria

Likert scale

1: Very Important; 2: Important; 3: Moderately Important; 4: Slightly Important; 5: Not Important

#	Sustainability criteria	Keep?	Rate (1-5)	Standard of measure	Standard of measure OK?
A1	Administrative procedures	Keep			
A1.1	Cooperative Sustainability Policy			Report if Corporate sustainability policy is in place	
A1.2	Sustainable Procurement Policy			Report if Sustainable procurement policy in place	
A1.3	Green Procurement Policy			Refer to SAM Appendix AP-A (see last tab) – Green Product Listing for products and their minimum required content levels. Points for this credit will be awarded based on the number of green products, as defined in Appendix AP-A, procured for general day-to-day office use.	
A1.4	Use of renewable materials			Report whether there is a program in place to monitor percentage of recycled input materials used	
				The percentage of paper recycled content is calculated as follows; % = (weight of chlorine-free paper/total weight of the paper)- % post-consumer recycled content	
				Percentage of recycled input materials used, using the formula: (Total recycled input materials used/Input materials used) x 100	
A1.5	Recycle used materials			Report if there is a program in place to monitor the percentage of (recyclable) materials recycled	
				Percentage of (recyclable) materials recycled, using the formula: (Total used materials recycled /Total used recyclable materials) x 100	

4. Propose new additional secondary criteria which you may consider important to include for the sustainability assessment

Propose additional secondary criteria - If you consider important for sustainability - in the order of increased importance	
Associated Primary criterion #	Additional Secondary criterion
e.g. A1	

#	Sustainability criteria	Keep?	Rate (1-5)	Standard of measure	Standard of measure OK?
A1.6	Environmental impact assessment (EIA) study			The requirement is one study for the whole project and this study should be updated if there is any additional facility or upgrading to the project.	
A1.7	Environmental Certificate			Obtain environmental certificates from local (i.e. PME) or international organizations (i.e. LEED, ISO 14001) expressed the company's interest in saving the environment (the law of PME requires an environmental license for companies in petroleum sector)	
A2	Water efficiency	Keep			
A2.1	Wastewater generation			Report initiatives to minimize the amount of pollutants and chemicals entering waste water (e.g. vehicle washing monitoring programs)	
				Report the percentage calculates as follow: % = (total amount of current wastewater / total amount of previous wastewater) × 100	
A2.2	Water withdrawal			Implement water use reduction programmes and report annual reduction achieved	
				The percentage of water withdrawal production calculates as follow: % = (the total amount of current water use / total amount of previous water use) × 100	
A2.3	Storm water management system			Implement storm water management programmes	
				Measure the quality of storm water in accordance with the applicable regulatory standards	
A2.4	Recycle/reuse water			Implement reuse/recycled water programmes and report annual reduction achieved	
				Total volume of water recycled/reused by the operation in cubic meters per year (%)	
A2.5	Landscaping water use			Identify water sources significantly affected by water withdrawal by the operation (i.e. Withdrawals that account for an average of 5% or more of the annual average volume of the local water body)	
A2.6	Water use reduction			Water saving percentage	
A3	Indoor environmental quality	Keep			
A3.1	Indoor ventilation and Air Quality			Report if ventilation systems have been designed using the Ventilation Rate Procedure or the applicable local code, whichever is more stringent	
				Increase outdoor air ventilation rates for all air-handling units serving occupied spaces by at least 30% above the minimum required by ASHRAE Standard 62.1-2007	
				Report if one of the two options mentioned below have been implemented: A. Modify or maintain each outside air intake, supply air fan, and/or ventilation distribution system to supply at least the outdoor air ventilation rate required by ASHRAE 62.1—2010 under all normal operating conditions, OR B. Modify or maintain the system to supply at least ten cubic feet per minute (cfm) of outdoor air per person under all normal operating conditions.	
A4	Energy	Keep			
A4.1	Energy savings from operation of pumps			Report the initiatives for energy savings due to conservation and efficiency improvements	

Propose additional secondary criteria - If you consider important for sustainability - in the order of increased importance	

#	Sustainability criteria	Keep?	Rate (1-5)	Standard of measure	Standard of measure OK?
[illegible]	Energy savings from operation of pumps			Report the electricity consumption savings* in %, as a result of the energy saving initiatives	
A4.2	Energy savings from operation of buildings			Report the initiatives for energy savings due to conservation and efficiency improvements	
				Report the electricity consumption savings* in %, as a result of the energy saving initiatives	
A4.3	Use of Renewable Energy			Report the utilization of renewable energy for on-site activities	
				Report the utilization of renewable energy for off-site activities	
A4.4	Vehicle fuel savings			Report the initiatives for motor vehicle fuel savings due to utilization of green (LNG/Electric) vehicles and implementation of alternative driving routes	
				Report the fuel consumption savings* in %, as a result of the fuel saving initiatives	
A5	Emissions	Keep			
A5.1	Reduction in VOC emissions			Report the initiatives to monitor VOC emissions by weight	
				Report the VOC reduction* in %, as a result of the VOC monitoring and reduction initiatives	
A5.2	Vehicle exhaust (GHG) emissions during movement/idling			Report the initiatives to monitor VOC and Greenhouse gases (GHG) emissions by weight and whether the location has considered a plan to optimize routes and idling times	
				Report the CO2 reduction* in %, as a result of the CO2 monitoring and reduction initiatives	
A5.3	Utilization of environmentally friendly vehicles			Report the initiatives to utilize 'green' or 'clean' vehicles (liquefied petroleum gas or electric) as a means to reduce VOC and Greenhouse Gases (GHG) emissions from vehicles' exhausts	
A5.4	Reduce GHG emissions associated with energy consumption			Report the initiatives to monitor VOC and GHG emissions by weight by kwWhr of electricity consumption	
				Report the CO2 reduction in %, as a result of the CO2 monitoring and reduction initiatives	
A6	Waste	Keep			
A6.1	Reduce Hazardous Wastes produced from ad-hoc activities (e.g. commissioning procedures) and spills			Report the initiatives to monitor and reduce hazardous wastes produced by type and by weight	
				Report the % of hazardous wastes reduced* by implementing specific initiatives	
A6.2	Reduce Hazardous Wastes produced from routine operation and maintenance			Report the initiatives to monitor and reduce hazardous wastes produced by type and by weight	
				Report the % of hazardous wastes reduced* by implementing specific initiatives	
A6.3	Reduce Non Hazardous Wastes produced from routine operation and maintenance			Report the initiatives to monitor and reduce non-hazardous wastes produced by type and by weight	
				Report the % of non-hazardous wastes reduced* by implementing specific initiatives	
A6.4	Pollution of land / waterways			Report the initiatives to monitor uncontained spills into the ground / waterways	
A7	Land Use & Biodiversity	Keep			
A7.1	Efficiency of land use			Report the availability of unoccupied land adjacent to the facilities	

Propose additional secondary criteria - If you consider important for sustainability - in the order of increased importance

#	Sustainability criteria	Keep?	Rate (1-5)	Standard of measure	Standard of measure OK?
A7.2	Impact of location and size of land used for operations in biodiversity			Report the initiatives to monitor significant direct and indirect positive and negative impacts with reference to the following: • Species affected; • Extent of areas impacted; • Duration of impacts; and • Reversibility or irreversibility of the impacts.	
A7.3	Impact of activities in biodiversity			Report the initiatives to monitor significant direct and indirect positive and negative impacts with reference to the following: • Species affected; • Extent of areas impacted; • Duration of impacts; and • Reversibility or irreversibility of the impacts.	
A8	Expenditures	Keep			
A8.1	Initiatives to monitor Environmental mitigation and protection expenditures			Report process to establish targets and monitor the monetary value of waste disposal, emissions treatment, and remediation costs related to the following items: • Treatment and disposal of waste; • Treatment of emissions (e.g. expenditures for filters, agents); • Expenditures for the purchase and use of emissions certificates; • Depreciation of related equipment, maintenance, and operating material and services, and related personnel costs; Insurance for environmental liability; and • Clean-up costs, including costs for remediation of spills	
A9	Noise	Keep			
A9.1	Noise pollution			Report initiatives to monitor noise levels from machinery and equipment used at airport fuel operation facilities (e.g. power generators, air-powered tools, fire fighting pumps etc.) against noise targets or limits applicable to the airport	

Propose additional secondary criteria - If you consider important for sustainability - in the order of increased importance

* data collected under the first performance review will become the baseline for each subsequent review.

0

ECONOMIC SUSTAINABILITY

Validate the proposed set of criteria

1. Rank the primary criteria in the order of importance

Rank the proposed primary criteria in the order of importance		Rank primary criteria (1-4)
#	Primary criterion	
B1	Economic performance analysis	
B2	Economic value retained	
B3	Market presence	
B4	Indirect economic impacts	

Use each rank number only once

2. Propose additional primary criteria which you may consider important to include for the sustainability assessment

Propose additional primary criteria - if you consider it necessary - in the order of increased importance	
#	Additional Primary criterion
B5	
B6	
B7	
B8	

3. (i) Rate all proposed criteria using the 1-5 Likert scale and (ii) Validate the standard of measure of secondary criteria

Likert scale

1: Very Important; 2: Important; 3: Moderately Important; 4: Slightly Important; 5: Not Important

#	Sustainability criteria	Keep?	Rate (1-5)	Standard of measure	Standard of measure OK?
B1	Economic performance analysis	Keep			
B1.1	Life-cycle cost analysis			Report whether project has been subjected to a life-cycle cost analysis/assessment before commencement	
B1.2	Assessment of Capital projects			Report whether capital projects have been subjected to analysis to predict operating and maintenance costs	
B1.3	Land and property value			Report whether land and property value has been assessed	
B1.4	Capital to sales ratio			Report capex to sales ratio (%)	
B1.5	Operating Expenses to Sales			Energy Average Expenses as a Percentage of Sales	
B1.6	Operating Expenses Effiency Control			Annual monetary agency inflation	
B1.7	Maintenance to Assets cost			Measured against maintenance functional benchmark (3%)	
B1.8	Working Capital To Sales			Assessed against the industry average ratio benchmark . Benchmarked against Saudi Ground services	
B2	Economic value retained	Keep			
B2.1	Direct economic value generated			Report programs in place to monitor direct economic value generated including revenues vs financial targets Note: Finance, treasury, or accounting departments should have the information required by this Indicator.	
B2.2	Economic value retained			Report programs in place to monitor Economic value generated and retained (Investments, equity release etc.) vs financial targets Note: Finance, treasury, or accounting departments should have the information required by this Indicator.	
B2.3	Net Present Value (NPV)			Project NPV	
B2.4	Pay back Period			Average pay back period	
B2.5	Return on Assets (ROA)			Measured against five years average of ROA of oil sector (8.1%)	

4. Propose new additional secondary criteria which you may cc

Propose additional secondary criteria - if you consider it necessary - in the order of increased importance	
Associated Primary criterion #	Additional Secondary criterion
e.g. B1	

#	Sustainability criteria	Keep?	Rate (1-5)	Standard of measure	Standard of measure OK?
B2.6	Financial implications due to emissions of pollutants and climate change substances			Report whether there are programs in place for the quantitatively estimations of the financial implications of climate change for the organization (e.g., cost of offsetting CO2 emissions or VOC emissions)	
B3	Market presence	Keep			
B3.1	Marketabtablitiy			Annual growth in Gross domestic product (GDP)	
B3.2	Standard entry level wage ratio			Report the organization's entry wage to the local minimum entry wage	
B3.3	Employment opportunity			Report the organization's plans to generate employment opportunities	
B3.4	Affordability			Report whether there is a process in place which uses a sustainability matrix to assess affordability	
B3.5	Long term plan			Report whether there is a long term business plan in place which uses a sustainability matrix to assess possible projects	
B4	Indirect Economic impacts	Keep			
B4.1	Indirect Economic impacts			Report indirect economic impacts and their significance in the context of external benchmarks and stakeholder priorities, such as national and international standards, protocols, and policy agendas	
B4.2	Non-monetary benefits			Report whether annual objectives and targets include quantification of nonmonetary benefits	
B4.3	Finance Leverage			Debt to Equity (DOE)	

* data collected under the first performance review will become the baseliew for each subsequent review.

Propose additional secondary criteria - if you consider it necessary - in the order of increased importance

0

SOCIAL SUSTAINABILITY

Validate the proposed set of criteria

1. Rank the primary criteria in the order of importance

2. Propose additional primary criteria which you may consider important to include for the sustainability assessment

Rank the proposed primary criteria in the order of importance		Rank primary criteria (1-9)	Propose additional primary criteria - if you consider it necessary - in the order of increased importance	
#	Primary criterion		#	Additional Primary criterion
C1	Occupational Health and Safety		C10	
C2	Security		C11	
C3	Community wellbeing and engagement		C12	
C4	Employment		C13	
C5	Labor / Management relations		C14	
C6	Education and Training		C15	
C7	Quality of services		C16	
C8	Regulatory compliance		C17	
C9	Cultural heritage		C18	

Use each rank number only once

3. (i) Rate all proposed criteria using the 1-5 Likert scale and (ii) Validate the standard of measure of secondary criteria

Likert scale

1: Very Important; 2: Important; 3: Moderately Important; 4: Slightly Important; 5: Not Important

#	Sustainability criteria	Keep?	Rate (1-5)	Standard of measure	Standard of measure OK?
C1	Occupational Health and Safety	Keep			
C1.1	Representation in HSSE committees			Report whether workforce is represented in formal joint management-worker health and safety committees	
				Internal HSSE Audit - 1 Year External HSSE Audit - 1 / 3 years Safety Walk by Mangement - 2 / Year Safety Meetings- 12/ Year Safety bulletin - 4/ Year KPI (HSSE) - Compilation - 4/ Year Minimum acceptable limit- 85% of Planned Vs. Actual.	
C1.2	Reduce Work-related injuries and fatalities			Report programs for monitoring and reducing rates of injury and total number of work-related fatalities	
				Goal is - ZERO Incident 2 minor incident / year is acceptable.	
C1.3	Work-related injuries and fatalities			Report reduction* in work-related injuries and fatalities	
				Number of Potential incidents reported, Annual HSSE Plan activities, Annual HSSE Plan investments, implementation of HSSE audit recommendations and implementation of HSSE Remedial Action Plan	

4. Propose new additional secondary criteria which you may consider important to include for the sustainability assessment

Propose additional secondary criteria - if you consider it necessary - in the order of increased importance	
Associated Primary criterion #	Additional Secondary criterion
e.g. C1	

#	Sustainability criteria	Keep?	Rate (1-5)	Standard of measure	Standard of measure OK?
C1.4	Eliminate occupational diseases, lost days, and absenteeism			Report programs for monitoring and reducing rates of occupational diseases, lost days, and absenteeism	
				Report absenteeism (%) dues to occupational diseases Absenteeism = 5 days/ year/ employee Sick leave= 8 days/year/emplyee	
C1.5	Health and Safety awareness and prevention			Report the programs related to assisting workforce members, their families, or community members regarding serious diseases	
C1.6	Education enhancement on HSSSE awareness			Education enhancement: Trainings: HSSE Policies: Smith Defense Drive Use PPE as required Minimum Acceptable Limit: 80%	
C1.7	Health and Safety covered in formal agreements with trade unions			Report whether there is a program in place to review whether formal agreements (either local or global) with trade unions cover health and safety.	
				Acceptable limit 100%.	
C1.8	Fuelling Vehicles - Tests of safety devices			Report whether the Weekly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded e.g. interlock function, Bonding wire, Elevating platform lowering , Elevating platform wand sensors	
				Report whether the Monthly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded e.g. Deadman, Fueller high level cut-off devices , Engine emergency stop switches	
				Report whether the Quarterly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded	
				Report whether the Semi-Annual, Annual and less frequent checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded	
C1.9	Fuelling Vehicles - safety equipment			Report whether the min required safety equipment have been considered / are in place: Fire extinguishers: 2x9 kg/vechicle Spill kit: 50 Ltr/vechicle Cones: 3/vechicle First aid box: 1 box/vechicle	
				Report whether the Weekly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded, e.g. bonding wires	

Propose additional secondary criteria - if you consider it necessary - in the order of increased importance	

#	Sustainability criteria	Keep?	Rate (1-5)	Standard of measure	Standard of measure OK?
C1.10	Fuel Storage - Tests of safety devices			Report whether the Monthly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded, e.g. Hydrant Emergency Shut-Down buttons	
				Report whether the Quarterly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded, e.g. safe procedures for entry in Valve chambers	
				Report whether the Semi-Annual, Annual and less frequent checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded, e.g. tank cleaning every 3-5 y, cathodic protection yearly	
C1.11	Fuel storage - safety equipment			Report whether the min required safety equipment have been considered / are in place: Fire extinguishers: Every 20m/ 10kg ; Spill kit: 2 X 120 ltr; Sprinkler system: every 1.5 m /1 nozzle; Fire Alarm syst. each 45 m/per unit; First aid box: 1 box / 3 - 4 min	
C1.12	Personal Protective Equipment (PPE)			Report whether the min standards/specifications for PPEs have been considered / are in place: Eye Protection : •EN166 / UV Protection SPF 15+; Fire Resistant & Antistatic Shirts/ Trousers : •NFPA 2112, •ASTM D6413 ; Fire Resistant & Antistatic Workwear Overalls : •ASTM D6413 •EN470-1•EN11612; QC Gloves ,Hand Gloves : •EN:388 – BS:EN:374; High Visibility Vest : •EN 471:2003 class 3; Safety Helmets : •EN 397; Ear Muffs : •ANSI S3.19-1974; Safety boots : •EN 345:EN ISO20345:2004/20346 •EN ISO2034520347•Height of 13cm •Anti-slip •Shock Absorbent ----- Acceptable limit-100%	
C2	Security	Keep			
C2.1	Initiatives to improve Security			Report programs in place for monitoring rates of security-related incidents	
				Fence: Height 2 - 3 m	
				Gates: 2 – Entry & Exit – 1 Crash Gate	
				CCTV camera day/night vision : 100 meter / 1 camera	
				Security Guards: Minimum 4 / Shift – 24 Hours Operations	
				Patrolling: 2hrs /1 Vehicle El	
C2.2	Security breach			Report reduction* in security incident rates, based on initiatives taken	
C3	Community wellbeing and engagement	Keep			
C3.1	Community awareness program			Report whether operations have implemented plans to raise community awareness on sustainability	

Propose additional secondary criteria - if you consider it necessary - in the order of increased importance

#	Sustainability criteria	Keep?	Rate (1-5)	Standard of measure	Standard of measure OK?
C3.2	Complaints			Number of complaints per year	
C3.3	Community engagement program			Report whether operations have implemented local community engagement, impact assessments, and development programs (e.g. Environmental impact assessments and ongoing monitoring; Public disclosure of results of environmental and social impact assessments; Local community development programs based on local communities' needs; Works councils, occupational health and safety committees and other employee representation bodies to deal with impacts)	
C3.4	Community appreciation			Number of times an Appreciation from community members is raised per year	
C3.5	Impacts of operations on local communities			Report Operations and associated communities with significant potential or actual negative impacts	
				Audit report gaps from Enimomental Authorities as per (EPA) Acceptal limit gaps = Zero	
C3.6	Prevention and mitigation measures program			Report whether prevention and mitigation measures were implemented and achieved or not	
C3.7	Initiatives for community			Number of initiatives taken: Education: Scholarships Environmental: Awareness & Contribution for green products Charity events sponsorships Participation voluntary services by employee to community	
C3.8	Compensations to personnel			Report programs to provide compensations by project and average per person	
				Number of Compensations	
C3.9	Contractors with sustainability orientation			Report whether contractor selection and placement process includes sustainability among the selection/assessment criteria	
				Contractors record from previous projects, enhancement since then Audit reports Strenth Vs Gaps 2 Strenth = 1 Gap	
C3.10	Diversity			Report whether contractor selection and placement process has considered diversity among the criteria	
				Preparation of Vendor List - Ethical Contractors, Safety and qualified & experience staff	

Propose additional secondary criteria - if you consider it necessary - in the order of increased importance

#	Sustainability criteria	Keep?	Rate (1-5)	Standard of measure	Standard of measure OK?
C3.11	Employee wellbeing			Report whether employee wellbeing programs have been developed (e.g. Sport facilities for staff, intercompany day nursery, All airport services can be used by employees, Every staff member has internet access, Planters and open green space etc.)	
				Training, PPE, safety at work place, Motivation and employee emoluments. Staff turn over % per Year	
C3.12	Business Continuity Plan			Measured against industry standard of having 5 peak days for jet fuel stored in the tanks	
C3.13	Local materials			Percentage of local materials	
C4	Employment	Keep			
C4.1	Employee hires and turnover			Report whether there are programs in place to monitor the rate of new employee hires entering and employees leaving employment during the reporting period	
				Exit interview feedback, Root cause analysis of staff of resignation. ⓘ	
C4.2	Staff localization			Measured against labor law minimum requirements	
C5	Labor / Management Relations	Keep			
C5.1	Notices of changes in operations			Report whether there are programs in place to ensure minimum number of weeks notice typically provided to employees and their elected representatives prior to the implementation of significant operational changes that could substantially affect them.	
C5.2	Hygiene standards			Measured against probability of reducing lung cancer	
C6	Education and Training	Keep			
C6.1	Training per year per employee			Report whether there are programs to monitor the average number of hours of training per year per employee, by employee category	
				Planned Vs Actual % Acceptable 90%	
C6.2	Skill management of employees			Report whether there are employee training or assistance programs in place to upgrade skills	
				Acceptable limit 80%	
C6.3	Performance and career development			Report whether there are programs in place for employees to receive a formal performance appraisal and review	
				Limit 100%	
C6.4	On-Job-Training			Mesurd against labor law standard percentage (12% of total manpower)	
C6.5	Sustainability research and development			Report whether the location implements a sustainability research and development program	
C7	Quality of services	Keep			

Propose additional secondary criteria - if you consider it necessary - in the order of increased importance

#	Sustainability criteria	Keep?	Rate (1-5)	Standard of measure	Standard of measure OK?
C7.1	Eliminate customer complaints			Report whether there are programs in place to obtain and address customer complaints	
				Acceptable limit: 2 Complaints / Year	
				Total number of substantiated complaints raised per year, relatively to the total number of customers over the assessment period	
C7.2	Improve customer satisfaction			Report whether there are programs in place to monitor the satisfaction results or key conclusions of surveys (based on statistically relevant sample sizes) conducted in the reporting period that were related to information about: The organization as a whole; Quality of services	
				Number of Complaints Vs Appreciations : max 2	
C7.3	Sustainable transportation of employees			To what extent is the airport supporting sustainable transportation through initiatives	
				Measure of Employees Timely Attendance Acceptable 95% on time	
C7.4	Improve employee satisfaction			Initiatives to improve the extent at which the airport employees are satisfied by the quality of airport services	
				To what extent are the airport employees satisfied by the quality of airport services based on HR surveys	
C8	Regulatory Compliance	Keep			
C8.1	Anti-competitive behavior			Report the number of occurrences of legal actions for anticompetitive behavior, anti-trust, and monopoly practices	
C8.2	Fines for non compliances with regulations			Report monetary value of significant fines and sanctions for non-compliance with laws and regulations	
C9	Cultural heritage	Keep			
C9.1	Financial contributions to cultural institutions			Report whether there is a program in place for financial support contributions (donations, sponsorships, etc.) to cultural-related institutions	

Propose additional secondary criteria - if you consider it necessary - in the order of increased importance

* data collected under the first performance review will become the baseline for each subsequent review.

0

Overall Evaluation

Respond if you agree (Yes/No) with the following statements and rate the level of your agreement in the 1-5 Likert scale presented below:

Note: an Answer "No" in the Agreement (Yes/No) question will result in automatically rating the question as "1"

1: Strongly agree; 2: Agree; 3: Neither agree nor disagree; 4: Disagree; 5: Strongly disagree

#	Question	Agree (Yes/No)?	Rate (1-5)	Comments
1	The hierarchy of the sustainability criteria contains sufficient number of sustainability criteria that covers the domain of airport fueling projects			
2	The hierarchy of the sustainability criteria contains sufficient number of sustainability criteria that covers the domain of airport fueling projects			
3	The classification of the sustainable criteria is suitable and it is easy to locate certain criteria			
4	The classification of the sustainable criteria is flexible to expand and to include additional airport-specific sustainability criteria			
5	The hierarchy of the sustainability criteria have no redundancy			
6	The hierarchy of the sustainability criteria have no duplicate criteria			
7	The hierarchy of the sustainability criteria have no missing criteria			

Appendix L: Email Draft for Participation for Focus Group

Subject: Participation at research project – Focus Group

Dear ……

As a part of my PhD research, your participation at a focus group session would be greatly appreciated. The session will be around one hour. I will present an overview of the project (around 30 minutes) and then a questionnaire will be requested to be filled (it will take you an approximate of 40 minutes).

The main objective of this research project is to develop a sustainability assessment model for airport fuelling system projects. The model has been implemented on actual projects case studies with actual data and design parameters of different design alternatives. Based on the model outputs/results, it highlights a design alternative with the highest sustainability and the lowest emissions and energy impacts.The proposed final model will benefit all potential stakeholders in selecting the most sustainable airport fuel system project.

You have been selected as a participant based on your background and knowledge. Participation is completely voluntary. You will have the right to withdraw from the participation at any time without any negative consequences by telling me directly or sending an email. Your personal details and contact information will not be shared with public. Your feedback will be stored with the researcher only and will be used for statistical analyses by the researcher only. It will be used to improve the selection of the final sustainability assessment criteria and the way of measuring them.

Appreciate your kind feedback if you are interested to get more details about the participation and to provide you with more details about the project.

Looking forward to hearing back from you.

Best Regards,

Azzam Qari

Appendix M: Consent Form for Focus Group

UNIVERSITY OF MANITOBA | Faculty of Engineering
Department of Civil Engineering

Engineering Building
15 Gillson Street
Winnipeg, Manitoba
Canada R3T 5V6
Tel (204) 474-8212/9220
Fax (204) 474-7513

Research Project Title: Stakeholder-Centred Sustainability Assessment of Airport Fuelling Projects

Principal Investigator and contact information: Azzam Qari, umqari@myumanitoba.ca

Research Supervisor and contact information: Dr. N. El-Gohary, gohary@illinois.edu

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The researcher has selected you as a participant based on your background and knowledge, mainly as part of potential airport fuelling system stakeholders (fuel operator, contractor, consultant, airport authority, airline representative, etc.).

The main objective of this research is to develop a sustainability assessment model for airport fuelling system projects. It consists of two sub-models that are presented as domain-specific measures of emissions and energy consumption. They can be used to analyze airport aircraft fuelling service project alternatives. The analysis of different alternatives using the proposed quantitative sub-models would facilitate identifying the project alternative with the lowest emissions and energy impacts (economic, social and environmental).

The model has been implemented on specific project case studies with actual data and design parameters with different design alternatives. Based on the model output/results, it highlights a design alternative with the highest sustainability and lowest emissions and energy impacts.

A brief presentation (about 30 minutes) of the case studies and model implementation will be presented by the researcher. Then a detailed instruction sheet will be provided to you along with a survey form. You will evaluate the model based on its representation, ease to navigate, flexibility/expandability, usability, quality, applicability, coverage, etc. In addition to the 30-minute presentation, you will need an average of 40 minutes to fill out the required hard copy form.

1/2

The researcher will analyze the participants' feedback, opinions and recommendations to assess the model's applicability, conduct and required improvement. The proposed final model will benefit all potential stakeholders in selecting the most sustainable airport fuel system project.

Your personal details and contact information will not be shared with the public and will be stored separately in a locked drawer. All personal data and contact information will be destroyed by shredding by January 2017. Your feedback will be stored with the researcher and used for statistical analyses only by the researcher. The analyses will be used to improve the selection of the final sustainability assessment criteria and the way of using the data as part of a PhD thesis and in potential publications.

You have the right to withdraw from the participation at any time without any negative consequences by contacting the researcher directly or sending an email. The researcher will provide the participant with a brief summary of the survey results by October 2016 by email or mail (based on your preference).

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.

This research has been approved by the Education/Nursing Research Ethics Board. If you have any concerns or complaints about this project you may contact any of the above-named persons or the Human Ethics Coordinator at 204-474-7122 email: humanethics@umanitoba.ca. A copy of this consent form has been given to you to keep for your records and reference.

Participant's Name ______________________________ Signature _____________ Date _________

☐ I would like to receive a summary of the results of this study by ☐email ☐other, by _________

Researcher's Signature __________________________ Date ____________

Appendix N: Focus Group Survey

Instructions

Introduction

This survey intended to gather input from the experts on the evaluation of the fuel sustainability assessment model and sub-models for emissions and energy calculations

0. Familiarize with the sustainability assessment model and sub-models to be assessed

As the first step before responding to this survey, you should become familiar with the sustainability assessment model and sub-models to be assessed

Allocate time to review and utilize the tools as required, and ask for clarifications to the custodian of the tools if necessary, before responding to this survey

Note: Ensure that you use the latest version of the tools and sub-models.

A clear understanding of the contents and the functionality of the tools is required before an assessment can be made using this input sheet

A. Input on Model Evaluation

Step 0 There are 3 tables in the next sheet which require input, as detailed below. Before you start, review the contents of the tables and seek assistance/clarifications if necessary

Step 1 Respond if you agree (Yes/No) with the statements displayed in the tables

Step 2 Rate the level of your agreement with each of the statements displayed under the tables, using the 1-5 Likert scale presented below:

1: Strongly agree; 2: Agree; 3: Neither agree nor disagree; 4: Disagree; 5: Strongly disagree

Step 3 If necessary, provide comments or suggestions to support or justify your responses, per steps 1-2

Step 4 Follow steps 1-3 to provide in Tables B and C for the sub-models for emissions and energy, respectively

---

Rev 2 - March 2016

Input

Respond if you agree (Yes/No) with the following statements and rate the level of your agreement in the 1-5 Likert scale presented below:

Note: an Answer "No" in the Agreement (Yes/No) question will result in automatically rating the question as "1"

1: Strongly agree; 2: Agree; 3: Neither agree nor disagree; 4: Disagree; 5: Strongly disagree

Assessment of the airport fueling sustainability assessment model

#	Airport fuel sustainability assessment model	Agree (Yes/No)?	Rate (1-5)	Comments
A1	Representation			
A1.1	The proposed assessment tool contains sufficient number of criteria, so it can adequately represent the domain of sustainable airport fueling projects			
A2	Navigation			
A2.1	It is easy to locate certain sustainability criteria			
A2.2	It is easy to use the assessment tool (reading instruction and entering data)			
A3	Flexibility/Expandability			
A3.1	The classification of the sustainable criteria is flexible to expand and to include additional airport-specific sustainability criteria			
A4	Categorization			
A4.1	Do you agree with the categorization of the sustainability criteria?			
A5	Usability			
A5.1	The proposed assessment tool will be useful for airport fueling projects			
A5.2	The proposed assessment tool will be beneficial for assessing airport fueling project sustainability			
A6	Quality			
A6.1	The model output provides a sufficient indicator for project sustainability			

Assessment of the aircraft refuelling emissions-oriented sustainability analysis sub-model

#	Emissions sub-model	Agree (Yes/No)?	Rate (1-5)	Comments
B1	Applicability			
B1.1	The proposed sub-model is capable of being applied to GCC airport fuelling facilities			
B2	Flexibility/Expandability			
B2.1	The proposed sub-model is flexible to include airport fuelling facilities with different design elements and operational requirements			
B3	Scalability			
B3.1	The proposed sub-model has the ability to be implemented at different airport fuelling facilities with different sizes and capacities			
B4	Usability			
B4.1	It is easy to use the assessment tool (reading instruction and entering data)			
B5	Usability			
B5.1	Do you agree that there are potential benefits of using the proposed sub-model?			
B6	Coverage			
B6.1	The proposed sub-model adequately covers the main sources of airport fuelling facilities emissions			

Assessment of the aircraft refuelling energy-oriented sustainability analysis sub-model

#	Energy sub-model	Agree (Yes/No)?	Rate (1-5)	Comments
C1	Applicability			
C1.1	The proposed sub-model is capable of being applied to GCC airport fuelling facilities			
C2	Flexibility/Expandability			
C2.1	The proposed sub-model is flexibile to include airport fuelling facilities with different design elements and operational requirements			
C3	Scalability			
C3.1	The proposed sub-model has the ability to be implemented at different airport fuelling facilities with different sizes and capacities			
C4	Usability			
C4.1	It is easy to use the assessment tool (reading instruction and entering data)			
C5	Usability			
C5.1	Do you agree that there are potential benefits of using the proposed sub-model?			
C6	Coverage			
C6.1	The proposed sub-model adequately covers the main sources of airport fuelling facilities energy consumption			

Appendix P: Case Study 1 - Sample

Alternative 1

Assessment

Instructions

Introduction

This tool is intended to support airport operators and stakeholders to conduct a sustainability assessment of new airport fuel system projects. A range of airport sustainability criteria has been defined, based on a literature review. Respondents of this self-assessment tool will determine how well the project is designed to manage environmental, social, and economic sustainability with regard to policies and programs, incentives and awareness and improving efficiencies and ongoing performance.

A. Input tab - Define priorities

1. In the Input table, provide input on the projected sales figures (lt/$) and define the Priority for the 3 sustainability categories (Environmental, Economic and Social) using the 1-5 Likert scale presented below.
2. For the criteria listed under each sustainability category, define: 1) Applicability (Applies or N/A) and 2) Priority (on the 1-5 scale)
3. For the sub-criteria listed under each criterion category, define: 1) Applicability (Applies or N/A) and 2) Priority (on the 1-5 scale)

Define Priority for the listed criteria and sub-criteria (Input tab) using the following 5-point Likert scale

5	4	3	2	1
Not Important	Slightly Important	Moderately Important	Important	Very Important

B. Sustainability Assessment - Assess the defined Environmental, Economic, Social sub-criteria

1. Go to each of the Environmental, Economic and Social tabs - All cells which are orange-coloured must be filled in
2. In each tab, select from the drop-down list in the Assessment column (G) the one option which describes more accurately the degree of sustainability for the criterion under assessment.
   Each selection has been associated with a utility number (in the hidden columns) in the scale 0-1
   Note: The standard assessment categories can be Subjective, i.e. one of the following: Programs or Policies, Plans for performance monitoring, Incentives and awareness or Objective
   Note: In the latter case, the assessment scale (0-4) has been defined, using industry-wide best practices and widely acceptable parameters - For more information, see the reference provided in the respective column

3. Depending upon the selection in col. G, the associated utility number (0-1) will automatically populate column H
   Score= 0 represents little or no awareness of the issue and no policies in place or no plans for programs; or the lowest assessment for the objective criteria; and Score=4 represents high awareness, accountability and long-term planning, and incentives aligned with performance; or the highest assessment for the objective criteria.
   For further information on the listed criteria, sub-criteria and the assessment method, see the references provided in the last column of each table.

C. Output tab - Review Sustainability Assessment outcome and aggregation analysis

1. A multi-criteria analysis method has been utilized to determine the sustainability index (0-1)
   - each sustainability category (Environmental, Economic, Social) is assessed separately
   - the overall sustainability index is determined for the project alternative under evaluation
2. Refer to the Output tab for the outcome of the analysis ; aggregate analysis results; and a facility to conduct graphical comparison of different project alternatives

INPUT

Instructions

> Projected Sales

Year	2015
Volume (lt)	200,000,000.0
Sales ($)	$66,666,666.7

Note: numbers shown below in the 'Priority' column are for demostration purposes only (examples) - Please edit as described below:

> Define priorities for the 3 sustainability dimensions and the primary/secondary criteria - Use the scale: (1: Not important, 2: Slightly important, 3: Moderately important, 4: Important, 5: Very important)

#	Environmental > Go to Assessment tab	Applicability?	Priority (1-5)
A	Environmental	Applies	4
A1	Administrative procedures	Applies	2
A1.1	Cooperative Sustainability Policy	Applies	2
A1.2	Sustainable Procurement Policy	Applies	2
A1.3	Green Procurement Policy	Applies	2
A1.4	Use of renewable materials	Applies	2
A1.5	Recycle used materials	Applies	3
A1.6	Environmental impact assessment (EIA) study	Applies	1
A1.7	Environmental Certificate	Applies	1
A2	Water efficiency	Applies	3
A2.1	Wastewater generation	Applies	2
A2.2	Water withdrawal	Applies	3
A2.3	Storm water management system	Applies	3
A2.4	Recycle/reuse water	Applies	3
A2.5	Landscaping water use	Applies	1
A2.6	Water use reduction	Applies	4
A3	Indoor environmental quality	Applies	4
A3.1	Indoor ventilation and Air Quality	Applies	4
A4	Energy	Applies	4
A4.1	Energy savings from operation of pumps	Applies	4
A4.2	Energy savings from operation of buildings	Applies	4
A4.3	Use of Renewable Energy	Applies	3
A4.4	Vehicle fuel savings	Applies	3
A5	Emissions	Applies	4
A5.1	Reduction in VOC emissions	Applies	4
A5.2	Vehicle exhaust (GHG) emissions during movement/idling	Applies	4
A5.3	Utilization of environmentally friendly vehicles	Applies	3
A5.4	Reduce GHG emissions associated with energy consumption	Applies	4
A6	Waste	Applies	4
A6.1	Reduce Hazardous Wastes produced from ad-hoc activities (e.g. commissioning procedures) and spills	Applies	4
A6.2	Reduce Hazardous Wastes produced from routine operation and maintenance	Applies	4
A6.3	Reduce Non Hazardous Wastes produced from routine operation and maintenance	Applies	4
A6.4	Pollution of land / waterways	Applies	4
A7	Land Use & Biodiversity	Applies	3
A7.1	Efficiency of land use	Applies	3
A7.2	Impact of location and size of land used for operations in biodiversity	Applies	3
A7.3	Impact of activities in biodiversity	Applies	1
A8	Expenditures	Applies	3
A8.1	Initiatives to monitor Environmental mitigation and protection expenditures	Applies	1
A9	Noise	Applies	2
A9.1	Noise pollution	Applies	2

#	Economic > Go to Assessment tab	Applicability?	Priority (1-5)
B	Economic	Applies	5
B1	Economic performance analysis	Applies	4
B1.1	Life-cycle cost analysis	Applies	3
B1.2	Assessment of Capital projects	Applies	4
B1.3	Land and property value	Applies	3
B1.4	Capital to sales ratio	Applies	4
B1.5	Operating Expenses to Sales	Applies	4
B1.6	Operating Expenses Efficiency Control	Applies	4
B1.7	Maintenance to Assets cost	Applies	3
B1.8	Working Capital To Sales	Applies	4
B2	Economic value retained	Applies	5
B2.1	Direct economic value generated	Applies	5
B2.2	Economic value retained	Applies	3
B2.3	Net Present Value (NPV)	Applies	4
B2.4	Pay back Period	Applies	5
B2.5	Return on Assets (ROA)	Applies	4
B2.6	Financial implications due to emissions of pollutants and climate change substances	Applies	3
B3	Market presence	Applies	3
B3.1	Marketability	Applies	3
B3.2	Standard entry level wage ratio	Applies	4
B3.3	Employment opportunity	Applies	4
B3.4	Affordability	Applies	3
B3.5	Long term plan	Applies	3
B4	Indirect Economic impacts	Applies	3
B4.1	Indirect Economic impacts	Applies	3
B4.2	Non-monetary benefits	Applies	3
B4.3	Finance Leverage	Applies	3

#	Social > Go to Assessment tab	Applicability?	Priority (1-5)
C	Social	Applies	4
C1	Occupational Health and Safety	Applies	5
C1.1	Representation in HSSE committees	Applies	3
C1.2	Reduce Work-related injuries and fatalities	Applies	5
C1.3	Work-related injuries and fatalities	Applies	5
C1.4	Eliminate occupational diseases, lost days, and absenteeism	Applies	4
C1.5	Health and Safety awareness and prevention	Applies	5
C1.6	Education enhancement on HSSSE awareness	Applies	5
C1.7	Health and Safety covered in formal agreements with trade unions	Applies	3
C1.8	Fuelling Vehicles - Tests of safety devices	Applies	5
C1.9	Fuelling Vehicles - safety equipment	Applies	5
C1.10	Fuel Storage - Tests of safety devices	Applies	5
C1.11	Fuel storage - safety equipment	Applies	5
C1.12	Personal Protective Equipment (PPE)	Applies	5
C2	Security	Applies	5
C2.1	Initiatives to improve Security	Applies	5
C2.2	Security breach	Applies	5
C3	Community wellbeing and engagement	Applies	3
C3.1	Community awareness program	Applies	3
C3.2	Complaints	Applies	4
C3.3	Community engagement program	Applies	3
C3.4	Community appreciation	Applies	1
C3.5	Impacts of operations on local communities	Applies	1
C3.6	Prevention and mitigation measures program	Applies	3
C3.7	Initiatives for community	Applies	2
C3.8	Compensations to personnel	Applies	3
C3.9	Contractors with sustainability orientation	Applies	3
C3.10	Diversity	Applies	4
C3.11	Employee wellbeing	Applies	4
C3.12	Business Continuity Plan	Applies	4
C3.13	Local materials	Applies	3
C4	Employment	Applies	4
C4.1	Employee hires and turnover	Applies	4
C4.2	Staff localization	Applies	4
C5	Labor / Management Relations	Applies	2
C5.1	Notices of changes in operations	Applies	2
C5.2	Hygiene standards	Applies	4
C6	Education and Training	Applies	4
C6.1	Training per year per employee	Applies	3
C6.2	Skill management of employees	Applies	1
C6.3	Performance and career development	Applies	4
C6.4	On-Job-Training	Applies	4
C6.5	Sustainability research and development	Applies	2
C7	Quality of services	Applies	4
C7.1	Eliminate customer complaints	Applies	4
C7.2	Improve customer satisfaction	Applies	4
C7.3	Sustainable transportation of employees	Applies	3
C7.4	Improve employee satisfaction	Applies	3
C8	Regulatory Compliance	Applies	3
C8.1	Anti-competitive behavior	Applies	2
C8.2	Fines for non compliances with regulations	Applies	3
C9	Cultural heritage	Applies	1
C9.1	Financial contributions to cultural institutions	Applies	1

Environmental

Instructions

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#	Environmental Criteria	Description / Definition	Assessment Standard of measure	Reference	Assessment Select an option from the drop-down list	Utility (0-1)
A	Environmental					
A1	Administrative procedures					
A1.1	Cooperative Sustainability Policy	Adopt an own corporate policy on sustainable standards	Report if Corporate sustainability policy is in place	CDA, Sustainable Airport Manual, 2013	Limited process, program or policy in place to address issues	0.25
A1.2	Sustainable Procurement Policy	Adopt an own sustainable procurement policy	Report if Sustainable procurement policy in place	CDA, Sustainable Airport Manual, 2013	Limited process, program or policy in place to address issues	0.25
A1.3	Green Procurement Policy	Reduce the environmental impact of products and services by developing a Green Purchasing Program.	Refer to SAM Appendix AP-A – Green Product Listing for products and their minimum required content levels. Points for this credit will be awarded based on the number of green products, as defined in Appendix AP-A, procured for general day-to-day office use.	CDA, Sustainable Airport Manual, 2013 (pp. AP-13)	0	0.00
A1.4	Use of renewable materials	Reduce the need for virgin materials , energy, and waste by promoting the use of renewable input materials	Report whether there is a program in place to monitor percentage of recycled input materials used	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	0.25
			The percentage of paper recycled content is calculated as follows; % = (weight of chlorine-free paper/total weight of the paper)× % post-consumer recycled content	CDA, Sustainable Airport Manual, 2013 (pp. AP-16)	30% -	0.00
			Percentage of recycled input materials used, using the formula: (Total recycled input materials used/Input materials used) x 100	Sustainable Airport Manual, Chicago Airport	Less than 10%	0.00
A1.5	Recycle used materials	Reduce the need for virgin materials, energy, and waste by promoting the recycle of used materials	Report if there is a program in place to monitor the percentage of (recyclable) materials recycled	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	0.25
			Percentage of (recyclable) materials recycled, using the formula: (Total used materials recycled /Total used recyclable materials) x 100	Sustainable Airport Manual, Chicago Airport	Less than 10%	0.00
A1.6	Environmental impact assessment (EIA) study	EIA applies to ensure commitment to environmental regulations and standards stated in the General Environmental law of Saudi Arabia.	The requirement is one study for the whole project and this study should be updated if there is any additional facility or upgrading to the project.	CDA, Sustainable Airport Manual (2013), General Environmental Law and Rules for Implementation (15 October 2001)	0	0.00
A1.7	Environmental Certificate	To show that the company is committed to environmental laws and standards of a local or international organizations	Obtain environmental certificates from local (i.e. PME) or international organizations (i.e. LEED, ISO 14001) expressed the company's interest in saving the environment (the law of PME requires an environmental license for companies in petroleum sector)	Best practice	1 local and 1 international certificate	0.50

A2	Water efficiency					
A2.1	Wastewater generation	Eliminate the generation of wastewater use of potable water resources for vehicle washing	Report initiatives to minimize the amount of pollutants and chemicals entering waste water (e.g. vehicle washing monitoring programs)	CDA, Sustainable Airport Manual, 2013	Process, program or policy embedded in airport operations and reflects best practice from the industry	0.75
			Report the percentage calculates as follow: % = (total amount of current wastewater / total amount of previous wastewater) × 100	CDA, Sustainable Airport Manual, 2013 Best practise	10% -	0.00
A2.2	Water withdrawal	Monitor and improve the efficient use of water	Implement water use reduction programmes and report annual reduction achieved	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75
			The percentage of water withdrawal production calculates as follow: % = (the total amount of current water use / total amount of previous water use) × 100	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	10% -	0.00
A2.3	Storm water management system	Effective drainage system is critical to minimize the effects of storm water on the environment and the operability of the airport	Implement storm water management programmes	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	0.25
			Measure the quality of storm water in accordance with the applicable regulatory standards	Sustainability Reporting Guidelines & Airport Operators Sector Supplement PME, General Environmental law, 2001	0	0.00
A2.4	Recycle/reuse water	Monitor and improve the water reuse/recycle	Implement reuse/recycled water programmes and report annual reduction achieved	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	0.50
			Total volume of water recycled/reused by the operation in cubic meters per year (%)	Sustainable Airport Manual, Chicago Airport	Less than 10%	0.00
A2.5	Landscaping water use	Water sources significantly affected by withdrawal of water	Identify water sources significantly affected by water withdrawal by the operation (i.e. Withdrawals that account for an average of 5% or more of the annual average volume of the local water body)	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Risks have not been assessed and performance is/will not be monitored	0.00
A2.6	Water use reduction	Efficiency to reduce the use of potable water & waste water	Water saving percentage	Sustainable Airport Manual, Chicago Airport	15% - 30%	0.50

A3	**Indoor environmental quality**					
A3.1	Indoor ventilation and Air Quality	Improve indoor air quality	Report if ventilation systems have been designed using the Ventilation Rate Procedure or the applicable local code, whichever is more stringent	Sustainable Airport Manual, Chicago Airport	Strong internal awareness, recognition and understanding of issues. Investment deemed a priority	0.75
			Increase outdoor air ventilation rates for all air-handling units serving occupied spaces by at least 30% above the minimum required by ASHRAE Standard 62.1-2007	Sustainable Airport Manual, Chicago Airport	30% -	0.00
			Report if one of the two options mentioned below have been implemented: A. Modify or maintain each outside air intake, supply air fan, and/or ventilation distribution system to supply at least the outdoor air ventilation rate required by ASHRAE 62.1—2010 under all normal operating conditions. OR B. Modify or maintain the system to supply at least ten cubic feet per minute (cfm) of outdoor air per person under all normal operating conditions.	Sustainable Airport Manual, Chicago Airport	Either Option A or B has been implemented	1.00
A4	**Energy**					
A4.1	Energy savings from operation of pumps	Reduce direct energy consumption associated with the operation of pumps	Report the initiatives for energy savings due to conservation and efficiency improvements	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75
			Report the electricity consumption savings* in %, as a result of the energy saving initiatives	Sustainable Airport Manual, Chicago Airport	Less than 15%	0.00
A4.2	Energy savings from operation of buildings	Reduce direct energy consumption associated with the operation of offices and buildings	Report the initiatives for energy savings due to conservation and efficiency improvements	Sustainability Reporting Guidelines & Airport Operators Sector Supplement; CDA, Sustainable Airport Manual, 2013	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75
			Report the electricity consumption savings* in %, as a result of the energy saving initiatives	Sustainable Airport Manual, Chicago Airport	Less than 15%	0.00
A4.3	Use of Renewable Energy	Encourage and recognize increasing levels of on-site and off-site renewable energy to reduce environmental impacts associated with fossil fuel energy use.	Report the utilization of renewable energy for on-site activities	Sustainable Airport Manual, Chicago Airport	Less than 4.5%	0.00
			Report the utilization of renewable energy for off-site activities	Sustainable Airport Manual, Chicago Airport	Less than 37.5%	0.00
A4.4	Vehicle fuel savings	Reduce fuel consumption for refueling, hydrant flushing and passenger due to vehicle movement/idling	Report the initiatives for motor vehicle fuel savings due to utilization of green (LNG/Electric) vehicles and implementation of alternative driving routes	Sustainability Reporting Guidelines & Airport Operators Sector Supplement; International Civil Aviation Organization, 2011	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75
			Report the fuel consumption savings* in %, as a result of the fuel saving initiatives	Sustainable Airport Manual, Chicago Airport	Less than 10%	0.00

A5	Emissions					
A5.1	Reduction in VOC emissions	Reduce VOC emissions from 1) aircraft vents during fueling operations; 2) refueller vents during filling operations, 3) hydrant LP flushing vehicle vents during LP flushing operations; 4) tank vents during routine operation and receipt of product into storage tanks	Report the initiatives to monitor VOC emissions by weight	International Civil Aviation Organization, 2011	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	0.50
			Report the VOC reduction* in %, as a result of the VOC monitoring and reduction initiatives	UNECE, Decision 2012/2 Amendment of the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, Annexes X and XI, Emission reduction commitments for Volatile Organic Compounds for 2020 and beyond	Less than 10%	0.00
A5.2	Vehicle exhaust (GHG) emissions during movement/idling	Explore options to optimize routes and idling times as a means to reduce VOC and Greenhouse Gases (GHG) emissions from the exhausts of refueling, hydrant flushing and passenger vehicles, during vehicle movement/idling	Report the initiatives to monitor VOC and Greenhouse gases (GHG) emissions by weight and whether the location has considered a plan to optimize routes and idling times	International Civil Aviation Organization, 2011	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75
			Report the CO2 reduction* in %, as a result of the CO2 monitoring and reduction initiatives	United Nations Framework Convention on Climate Change 2011	Less than 15%	0.00
A5.3	Utilization of environmentally friendly vehicles	Explore options to utilize 'green' or 'clean' vehicles (liquefied petroleum gas or electric) as a means to reduce VOC and Greenhouse Gases (GHG) emissions from vehicles' exhausts	Report the initiatives to utilize 'green' or 'clean' vehicles (liquefied petroleum gas or electric) as a means to reduce VOC and Greenhouse Gases (GHG) emissions from vehicles' exhausts	Airport cooperative Research Program, Airport Sustainability Practices	Limited process, program or policy in place to address issues	0.25
A5.4	Reduce GHG emissions associated with energy consumption	Reduce VOC and Greenhouse Gases (GHG) emissions associated with energy savings	Report the initiatives to monitor VOC and GHG emissions by weight by kwWhr of electricity consumption	International Civil Aviation Organization, 2011 US Environmental Protection Agency	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	0.25
			Report the CO2 reduction in %, as a result of the CO2 monitoring and reduction initiatives	United Nations Framework Convention on Climate Change 2011	Less than 15%	0.00

A6	Waste					
A6.1	Reduce Hazardous Wastes produced from ad-hoc activities (e.g. commissioning procedures) and spills	Reduce hazardous wastes produced during ad-hoc activities and spills, e.g. commissioning operations of equipment and facilities (e.g. soaked fuel after soak tests for New storage tanks or refueling vehicles, wastewater after initial pressure strength test of new hydrant systems etc.)	Report the initiatives to monitor and reduce hazardous wastes produced by type and by weight	JIG 1,2,4 and EI/JIG 1530 US Environmental Protection Agency	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75
			Report the % of hazardous wastes reduced* by implementing specific initiatives	Sustainable Airport Manual, Chicago Airport	Less than 10%	0.00
A6.2	Reduce Hazardous Wastes produced from routine operation and maintenance	Reduce hazardous wastes produced over the course of normal/routine operations (tank farm, hydrant and ITPO), e.g. fuel slops, used filter elements, used hoses, vehicle tyres etc.	Report the initiatives to monitor and reduce hazardous wastes produced by type and by weight	JIG 1,2,4 and EI/JIG 1530 US Environmental Protection Agency	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75
			Report the % of hazardous wastes reduced* by implementing specific initiatives	Sustainable Airport Manual, Chicago Airport	Less than 10%	0.00
A6.3	Reduce Non Hazardous Wastes produced from routine operation and maintenance	Reduce non hazardous wastes produced over the course of routine operations (tank farm, hydrant, ITPO and house-hold type of wastes from buildings and offices)	Report the initiatives to monitor and reduce non-hazardous wastes produced by type and by weight	CDA, Sustainable Airport Manual, 2013	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75
			Report the % of non-hazardous wastes reduced* by implementing specific initiatives	Sustainable Airport Manual, Chicago Airport	Less than 10%	0.00
A6.4	Pollution of land / waterways	Reduce emissions of uncontained spills into the ground / waterways	Report the initiatives to monitor uncontained spills into the ground / waterways	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75

A7	**Land Use & Biodiversity**					
A7.1	Efficiency of land use	Efficiency of land use by optimizing site location, land acquisition, future expansion, and visual harmony.	Report the availability of unoccupied land adjacent to the facilities	CDA, Sustainable Airport Manual, 2013	Strong internal awareness, recognition and understanding of issues. Investment deemed a priority	0.75
A7.2	Impact of location and size of land used for operations in biodiversity	Description of significant impacts of land that lies within, contains, or is adjacent to legally protected areas on biodiversity in these areas	Report the initiatives to monitor significant direct and indirect positive and negative impacts of land (location and size) with reference to the following: • Species affected; • Extent of areas impacted; • Duration of impacts; and • Reversibility or irreversibility of the impacts.	CDA, Sustainable Airport Manual, 2013	Issue not on radar screen, relevancy to the organization undetermined. No budget allocation for activity	0.00
A7.3	Impact of activities in biodiversity	Description of significant impacts of activities, products, and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas.	Report the initiatives to monitor significant direct and indirect positive and negative impacts of activities with reference to the following: • Species affected; • Extent of areas impacted; • Duration of impacts; and • Reversibility or irreversibility of the impacts.	CDA, Sustainable Airport Manual, 2013	Issue not on radar screen, relevancy to the organization undetermined. No budget allocation for activity	0.00
A8	**Expenditures**					
A8.1	Initiatives to monitor Environmental mitigation and protection expenditures	Measure environmental mitigation and protection expenditures to allow the assessment of the efficiency of the environmental initiatives	Report process to establish targets and monitor the monetary value of waste disposal, emissions treatment, and remediation costs related to the following items: • Treatment and disposal of waste; • Treatment of emissions (e.g., expenditures for filters, agents); • Expenditures for the purchase and use of emissions certificates; • Depreciation of related equipment, maintenance, and operating material and services, and related personnel costs; Insurance for environmental liability; and • Clean-up costs, including costs for remediation of spills	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	0.50
A9	**Noise**					
A9.1	Noise pollution	Maintain noise levels from machinery and equipment at permissible levels	Report initiatives to monitor noise levels from machinery and equipment used at airport fuel operation facilities (e.g. power generators, air-powered tools, fire fighting pumps etc.) against noise targets or limits applicable to the airport	Sustainability Reporting Guidelines & Airport Operators Sector Supplement; ICAO Annex 16, ACI Noise Rating Index	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	0.50

Economic

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#	Economic Criteria	Description / Definition	Assessment Standard of measure	Reference	Assessment Select an option from the drop-down list	Utility (0-1)
B	**Economic**					
B1	**Economic performance analysis**					
B1.1	Life-cycle cost analysis	All new projects require life-cycle costing before implementation.	Report whether project has been subjected to a life-cycle cost analysis/assessment before commencement	Airport cooperative Research Program, Airport Sustainability Practices		1.00
B1.2	Assessment of Capital projects	Capital projects are required to predict operating and maintenance costs	Report whether capital projects have been subjected to analysis to predict operating and maintenance costs	Airport cooperative Research Program, Airport Sustainability Practices	Process, program or policy embedded in airport operations and reflects best practice from the industry	0.75
B1.3	Land and property value	Assessment of land and property value	Report whether land and property value has been assessed	Airport cooperative Research Program, Airport Sustainability Practices	Process, program or policy embedded in airport operations and reflects best practice from the industry	0.75
B1.4	Capital to sales ratio	Assessment of total Capital expenses ($)	Report capex to sales ratio (%)	Industry best practice	Capex to sales ratio is below average industry benchmark by up to 0.75%	0.75

> Calculations

		Fuel System	ITP
B1.4.1	**Fuel Costs**		
	Cost of Initial Jet Fuel in Hydrant System	*$800,000.00*	*$0.00*
	Cost of Initial Jet Fuel in Tank Farm	*$537,600.00*	*$0.00*
B1.4.2	**Initial Jet fuel transportation costs**	*$60,192.00*	*$0.00*
B1.4.3	**Civil Works costs**		
	Security fence cost	*$77,333.33*	*$0.00*
	Gates cost	*$13,333.33*	*$0.00*
	Facility roads & pavement cost	*$600,000.00*	*$458,533.33*
	Tank farm cost	*$600,000.00*	*$0.00*
	Administration Building cost	*$280,000.00*	*$234,240.00*
	Fire fighting cost	*$96,000.00*	*$0.00*
	Electrical room cost	*$120,000.00*	*$0.00*
	Pump & filtration	*$960,000.00*	*$0.00*
	Off-Loading office	*$20,148.00*	*$0.00*
	Security room	*$10,666.67*	*$0.00*
	Off-Loading pavement & shed	*$432,363.20*	*$0.00*
	Loading pavement & Test facility	*$375,129.07*	*$0.00*
	Demolition Works	*$0.00*	*$0.00*
	Wash Bay	*$0.00*	*$40,000.00*
	Earthworks (Backfilling)	*$0.00*	*$391,600.00*
	Safety Signs& Branding	*$0.00*	*$6,666.67*
	Landscaping & irrigation	*$0.00*	*$0.00*
	Truck Parking Shed	*$0.00*	*$0.00*
	Maintenance Building	*$0.00*	*$0.00*
	Soil Test	*$0.00*	*$8,000.00*
B1.4.4	**Mechanical works**		
	Equipment (Pumps, meters, and Filters)	*$0.00*	*$0.00*
	Transfer Pumps	*$746,666.67*	*$0.00*
	Jockey Pumps	*$106,666.67*	*$0.00*
	Flow meter- Loading	*$40,000.00*	*$0.00*
	Filter vessel	*$533,333.33*	*$0.00*
	Off-Loading Skid	*$800,000.00*	*$0.00*
	De-fueling pump	*$40,000.00*	*$0.00*
	De-fueling filter	*$22,666.67*	*$0.00*
	De-fueling flow meter	*$12,000.00*	*$0.00*
	Oil Water Seperator	*$0.00*	*$66,666.67*
	Storm Drainage	*$0.00*	*$13,333.33*
	Sewer System	*$0.00*	*$46,666.67*
B1.4.5	**Sampling system**	*$400,000.00*	*$0.00*
B1.4.6	**Valves & Fittings**	*$600,000.00*	*$0.00*

	Sub-totals ($)
Fuel Costs	***$1,337,600.00***
Initial Jet fuel transportation costs	***$60,192.00***
Civil Works costs	***$4,724,013.60***
Mechanical works	***$2,428,000.00***
Sampling system	***$400,000.00***
Valves & Fittings	***$600,000.00***
Storage tanks	***$3,533,333.33***
Pipes	***$0.00***
Fire fighting system	***$560,000.00***
Electrical Works	***$3,460,000.00***
Controls and Instrumentation	***$2,573,333.33***
Engineering consultation Fees/Charges	***$26,666.67***
Office equipment & furniture	***$1,722,133.33***
Service Vehicles	***$229,333.33***
Mobile equipment (refueller, dispensers, hydrant cleaning, etc.)	***$85,333.33***
Total capital costs ($) >	***$21,739,938.93***
Total capex costs to sales ratio (%) >	**32.6%**

B1.4.7	**Storage tanks**		
	Jet Fuel main Tanks	*$3,200,000.00*	*$0.00*
	De-fueling storage tank	*$93,333.33*	*$0.00*
	Water Tank	*$240,000.00*	*$0.00*
	Fuel Tanks Modification	*$0.00*	*$0.00*
	Platforms & Railings	*$0.00*	*$0.00*
B1.4.8	**Pipes**	*$862,666.67*	*$0.00*
	Pipe Rack & Supports	*$0.00*	*$0.00*
B1.4.9	**Fire fighting system**	*$400,000.00*	*$160,000.00*
B1.4.10	**Electrical Works**		
	Transformers	*$400,000.00*	*$80,000.00*
	Wires / Cables	*$400,000.00*	*$20,000.00*
	Stand-by Generator	*$666,666.67*	*$0.00*
	Electrical panels	*$266,666.67*	*$20,000.00*
	HVAC system	*$666,666.67*	*$0.00*
	Accessories	*$373,333.33*	*$40,000.00*
	Fire Alarm system	*$133,333.33*	*$13,333.33*
	Safety & Security System(CCTV)	*$200,000.00*	*$53,333.33*
	Flight Monitoring System	*$0.00*	*$53,333.33*
	Area & Road Lighting	*$0.00*	*$40,000.00*
	Lightning System	*$0.00*	*$20,000.00*
	Grounding System	*$0.00*	*$13,333.33*
B1.4.11	**Controls and Instrumentation**		
	Tank Gauging System	*$160,000.00*	*$0.00*
	Control valves	*$746,666.67*	*$0.00*
	Valves and accessories	*$600,000.00*	*$0.00*
	Control system/software	*$666,666.67*	*$0.00*
	Terminal management system	*$400,000.00*	*$0.00*
B1.4.12	**Engineering consultation Fees/Charges**	*$1,722,133.33*	*$133,333.33*
	Mobilization (Preliminaries, project Documentation, temporary Facility...)	*$0.00*	*$26,666.67*
B1.4.13	**Office equipment & furniture**	*$229,333.33*	*$15,333.33*
B1.4.14	**Service Vehicles**	*$85,333.33*	*$0.00*
B1.4.15	**Mobile equipment (refueller, dispensers, hydrant cleaning, etc.)**	*$760,000.00*	*$0.00*

B1.5	**Operating Expenses to Sales**	The measure the performance and effeciency of controlling expenses.	Average Expenses as a Percentage of Sales (%)	https://saibooks.com/index.php?option=com_content&view=article&id=64&Itemid=65	Opex to sales ratio is below average industry benchmark by up to 0.5%	0.50

> Calculations

		Fuel System	ITP		Sub-totals ($)
B1.5.1	**Variable costs**				
	Jet Fuel Evaporation Losses Cost	*$128,000.00*	*$64,000.00*	**Variable costs**	***$192,000.00***
B1.5.2	**Fixed costs**			**Fixed costs**	***$9,203,050.67***
	Employee cost (total of salary, wages, b	*$956,800.00*	*$736,000.00*	**Depreciation costs**	***$1,510,550.72***
	Employee Training Cost	*$28,704.00*	*$22,080.00*	**Regulatory-driven costs**	***$54,000.00***
	Utilities Cost	*$126,400.00*	*$32,000.00*		
	Employee Uniform	*$6,933.33*	*$5,333.33*	**Total Opex costs ($) >**	***$10,959,601.39***
	Licenses Cost	*$21,333.33*	*$2,666.67*		
	Rent Cost	*$5,866,666.67*	*$93,333.33*	**Total Opex costs to sales ratio (%) >**	**16.4%**
	Insurance Cost	*$356,000.00*	*$60,000.00*		
	Maintenance and spare parts Cost	*$162,666.67*	*$106,666.67*		
	Quality & HSSE equipment cost	*$18,133.33*	*$5,333.33*		
	Professional Fees & Inspections Cost	*$64,000.00*	*$32,000.00*		
	Contracted Services Cost	*$32,000.00*	*$12,800.00*		
	Security Services Cost	*$128,000.00*	*$16,000.00*		
	Operating Items Cost	*$45,333.33*	*$26,666.67*		
	Mobilization and Pre-operating costs	*$239,200.00*	*$0.00*		
B1.5.3	**Depreciation costs**				
	Depreciation of Vehicles	*$1,111,884.06*	*$266,666.67*		
	Depreciation of Office Equipment, IT, and Supplies	*$40,000.00*	*$33,333.33*		
	Depreciation of equipment and Technical Operating Items	*$26,666.67*	*$32,000.00*		
B1.5.4	**Regulatory-driven costs**				
	Taxes	*$0.00*	*$0.00*		
	Audit and legal costs	*$0.00*	*$0.00*		
	Bank Guarantee Cost	*$40,000.00*	*$14,000.00*		

B1.6	*Operating Expenses Efficiency Control*	*Ability to control and contain Opex to not exceed level of inflation*	Annual monetary agency inflation	Saudi Arabian Monetary Agency (SAMA)	Annual increase in Opex is below the average declared inflation rate by 0.5%	0.25
B1.7	*Maintenance to Assets cost*	*Maintenance to Assets cost indicates the percentage of maintenance cost to total asset cost.*	Measured against maintenance functional benchmark (3%)	http://cleanbayarea.com/recycling-environment/maintenance-cost-vs-asset-replacement-value-rav/	Maintenance to asset cost is 3% or below	1.00
B1.8	*Working Capital To Sales*	*Indicates the firm's ability to finance additional sales without incurring additional debt. Formula: Working capital ÷ sales revenue.*	Assessed against the industry average ratio benchmark . Benchmarked against Saudi Ground services	http://www.tadawul.com.sa/Resources/fsPdf/644_2015-07-07_08-10-57_Arabic.pdf	Working captial is between 34% - 36% to sales revenue	0.75

B2	**Economic value retained**					
B2.1	Direct economic value generated	Direct economic value generated. Net sales plus revenues from financial investments and sales of assets	Report programs in place to monitor direct economic value generated including revenues vs financial targets Note: Finance, treasury, or accounting departments should have the information required by this Indicator.	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Process, program or policy is well developed and reflects good practice from the industry	0.50
B2.2	Economic value retained	Direct economic value retained	Report programs in place to monitor Economic value generated and retained (Investments, equity release etc.) vs financial targets Note: Finance, treasury, or accounting departments should have the information required by this Indicator.	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	0.50
B2.3	Net Present Value (NPV)	A measure of the project's profitability and the amount of value added to the firm	Project NPV	http://capitalbudgeting.tripod.com/id24.html http://www.gulfbase.com/ScheduleReports/250364a2_GCCEquityRiskPremium-October2012.pdf	NPV >0 and NPV above equity risk premium by 4%	0.75
B2.4	Pay back Period	The number of years required to recover a project's cost. Pay back period provides a measure of the liquidity of the project.	Average pay back period	ICAO , Emission reduction measure pay back period http://www.icao.int/Meetings/EnvironmentalWorkshops/Documents/2014-Malaysia/9-1_Financing.pdf	Pay back period is 7 to 8 years	0.75
B2.5	Return on Assets (ROA)	A performance measure used to evaluate the efficiency of an investment . A profitability ratio calculated as net income divided by total assets.	Measured against five years average of ROA of oil sector (8.1%)	https://www.stock-analysis-on.net/NYSE/Company/Exxon-Mobil-Corp/Ratios/Profitability	ROA is above five years average of oil & gas industry sectors by 0.75%	0.75
B2.6	Financial implications due to emissions of pollutants and climate change substances	Financial implications due to climate change	Report whether there are programs in place for the quantitatively estimations of the financial implications of climate change for the organization (e.g., cost of offsetting CO2 emissions or VOC emissions)	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Risks have not been assessed and performance is/will not be monitored	0.00
B3	**Market presence**					
B3.1	Marketability	Ability to attract and increase sales volume	Annual growth in Gross domestic product (GDP)	Netherlands Airport Consultants B.V., NACO, Kingdom's Airport Aviation and Logistics. Saudi Arabia, May 2012	Growth in Annual sales volume is above annual GDP Growth by 0.5%	0.25
B3.2	Standard entry level wage ratio	Range of ratios of standard entry level wage compared to local minimum wage at significant locations of operation. Economic well-being is one of the ways in which an organization invests in its employees	Report the organization's entry wage to the local minimum entry wage	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Process, program or policy is well developed and reflects good practice from the industry	0.50
B3.3	Employment opportunity	Employment opportunities generated	Report the organization's plans to generate employment opportunities	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Limited process, program or policy in place to address issues	0.25
B3.4	Affordability	Use sustainability tools to assess mid- and long-term affordability	Report whether there is a process in place which uses a sustainability matrix to assess affordability	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	No process, program or policy in place	0.00
B3.5	Long term plan	The 20-year master plan uses a sustainability matrix to assess possible projects.	Report whether there is a long term business plan in place which uses a sustainability matrix to assess possible projects	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	No process, program or policy in place	0.00

B4	**Indirect Economic impacts**					
B4.1	Indirect Economic impacts	Understanding and describing significant indirect economic impacts, including the extent of impacts. Indirect economic impacts include the additional impacts generated as money circulates through the economy.	Report indirect economic impacts and their significance in the context of external benchmarks and stakeholder priorities, such as national and international standards, protocols, and policy agendas	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Risks have not been assessed and performance is/will not be monitored	0.00
B4.2	Non-monetary benefits	Annual objectives and targets should include quantification of nonmonetary benefits	Report whether annual objectives and targets include quantification of nonmonetary benefits	Airport cooperative Research Program, Airport Sustainability Practices	Risks have not been assessed and performance is/will not be monitored	0.00
B4.3	Finance Leverage	The Debt to Equity (DOE) ratio indicates how much debt is used to finance assets relative to the amount of value represented in shareholders' equity. E = Total Liabilities / (Total Assets - Total Liabilities)	Debt to Equity (DOE)	https://www.stock-analysis-on.net/NYSE/Company/Exxon-Mobil-Corp/Long-Term-Trends/Debt-to-Equity#Comparison-to-Industry	Debt to equity is higher than energy sector benchmark by 0.1%	0.75

Social

FILL IN ALL ORANGE-COLOURED CELLS

Instructions

#	Social Criteria	Description / Definition	Assessment Standard of measure	Reference	Assessment Select an option from the drop-down list	Utility (0-1)
C	**Social**					
C1	**Occupational Health and Safety**					
C1.1	Representation in HSSE committees	Workforce represented in formal joint management worker health and safety committees that help monitor and advise on occupational health and safety programs	Report whether workforce is represented in formal joint management-worker health and safety committees	Sustainability Reporting Guidelines & Airport Operators Sector Supplement		
			Internal HSSE Audit - 1 Year External HSSE Audit - 1 / 3 years Safety Walk by Mangement - 2 / Year Safety Meetings- 12/ Year Safety bulletin - 4/ Year KPI (HSSE) - Compilation - 4/ Year Minimum acceptable limit- 85% of Planned Vs. Actual.	Best industry practice	if less than 85%	0.00
C1.2	Reduce Work-related injuries and fatalities	Protective and preventive measures are applied to protect personnel from occupational health hazards associated with hazardous materials, Exposure of personnel to physical hazards (e.g. noise, Air quality and water quality) Personnel undergo medical assessments, including colour blindness, Audiogram and Drug tests at the time of employment and at regular intervals. Employer have to Provide adequate PPE.	Report programs for monitoring and reducing rates of injury and total number of work-related fatalities	JIG HSSE statistics	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	1.00
			Goal is - ZERO Incident 2 minor Incident / year is acceptable.	Best industry practice	> 3	0.00
C1.3	Work-related injuries and fatalities	Reduce rates of injury and total number of work-related fatalities	Report reduction* in work-related injuries and fatalities	JIG HSSE statistics	Reduction in incident rates less than 20%	0.00
			Number of Potential Incidents reported, Annual HSSE Plan activities, Annual HSSE Plan investments, implementation of HSSE audit recommendations and Implementation of HSSE Remedial Action Plan	Best industry practice	> 3 Injuries	0.00

C1.4	Eliminate occupational diseases, lost days, and absenteeism	Reduce rates of occupational diseases, lost days, and absenteeism	Report programs for monitoring and reducing rates of occupational diseases, lost days, and absenteeism	JIG HSSE statistics	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75
			Report absenteeism (%) dues to occupational diseases Absenteeism = 5 days/ year/ employee Sick leave= 8 days/year/emplyee	JIG HSSE statistics	Absenteeism more than 10%	0.00
C1.5	Health and Safety awareness and prevention	Education, training, counseling, prevention, and risk-control programs in place to assist workforce members, their families, or community members regarding serious diseases	Report the programs related to assisting workforce members, their families, or community members regarding serious diseases	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Process, program or policy is well developed and reflects good practice from the industry	0.50
C1.6	Education enhancement on HSSSE awareness	Enhancement of education, Risk Assessment, Work Control Permit, Safety Meeting, Fundamental of Safety, Smith Defense Drive, Law and workplace health and safety policies and procedures, Use PPE as required	Education enhancement: Trainings: HSSE Policies: Smith Defense Drive Use PPE as required Minimum Acceptable Limit: 80%	Best industry practice	95 to 99.99%	0.75
C1.7	Health and Safety covered in formal agreements with trade unions	Formal agreements can promote the acceptance of responsibilities by both parties and the development of a positive health and safety culture.	Report whether there is a program in place to review whether formal agreements (either local or global) with trade unions cover health and safety.	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Process, program or policy embedded in airport operations and reflects best practice from the industry	0.75
			Acceptable limit 100%.	Business Ethics	if less than 85%	0.00
C1.8	Fuelling Vehicles - Tests of safety devices	The procedure & guidelines for performing the tests and checks to determine that they are functioning adequately	Report whether the Weekly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded e.g. Interlock function, Bonding wire, Elevating platform lowering , Elevating platform wand sensors	AAFQCO Manual	All Weekly checks and records in place (per AAFQCO Manual)	1.00
			Report whether the Monthly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded e.g. Deadman, Fueller high level cut-off devices , Engine emergency stop switches	AAFQCO Manual	All Monthly checks and records in place (per AAFQCO Manual)	1.00
			Report whether the Quarterly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded	AAFQCO Manual	All Quarterly checks and records in place (per AAFQCO Manual)	1.00
			Report whether the Semi-Annual, Annual and less frequent checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded	AAFQCO Manual	All Semi-annual/annual/less freq. checks and records in place (per AAFQCO Manual)	1.00

C1.9	Fuelling Vehicles - safety equipment	Minim required Safety equipment considered / in place	Report whether the min required safety equipment have been considered / are in place: Fire extinguishers: 2x9 kg/vechicle Spill kit: 50 Ltr/vechicle Cones: 3/vechicle First aid box: 1 box/vechicle	AAFQCO Manual	Minimum equipment in place	1.00
C1.10	Fuel Storage - Tests of safety devices	The procedure & guidelines for performing the tests and checks to determine that they are functioning adequately	Report whether the Weekly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded, e.g. bonding wires	AAFQCO Manual	All Weekly checks and records in place (per AAFQCO Manual)	1.00
			Report whether the Monthly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded, e.g. Hydrant Emergency Shut-Down buttons	AAFQCO Manual	All Monthly checks and records in place (per AAFQCO Manual)	1.00
			Report whether the Quarterly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded, e.g. safe procedures for entry in Valve chambers	AAFQCO Manual	All Quarterly checks and records in place (per AAFQCO Manual)	1.00
			Report whether the Semi-Annual, Annual and less frequent checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded, e.g. tank cleaning every 3-5 y, cathodic protection yearly	AAFQCO Manual	All Semi-annual/annual/less freq. checks and records in place (per AAFQCO Manual)	1.00
C1.11	Fuel storage - safety equipment	Minim required Safety equipment considered / in place	Report whether the min required safety equipment have been considered / are in place: Fire extinguishers: Every 20m/ 10kg ; Spill kit: 2 X 120 ltr; Sprinkler system: every 1.5 m /1 nozzle; Fire Alarm syst. each 45 m/per unit; First aid box: 1 box / 3 - 4 min	AAFQCO Manual	Minimum equipment in place	1.00
C1.12	Personal Protective Equipment (PPE)	To ensure the greatest possible protection for employees at workplace, employer have to arrange and pay for required PPE.	Report whether the min standards/specifications for PPEs have been considered / are in place: Eye Protection : •EN166 / UV Protection SPF 15+; Fire Resistant & Antistatic Shirts/ Trousers : •NFPA 2112, •ASTM D6413 ; Fire Resistant & Antistatic Workwear Overalls : •ASTM D6413 •EN470-1•EN11612; QC Gloves ,Hand Gloves : •EN:388 – BS:EN:374; High Visibility Vest : •EN 471:2003 class 3; Safety Helmets : •EN 397; Ear Muffs : •ANSI S3.19-1974; Safety boots : •EN 345:EN ISO20345:2004/20346 •EN ISO2034520347•Height of 13cm •Anti-slip •Shock Absorbent ----- Acceptable limit-100%	NFPA , OSHA ,AAFQCO Manual	All requirements met	1.00

C2	Security					
C2.1	Initiatives to improve Security	Initiatives to improve Rates of security-related incidents	Report programs in place for monitoring rates of security-related incidents	JIG HSSE statistics	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75
			Fence: Height 2 - 3 m	Security Recommended Practice of industry & Best industry practice.	3 meters	1.00
			Gates: 2 – Entry & Exit – 1 Crash Gate	Security Recommended Practice of industry & Best industry practice.	3	1.00
			CCTV camera day/night vision : 100 meter / 1 camera	Security Recommended Practice of industry & Best industry practice.	150 meters	0.75
			Security Guards: Minimum 4 / Shift – 24 Hours Operations	Security Recommended Practice of industry & Best industry practice.	4	1.00
			Patrolling: 2hrs /1 Vehicle	Security Recommended Practice of industry & Best industry practice.	3.5 hours	0.50
C2.2	Security breach	Rates of security-related incidents	Report reduction* in security incident rates, based on initiatives taken	JIG HSSE statistics	Reduction in security incident rates less than 20%	0.00

C3	Community wellbeing and engagement					
C3.1	Community awareness program	Identify opportunities to raise awareness of employees and stakeholders on sustainability (e.g. development of leaflets to inform stakeholders about good environmental practices, websites, social media etc.)	Report whether operations have implemented plans to raise community awareness on sustainability	Airport cooperative Research Program, Airport Sustainability Practices	Process, program or policy is well developed and reflects good practice from the industry	0.50
C3.2	Complaints	Number of complaints per year	Number of complaints per year	Industry best practices	8	0.00
C3.3	Community engagement program	Identify areas to improve/implement local community engagement, impact assessments, and development programs	Report whether operations have implemented local community engagement, impact assessments, and development programs (e.g. Environmental impact assessments and ongoing monitoring; Public disclosure of results of environmental and social impact assessments; Local community development programs based on local communities' needs; Works councils, occupational health and safety committees and other employee representation bodies to deal with impacts)	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	No process, program or policy in place	0.00
C3.4	Community appreciation	Community appreciation	Number of times an Appreciation from community members is raised per year	Best industry practice, Work Control Procedures	0	0.00
C3.5	Impacts of operations on local communities	Impacts of operations on local communities	Report Operations and associated communities with significant potential or actual negative impacts	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Issue not on radar screen, relevancy to the organization undetermined. No budget allocation for activity	0.00
			Audit report gaps from Enirnomental Authorities as per (EPA) Acceptal limit gaps = Zero	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	More than 3	0.00
C3.6	Prevention and mitigation measures program	Prevention and mitigation measures implemented in operations with significant potential or actual negative impacts on local communities	Report whether prevention and mitigation measures were implemented and achieved or not	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	No process, program or policy in place	0.00
C3.7	Initiatives for community	Education: Scholarships Environmental: Awareness & Contribution for green products Charity events sponsorships Participation voluntary services by employee to community	Number of initiatives taken: Education: Scholarships Environmental: Awareness & Contribution for green products Charity events sponsorships Participation voluntary services by employee to community	Best industry practice, Work Control Procedures	0	0.00

C3.8	Compensations to personnel	Number of persons physically or economically displaced, either voluntarily or involuntarily, by the airport operator or on its behalf by a governmental or other entity, and compensation provided	Report programs to provide compensations by project and average per person	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Problems identified. Stakeholders take the lead in raising issue. Limited budget allocation for managing issue	0.25
		Number of persons physically or economically displaced, either voluntarily or involuntarily, by the airport operator or on its behalf by a governmental or other entity, and compensation provided	Number of Compensations	Saudi labour laws	4 and more	0.00
C3.9	Contractors with sustainability orientation	Engage contractors who use environmentally friendly practices and are sustainability-oriented	Report whether contractor selection and placement process includes sustainability among the selection/assessment criteria	Airport cooperative Research Program, Airport Sustainability Practices	Limited process, program or policy in place to address issues	0.25
		Engage contractors who use environmentally friendly practices and are sustainability-oriented	Contractors record from previous projects, enhancement since then Audit reports Strenth Vs Gaps 2 Strenth = 1 Gap	Airport cooperative Research Program, Airport Sustainability Practices	0	0.00
C3.10	Diversity	Identify areas to improve contract opportunities for Small/medium enterprises	Report whether contractor selection and placement process has considered diversity among the criteria	Airport cooperative Research Program, Airport Sustainability Practices	Process, program or policy embedded in airport operations and reflects best practice from the industry	0.75
			Preparation of Vendor List - Ethitical Contractors, Safety and qualified & experience staff	Industry best practice	Yes	1.00
C3.11	Employee wellbeing	Identify opportunities to improve the wellbeing of employee working at the facility	Report whether employee wellbeing programs have been developed (e.g. Sport facilities for staff, intercompany day nursery, All airport services can be used by employees, Every staff member has internet access, Planters and open green space etc.)	Airport cooperative Research Program, Airport Sustainability Practices	Process, program or policy is well developed and reflects good practice from the industry	0.50
			Training, PPE, safety at work place, Motivation and employee emoluments. Staff turn over % per Year	Industry best practice	19% & above	0.00
C3.12	Business Continuity Plan	Businesses continuity plan include the Minimum Fuel Storage requirements for the quantity of fuel that needs to be stored in Airport Tanks to cover any interruptions of supply chain. The minimum fuel storage requirements shall be able to cover 5 peak days in term of Airport fuel Uplifts	Measured against industry standard of having 5 peak days for jet fuel stored in the tanks	IATA Guidelines for Minimum Fuel storage requirements https://www.iata.org/policy/Documents/guidance-fuel-storage-may08.pdf	If minimum storage quantity is above 6.5 days	1.00
C3.13	Local materials	The demand of local materials (manufactured, extracted, or recovered locally)	Percentage of local materials	Sustainable Airport Manual, Chicago Airport	15% - 30%	0.50

C4	Employment					
C4.1	Employee hires and turnover	Rate of new employee hires and employee turnover results in changes to the human and intellectual capital of the organization and can impact productivity	Report whether there are programs in place to monitor the rate of new employee hires entering and employees leaving employment during the reporting period	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Process, program or policy embedded in airport operations and reflects best practice from the industry	0.75
			Exit Interview feedback, Root cause analysis of staff of resignation.	US Survey 2013 & Industry Best Practice	19% & above	0.00
C4.2	Staff localization	Staff localization is the percentage of the staff that are hired from local area	Measured against labor law minimum requirements	http://www.emol.gov.sa/nitaqat/nitaqat.pdf	Local staff is above 60% of total staff	1.00
C5	Labor / Management Relations					
C5.1	Notices of changes in operations	Minimum notice period(s) regarding significant operational changes, including whether it is specified in collective agreements	Report whether there are programs in place to ensure minimum number of weeks notice typically provided to employees and their elected representatives prior to the implementation of significant operational changes that could substantially affect them.	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Process, program or policy embedded in airport operations and reflects best practice from the industry	0.75
C5.2	Hygiene standards	Hygiene standards such providing milk to staff can have positve anti-tumor effect	Measured against probablity of reducing lung cancer	http://www.acsu.buffalo.edu/~andersh/research/milkcancer.asp	one liter or above	1.00

C6	Education and Training					
C6.1	Training per year per employee	Maintaining and improving human capital, particularly through training that expands the knowledge base of employees, is a key element in organizational development	Report whether there are programs to monitor the average number of hours of training per year per employee, by employee category	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Industry leading process, program or policy. Long term planning horizon	1.00
			Planned Vs Actual % Acceptable 90%	Industry Best Practice	less than 75%	0.00
C6.2	Skill management of employees	Programs for skills management and lifelong learning that support the continued employability of employees and assist them in managing career endings	Report whether there are employee training or assistance programs in place to upgrade skills	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Process, program or policy embedded in airport operations and reflects best practice from the industry	0.75
			Acceptable limit 80%	Industry Best Practice	Less than 65%	0.00
C6.3	Performance and career development	Percentage of employees receiving regular performance and career development reviews,	Report whether there are programs in place for employees to receive a formal performance appraisal and review	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Industry leading process, program or policy. Long term planning horizon	1.00
			Limit 100%	Industry Best Practice	Less than 70%	0.00
C6.4	On-Job-Training	On-the-job training describes the process of teaching an employee to complete the key activities needed for their job after they are hired	Mesurd against labor law standard percentage (12% of total manpower)	http://portal.mol.gov.sa/Sites/default.aspx	On job training is between 14 and 15 %	0.75
C6.5	Sustainability research and development	Sustainability research and development is a way for airports to improve existing, environmental, social, and economic practices, and discover new ones. Research and development can also benefit airports through the implementation of new technologies, processes, and ideas.	Report whether the location implements a sustainability research and development program	Airport cooperative Research Program, Airport Sustainability Practices	Limited process, program or policy in place to address issues	0.25

C7	Quality of services					
C7.1	Eliminate customer complaints	Initiatives taken to monitor and eliminate number of substantiated complaints	Report whether there are programs in place to obtain and address customer complaints	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Industry leading process, program or policy. Long term planning horizon	1.00
			Acceptable limit: 2 Complaints / Year	Industry Best Practice	0	0.00
			Total number of substantiated complaints raised per year, relatively to the total number of customers over the assessment period	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	More than 8% of customers	0.00
C7.2	Improve customer satisfaction	Practices related to customer satisfaction, including results of surveys measuring customer satisfaction	Report whether there are programs in place to monitor the satisfaction results or key conclusions of surveys (based on statistically relevant sample sizes) conducted in the reporting period that were related to information about: The organization as a whole; Quality of services	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75
			Number of Complaints Vs Appreciations : max 2	Industry Best Practice	>5	0.00
C7.3	Sustainable transportation of employees	Practices related to sustainable transportation and alleviating road congestion, i.e. support public transports for employees, enhance cyclist access and facilities for employees, side roads	To what extent is the airport supporting sustainable transportation through initiatives	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Some awareness of issue inside organization. Policy or program is communicated and enforced. Funding allocation to manage issue established on annual basis	0.50
			Measure of Employees Timely Attendance Acceptable 95% on time	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Less than 80 %	0.00
C7.4	Improve employee satisfaction	Practices related to satisfaction of employees at the fuel facility, quality of emergency response services, fire brigade response etc.	Initiatives to improve the extent at which the airport employees are satisfied by the quality of airport services	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Some awareness of issue inside organization. Policy or program is communicated and enforced. Funding allocation to manage issue established on annual basis	0.50
			To what extent are the airport employees satisfied by the quality of airport services based on HR surveys	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Less than 10%	0.00

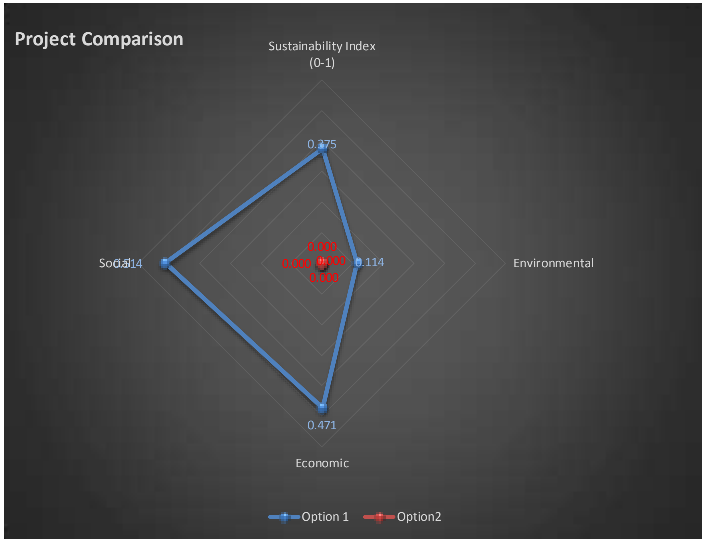
C8	Regulatory Compliance					
C8.1	Anti-competitive behavior	Total number of legal actions for anti-competitive behavior, anti-trust, and monopoly practices and their outcomes.	Report the number of occurrences of legal actions for anticompetitive behavior, anti-trust, and monopoly practices	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Has occurred at least once	0.00
C8.2	Fines for non compliances with regulations	Significant fines from sanctions for non-compliance with laws and regulations	Report monetary value of significant fines and sanctions for non-compliance with laws and regulations	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Fines more than $50K	0.00
C9	Cultural heritage					
C9.1	Financial contributions to cultural institutions	Participation in initiatives for financial support contributions (donations, sponsorships, etc.) to cultural-related institutions	Report whether there is a program in place for financial support contributions (donations, sponsorships, etc.) to cultural-related institutions	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Process, program or policy is well developed and reflects good practice from the industry	0.50

OUTPUT

Instructions

Sustainability Index

		Option 1	Option2
		do not edit these cells- automatic calcs	manually add values here
	Sustainability Index (0-1)	**0.375**	**0.000**
Utility	**Environmental**	0.114	0.000
Utility	**Economic**	0.471	0.000
Utility	**Social**	0.514	0.000



NOTE:

Option1 = The sustainability index and the utility for each of the e sustainability factors are **automatically** calculated based on input provided in this sheet - **DO NOT EDIT THE CELLS UNDER OPTION 1**

Option2 = For comparison purposes, **manually enter the values under Option 2**, from separate calculations for a different project alternative - (i.e. add the other alternative's sustainability index and the utility for each of the 3 sustainability dimensions)

Aggregation Analysis

#	Environmental > Go to Assessment tab	Priority (1-5)	Utility (0-1)		#	Economic > Go to Assessment tab	Priority (1-5)	Utility (0-1)		#	Social > Go to Assessment tab	Priority (1-5)	Utility (0-1)
A	**Environmental**	4	**0.114**		**B**	**Economic**	5	**0.471**		**C**	**Social**	4	**0.514**
A1	Administrative procedures	2	**0.138**	0	B1	Economic performance analysis	4	**0.698**	3	C1	Occupational Health and Safety	5	**0.681**
A1.1	Cooperative Sustainability Policy	2	0.250	1	B1.1	Life-cycle cost analysis	3	1.000	3	C1.1	Representation in HSSE committees	3	0.000
A1.2	Sustainable Procurement Policy	2	0.250	1	B1.2	Assessment of Capital projects	4	0.750	3			3	0.000
A1.3	Green Procurement Policy	2	0.000	0	B1.3	Land and property value	3	0.750	2	C1.2	Reduce Work-related injuries and fatalities	5	1.000
A1.4	Use of renewable materials	2	0.250	1	B1.4	Capital to sales ratio	4	0.750	3			5	0.000
		2	0.000	0	B1.5	Operating Expenses to Sales	4	0.500	2	C1.3	Work-related injuries and fatalities	5	0.000
		2	0.000	0	B1.6	Operating Expenses Efficiency Control	4	0.250	1			5	0.000
A1.5	Recycle used materials	3	0.250	1	B1.7	Maintenance to Assets cost	3	1.000	3	C1.4	Eliminate occupational diseases, lost days, and absenteeism	4	0.750
		3	0.000	0	B1.8	Working Capital To Sales	4	0.750	3			4	0.000
A1.6	Environmental impact assessment (EIA) study	1	0.000	0	B2	Economic value retained	5	**0.573**	3	C1.5	Health and Safety awareness and prevention	5	0.500
A1.7	Environmental Certificate	1	0.500	1	B2.1	Direct economic value generated	5	0.500	3	C1.6	Education enhancement on HSSE awareness	5	0.750
A2	Water efficiency	3	**0.296**	1	B2.2	Economic value retained	3	0.500	2	C1.7	Health and Safety covered in formal agreements with trade unions	3	0.750
A2.1	Wastewater generation	2	0.750	2	B2.3	Net Present Value (NPV)	4	0.750	3			3	0.000
		2	0.000	0	B2.4	Pay back Period	5	0.750	4	C1.8	Fuelling Vehicles - Tests of safety devices	5	1.000
A2.2	Water withdrawal	3	0.750	2	B2.5	Return on Assets (ROA)	4	0.750	3			5	1.000
		3	0.000	0	B2.6	Financial implications due to emissions of pollutants and climate change substances	3	0.000	0			5	1.000
A2.3	Storm water management system	3	0.250	1	B3	Market presence	3	**0.221**	1			5	1.000

		3	0.000	0
A2.4	Recycle/reuse water	3	0.500	2
		3	0.000	0
A2.5	Landscaping water use	1	0.000	0
A2.6	Water use reduction	4	0.500	2
A3	Indoor environmental quality	4	**0.583**	2
A3.1	Indoor ventilation and Air Quality	4	0.750	3
		4	0.000	0
		4	1.000	4
A4	Energy	4	**0.295**	1
A4.1	Energy savings from operation of pumps	4	0.750	3
		4	0.000	0
A4.2	Energy savings from operation of buildings	4	0.750	3
		4	0.000	0
A4.3	Use of Renewable Energy	3	0.000	0
		3	0.000	0
A4.4	Vehicle fuel savings	3	0.750	2
		3	0.000	0
A5	Emissions	4	**0.250**	1
A5.1	Reduction in VOC emissions	4	0.500	2
		4	0.000	0
A5.2	Vehicle exhaust (GHG) emissions during movement/idling	4	0.750	3
		4	0.000	0

B3.1	Marketability	3	0.250	1
B3.2	Standard entry level wage ratio	4	0.500	2
B3.3	Employment opportunity	4	0.250	1
B3.4	Affordability	3	0.000	0
B3.5	Long term plan	3	0.000	0
B4	Indirect Economic impacts	3	**0.250**	1
B4.1	Indirect Economic impacts	3	0.000	0
B4.2	Non-monetary benefits	3	0.000	0
B4.3	Finance Leverage	3	0.750	2

C1.9	Fuelling Vehicles - safety equipment	5	1.000
C1.10	Fuel Storage - Tests of safety devices	5	1.000
		5	1.000
		5	1.000
		5	1.000
C1.11	Fuel storage - safety equipment	5	1.000
C1.12	Personal Protective Equipment (PPE)	5	1.000
C2	Security	5	**0.714**
C2.1	Initiatives to improve Security	5	0.750
		5	1.000
		5	1.000
		5	0.750
		5	1.000
		5	0.500
C2.2	Security breach	5	0.000
C3	Community wellbeing and engagement	3	**0.330**
C3.1	Community awareness program	3	0.500
C3.2	Complaints	4	0.000
C3.3	Community engagement program	3	0.000
C3.4	Community appreciation	1	0.000
C3.5	Impacts of operations on local communities	1	0.000
		1	0.000
C3.6	Prevention and mitigation measures program	3	0.000

A5.3	Utilization of environmentally friendly vehicles	3	0.250	1
A5.4	Reduce GHG emissions associated with energy consumption	4	0.250	1
		4	0.000	0
A6	Waste	4	**0.429**	2
A6.1	Reduce Hazardous Wastes produced from ad-hoc activities (e.g. commissioning procedures) and spills	4	0.750	3
		4	0.000	0
A6.2	Reduce Hazardous Wastes produced from routine operation and maintenance	4	0.750	3
		4	0.000	0
A6.3	Reduce Non Hazardous Wastes produced from routine operation and maintenance	4	0.750	3
		4	0.000	0
A6.4	Pollution of land / waterways	4	0.750	3
A7	Land Use & Biodiversity	3	**0.321**	1
A7.1	Efficiency of land use	3	0.750	2
A7.2	Impact of location and size of land used for operations in biodiversity	3	0.000	0
A7.3	Impact of activities in biodiversity	1	0.000	0
A8	Expenditures	3	**0.500**	2
A8.1	Initiatives to monitor Environmental mitigation and protection expenditures	1	0.500	1
A9	Noise	2	**0.500**	1
A9.1	Noise pollution	2	0.500	1

C3.7	Initiatives for community	2	0.000
C3.8	Compensations to personnel	3	0.250
		3	0.000
C3.9	Contractors with sustainability orientation	3	0.250
		3	0.000
C3.10	Diversity	4	0.750
		4	1.000
C3.11	Employee wellbeing	4	0.500
		4	0.000
C3.12	Business Continuity Plan	4	1.000
C3.13	Local materials	3	0.500
C4	Employment	4	**0.583**
C4.1	Employee hires and turnover	4	0.750
		4	0.000
C4.2	Staff localization	4	1.000
C5	Labor / Management Relations	2	**0.917**
C5.1	Notices of changes in operations	2	0.750
C5.2	Hygiene standards	4	1.000
C6	Education and Training	4	**0.511**
C6.1	Training per year per employee	3	1.000
		3	0.000

C6.2	Skill management of employees	1	0.750
		1	0.000
C6.3	Performance and career development	4	1.000
		4	0.000
C6.4	On-Job-Training	4	0.750
C6.5	Sustainability research and development	2	0.250
C7	Quality of services	4	**0.313**
C7.1	Eliminate customer complaints	4	1.000
		4	0.000
		4	0.000
C7.2	Improve customer satisfaction	4	0.750
		4	0.000
C7.3	Sustainable transportation of employees	3	0.500
		3	0.000
C7.4	Improve employee satisfaction	3	0.500
		3	0.000
C8	Regulatory Compliance	3	**0.000**
C8.1	Anti-competitive behavior	2	0.000
C8.2	Fines for non compliances with regulations	3	0.000
C9	Cultural heritage	1	**0.500**
C9.1	Financial contributions to cultural institutions	1	0.500

Emissions Calculator

Sustainability of airport operations

Part 1: Emissions associated with Aviation fuel storage and handling activities

Instructions

1. Fill in all applicable data required in the "INPUT" tab
   - 1.1. Ensure the data correspond to 1 day
   - 1.2. Ensure the values reported correspond to the units displayed next to each data box
2. Once all data have been provided, go to the Output tabs (in yellow):
   - 2.1. Environmental Impact: calculated emissions based on the input provided
   - 2.2. Financial Impact: costs corresponding to offsetting/recovering the calculated emissions
   - 2.3. Social Impact: estimations of health-related impact of VOC and equivalency of CO_2 emissions into every days' (community) terms
3. References tab: Includes a list of references (for info)
4. Calculation sheets (for info)
   - 4.1. Calculator tabs are locked to protect against accidental loss of calculation equations and data

Contents

1. INPUT
2. Environmental Impact
3. Financial Impact
4. Social Impact

A. Emissions related to aircraft refuelling
B. Emissions from tank farms
C. Emissions from vehicle traffic
D. Emissions from hydrant operations

Input tab

Reported values should correspond to 1 day

Airport: PMIA

Aircraft Fuelling

	Daily	Units
Jet Fuel delivered	50,000.0	lt
Jet fuel by Hydrant System	80.0%	%
Jet Fuel density	0.80	kg/lt
Jet fuel by Refueller	20.0%	%
Jet fuel defuelled into Refueller	1,000.0	lt
Avgas delivered by Refueller		lt
Avgas density		kg/lt

Airport Area

Total area of the airport	27,126,850.0	sq. miles

Hydrant operation

Number of low points flushed daily	1.0	# low points
Average quantity flushed per low point	200.0	lt

Tank Farm

	Daily		
Basic Input Data	**JET A1 Tanks**	**Avgas Tanks**	Units
Vapor recovery system present?	No		Yes/No
Tank Data			
Diameter	22.5		m
Capacity	5,000,000.0		lt
(C)onical or **(D)**ome roof?	C		"C" or "D"
Shell height	13.5		m
Liquid Data			
Maximum daily throughput	50,000.0		lt/day/tank
Number of tanks in tankfarm	3.0		

Vehicle Movement - ITPO vehicles

	HDDV	HDGV	LDDV	LDGV	Units
Total Road length - all vehicles (by type)	878.0		201.5		Km
Total Idle time - all vehicles (by type)	3,162.5		1,290.0		min
Average consumption, lt/100km	215.0		15.0		lt/100km driven

HDDV *Heavy-Duty Diesel Vehicles*
HDGV *Heavy-Duty Gasoline Vehicles*
LDDV *Light-Duty Diesel Vehicles*
LDGV *Light-Duty Gasoline Vehicles*

Hydrant Low Point (LP) flushing Vehicle

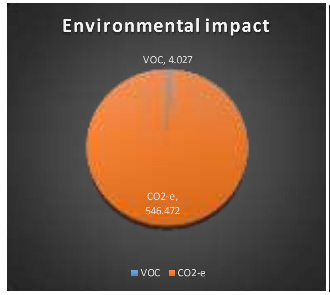
	HDDV	Units
Total Road length - all LP flushing vehicles	7.0	Km
Total Idle time - all LP flushing vehicles	20.0	min
Average consumption, lt/100km	15.0	lt/100km driven

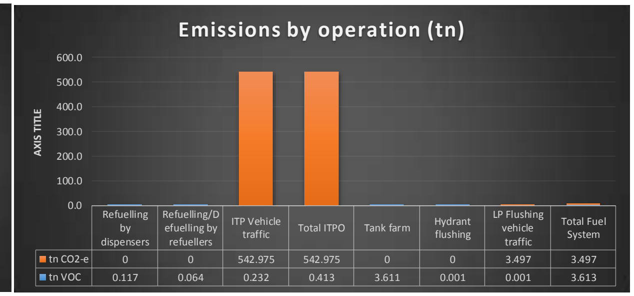
Environmental Impact

PMIA **Airport**

Total Emission calculations

Environmental impact - Emissions		per year	Units
Total emissions, VOC	VOC	**4.027**	tn
Total emissions, CO2-e	CO2-e	**546.472**	tn
Total emissions, Other Vehicle Exhaust	Other	4.818	tn
Total emissions, THC	THC	0.235	tn
Total emissions, CO	CO	1.305	tn
Total emissions, NOx	NOx	3.191	tn
Total emissions, $PM_{2.5}$+PM_{10}	PM	0.0820	tn
Total emissions, CH4	CH4	0.0023	tn
Total emissions, N2O	N2O	0.0018	tn





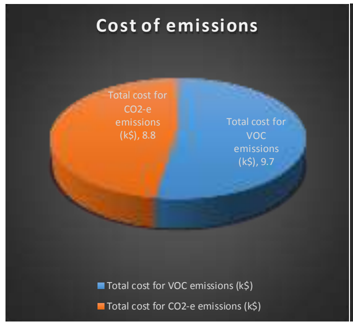
	ITPO				Fuel System				
	Refuelling by dispensers	Refuelling/Defuelling by ref	ITP Vehicle traffic	**Total ITPO**	Tank farm	Hydrant flushing	LP Flushing vehicle t	**Total Fuel System**	
tn VOC	0.117	0.064	0.232	**0.413**	3.611	0.001	0.001	**3.613**	tn VOC
tn CO2-e	0	0	542.975	**542.975**	0	0	3.497	**3.497**	tn CO2
				543.388				**7.110**	tn

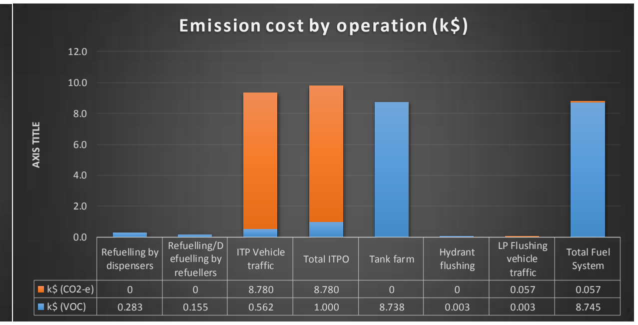
Financial Impact

PMIA Airport

Total Financial calculations

Financial Impact	per year	Units
Unit cost to recover VOC [2]	2,420.0	$/tn VOC reduced
Total cost for VOC emissions (k$)	9.7	k$
Unit cost for to off-set CO2-e [4], [5]	16.2	$/tn CO2 offset
Total cost for CO2-e emissions (k$)	8.8	k$
Total cost	18.6	k$





	ITPO				Fuel System				
	Refuelling by dispensers	Refuelling/Defuelling b	ITP Vehicle traffic	**Total ITPO**	Tank farm	Hydrant flushing	LP Flushing vehicle tra	**Total Fuel System**	
k$ (VOC)	0.283	0.155	0.562	**1.000**	8.738	0.003	0.003	**8.745**	k$
k$ (CO2-e)	0	0	8.780	**8.780**	0	0	0.057	**0.057**	k$
				9.780				**8.801**	k$

Social impact

PMIA **Airport**

> Social impact of VOC emissions [15]

Health effect of VOC emissions

		Units
Brain and nervous system cancer incidence rate	**0.000**	new cancers occurring per 100,000 people per year

>Social impact of CO2-e emissions [18]

Total CO2-e emissions 546.47 tn CO2

Equivalencies of CO2-e emissions

Greenhouse gas emissions from

104.4 Passenger vehicles driven for one year

Carbon sequestered by

12,732.8 tree seedlings grown for 10 years

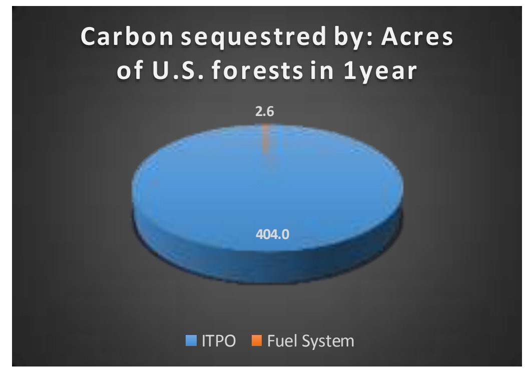
406.6 acres of U.S. forests in one year

CO_2 emissions from

45.4 homes' energy use for one year

55740.1 gallons of gasoline consumed

1147.6 barrels of oil consumed



	ITPO	Fuel System
CO2-e (tn)	542.97469	3.49698
Carobon sequestered by acres of U.S. forests in one year	**404.0**	**2.6**

Equivalencies from:

http://www2.epa.gov/energy/greenhouse-gas-equivalencies-calculator

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Calculations

		Units
VOC emissions		
VOC concentration at t	**0.000**	pounds VOC/sq. mile

Equations for cancer incedence rates as a function of VOC emissions

Linear model for VOC	m (x 10-4)	b
Brain and nervous system	7.367	5.877

Linear model : Y = mX + b,

Y is the cancer incidence rate

X the pounds of emissions/square mile,

b is a constant, and

m is a coefficient

Correlation with Nonchlorinated VOC emissions

Calculation Sheet: Emissions from Aircraft and Refueller Vents

PMIA **Airport**

Emissions from aircraft fuel tank vents during aircraft refuelling and Emissions from tank truck vent during loading

Data below correspond to:	1	days	**Calculations correspond to**	365	days

Input

		Units
Jet Fuel delivered	50,000.0	lt
Jet fuel by Hydrant System	80.0%	%
Jet Fuel density	0.80	kg/lt
Jet fuel by Refueller	20.0%	%
Jet fuel defuelled into Refueller	1,000.0	lt
Avgas delivered by Refueller	0.0	lt
Avgas density	0.00	kg/lt

Emission Calculations

	per year	Units
Total emissions, Jet fuel	181.040	kg VOC
Total emissions, Avgas	0.000	kg VOC
A. Total emissions	**181.040**	kg VOC
A1. By Dispensers	116.800	kg VOC
A2. By Refuellers	64.240	kg VOC

Financial Impact

		Units
Unit cost for reducing VOC [2]	2,420.0	$/tn VOC reduced
Total cost for VOC emissions	0.438	k$

Factors [1]

Jet fuel Emission factor	0.01	gr VOC/kg fuel
Avgas Emission factor	1.27	gr VOC/kg fuel

Equations

Equation used for the above calculation

Emissions [g VOC] = Σfuel types ((fuelhydrant delivered [kg] + 2 × fueltanker delivered [kg]) × emission factor [g/kg]) + (2 × fueltanker defuelled [kg]) × emission factor [g/kg])

Calculation Sheet: Emissions from Hydrant operations

PMIA **Airport**

Emissions from low point flushing vehicle, during hydrant low point flushing activity

Data below correspond to:	1	days	**Calculations correspond to**	365	days

Input

		Units
Number of low points flushed daily	1.0	# low points
Average quantity flushed per low point	200.0	lt
Jet Fuel density	0.8	kg/lt

Emission Calculations

	per year	Units
Total emissions, Jet fuel	1.168	kg VOC

Note: The Hydrant LP Vehicle exhaust emissions are calculated in the "Vehicle Trafiic" tab

Link to LP Vehicle exhaust emissions

Financial Impact

		Units
Unit cost for reducing VOC [2]	2,420.0	$/tn VOC reduced
Total cost for VOC emissions	0.003	k$

Factors [1]

Jet fuel Emission factor	0.01	gr VOC/kg fuel

Equations

Equation used for the above calculation

Emissions [g VOC] = (fuel flushed per low point [kg]) × emission factor [g/kg])

Calculation Sheet: Emissions from Storage Tanks

PMIA **Airport**

Emissions from handling aviation fuels into storage tanks

Data below correspond to:	1	days	
Calculations correspond to	365	days	

Input

	JET A1 Tanks	Avgas Tanks	Units
Basic Input Data			
Vapor recovery system present?	No	No	Yes/No
Tank Data			
Diameter	22.5	0.0	m
Capacity	5,000,000.0		lt
(C)onical or **(D)**ome roof?	C	C	"C" or "D"
Shell height	13.5	0.0	m
Liquid Data			
Maximum daily throughput	1,320,000.0	0.0	lt/day/tank
Number of tanks in tankfarm	3.0	0.0	

Emission Calculations

	per year	Units
Total emissions, Jet fuel	3,610.890	kg VOC
Total emissions, Avgas	0.000	kg VOC
Total emissions	**3,610.890**	kg VOC

Financial Impact

		Units
Unit cost for reducing VOC [2]	2,420.0	$/tn VOC reduced
Total cost for VOC emissions	8.738	k$

Equations [1],[3]

Equation used for the above calculation

Emissions [kg VOC] = SL + WL

Calculation Sheet: Emissions from vehicle traffic

PMIA **Airport**

Emissions from vehicle traffic of refuelling and servicing vehicles

Data correspond to: 1 days

Input	Hydrant flushing vehicle	ITPO vehicles				
	Heavy-Duty Diesel Vehicles	Heavy-Duty Diesel Vehicles	Heavy-Duty Gasoline Vehicles	Light-Duty Diesel Vehicles	Light-Duty Gasoline Vehicles	
	HDDV	HDDV	HDGV	LDDV	LDGV	Units
Total Road length - all vehicles (by type)	7.0	878.0	0.0	201.5	0.0	Km
Total Idle time - all vehicles (by type)	20.0	3,162.5	0.0	1,290.0	0.0	min
Average consumption, lt/100km	15.0	215.0	0.0	15.0	0.0	lt/100km driven
Average consumption, lt/min idling	0.063	0.063	0.063	0.063	0.063	lt/min idling
Calculation of total consumption						
Corresponding fuel consumption per year	843.8	761,836.3	0.0	40,738.1	0.0	lt

Calculations correspond to 365 days

Emission Calculations	Hydrant flushing vehicle per year	ITPO vehicles per year	Units
Total emissions, VOC	1.416	232.234	kg
Total emissions, THC	1.428	234.013	kg
Total emissions, CO	8.483	1,296.962	kg
Total emissions, NOx	22.230	3,169.139	kg
Total emissions, $PM_{2.5}$	0.565	81.451	kg
Total emissions, PM_{10}	0.617	89.025	kg
Total emissions, CH4	0.016	2.314	kg
Converted CH4 emissions to CO2-e	0.398	57.856	kg
Total emissions, N2O	0.012	1.801	kg
Converted N2O emissions to CO2-e	3.533	531.213	kg
Total emissions, CO2-e	3,496.980	542,974.689	kg

Financial Impact		Units
Unit cost for reducing VOC [2]	2,420.0	$/tn VOC reduced
Total cost for VOC emissions	0.565	k$
Unit cost for CO2 [4], [5]	16.17	$/tn CO2 offset
Total cost for CO2 emissions	8.836	k$
Total cost for all emissions	9.402	k$

Emission Factors [6], [7], [17]	**HDDV**	**HDGV**	**LDDV**	**LDGV**	
VOC Emission factor (driving)	0.347	1.232	0.147	1.051	gr/Km driven
VOC Emission factor (idle)	0.073	0.135	0.056	0.084	gr/min
THC Emission factor (driving)	0.352	1.270	0.151	1.087	gr/Km driven
THC Emission factor (idle)	0.073	0.151	0.056	0.101	gr/min
CO Emission factor (driving)	1.795	10.198	0.652	8.715	gr/Km driven
CO Emission factor (idle)	0.534	3.165	0.123	1.515	gr/min
NOx Emission factor (driving)	6.690	2.263	2.398	2.124	gr/Km driven
NOx Emission factor (idle)	0.704	0.111	0.078	0.085	gr/min
$PM_{2.5}$ Emission factor (driving)	0.157	0.034	0.071	0.033	gr/Km driven
$PM_{2.5}$ Emission factor (idle)	0.023	0.000	0.000	0.000	gr/min
PM_{10} Emission factor (driving)	0.170	0.040	0.077	0.038	gr/Km driven
PM_{10} Emission factor (idle)	0.025	0.000	0.000	0.000	gr/min
CH4 Emission factor (driving)	0.004	0.038	0.001	0.027	gr/Km driven
CH4 Emission factor (idle*)	0.001	0.008	0.000	0.005	gr/min
N2O Emission factor (driving)	0.003	0.068	0.001	0.039	gr/Km driven
N2O Emission factor (idle*)	0.001	0.014	0.000	0.008	gr/min
CO2 Emission factor (driving)	870.000	924.000	374.000	400.000	gr/Km driven
CO2 Emission factor (idle*)	174.000	184.800	74.800	80.000	gr/min

*Due to lack of data, emission rates for idling are given as estimations, considering idling factors are 20% of emission factors during driving

Equations

Equation used for the above VOC calculations

E = RL × EF,
E=Emissions (grams),
RL=road length (km),
EF=emission factor, grams/vehicle-km driven

E = T × EF1,
E=Emissions (grams),
T=idle time (mins),
EF1=idle emission factor

Energy Calculator

Sustainability of airport operations

Part 2: Energy consumption associated with Aviation fuel storage and handling activities

Instructions

1. Fill in all applicable data required in the tabs "Pumps and Instruments", "Buildings" and "Vehicles"
   The tabs above include an INPUT section (where input is to be provided) and an OUTPUT section (with calculations)
   1.1. Ensure input is given in all white-coloured cells in the INPUT section of each tab
   1.2. Ensure the values reported correspond to the units displayed next to each data box
2. Once all data have been provided, go to the Output tabs (in yellow) to see Impacts:
   2.1. Environmental: calculated CO_2 emissions, based on calculated energy consumption for pumps/equipment, energy consumption for buildings and fuel consumption for vehicles
   2.2. Financial: costs for electricity consumption of pumps/equipment and buildings, along with costs for motor vehicle fuel and cost to offset calculated CO_2 emissions
3. References tab: Includes a list of references (for info)

Contents

Airport:

Add Name of the airport

Input - Pumps

INPUT

Colour-coding:

White cells: Add Input, Grey Cells: Add input if site specific data are available, otherwise leave default values, Orange cells: indicate calculations (do not change)

INPUT ON GENERAL PARAMETERS

			Units
Electricity Average Unit Price	:	0.085	$/kWh

Input for 1 day

INPUT for Pumps		Tankfarm											Hydrant
	Name pump>	Jet Pump	Slop	Tank transfer/recovery	Unloading	Other Depot	Other Depot	Other Depot	Other Depot	Other Depot	Foam	Fire water	Hydrant
# of pumps working concurrently	**Units**	1	0	1	1								
Concurrency factor*			0.3	0.7	1.0						0.0	0.3	
Operating Hrs per day	Hrs	20.0	1.0	3.0	42.0							1.0	20.0
Density**	kg/m³	800.0	800.0	800.0	800.0						1200.00	1000.00	800.0
Output	m³/h	275.0	30.0	120.0	90.0								
Delivery height	m		3.5	3.5	10.0								2.0
Efficiency of pump**		0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.80	0.80	0.75
Efficiency of motor**		0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.80	0.80	0.95
Overall efficiency		0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.64	0.64	0.71

*Concurrency factor: No operation: 0, Low Operation: 0.3, High operation:0.7, Full operation: 1

**If no site specific data are available, leave default values

Input for 1 day

INPUT for Instruments		Tankfarm				Hydrant			
		Number	Concurrency factor*	Estimated energy consumption (kW)**	Operating hrs (per day)	Number	Concurrency factor	Estimated energy consumption (kW)**	Operating hrs (per day)
Electrical actuators	#	60	0.3	1.2	1	25	0.3	1.2	0.5
Instruments	#	47	1	0.04	24	39	0.3	0.04	24
Outdoor spotlights on poles	#	120	0.7	0.4	12	0	0.7	0.4	0
Outdoor fluorescent light fittings	#	70	0.3	0.12	12	34	0.7	0.12	0
Cathodic protection	#	3	1	0.4	24	1	1	0.4	0

OUTPUT

Calculations for 1 year

Pumps		Pumps - Tankfarm											Pumps - hydrant
		Jet Pump	Slop	Tank transfer/recovery	Unloading	Other Depot	Other Depot	Other Depot	Other Depot	Other Depot	Foam	Fire water	Hydrant
Energy consumption	kWh	**0.0**	**10.6**	**985.0**	**42214.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Total		Tankfarm	**43209.5**	kWh	Hydrant	**0.0**	kWh						
		CO_2 emissions:	**34567.6**	kgCO2	CO_2 emissions:	**0.0**	kgCO2						

Calculations
Energy cons. = 365 (days) x Number of pumps working concurrently x Concurrency factor x Operating hrs per day x Pump Output flowrate (m3/hr) x Delivery height (m) x Density (kg/m3) x gravity (g=9.81m2/s) / (Overall efficiency x 3.6*10^6)
CO2 emissions = Energy consumption (kWh) x Emission factor (kgCO2/kWh)

Calculations for 1 year

Instruments	Tankfarm		Hydrant	
Energy consumption	kWhr	CO2 emissions (kg CO2)	kWhr	CO2 emissions (kg CO2)
Electrical actuators	7884	6307	1642.5	1314
Instruments	16468.8	13175	4099.68	3280
Outdoor spotlights on poles	147168	117734	0	0
Outdoor fluorescent light fittings	11037.6	8830	0	0
Cathodic protection	10512	8410	0	0
Total	**193070.4**	**154456.3**	**5742.2**	**4593.7**

Calculations
Energy consumption = 365 (days) x Number of instruments working concurrently x Concurrency factor x Operating hrs per day x Estimated energy consumption
CO2 emissions = Energy consumption (kWh) x Emission factor (kgCO2/kWh)

GENERAL PARAMETERS (Default values)			Ref:
Unit cost for CO_2 offset	16.17	$/tn CO_2	("Carbon Portal," n.d.)
CO_2 Emission Factor (Electricity)	0.8	$kgCO_2/kWh$	("US Environmental Protection Agency | US EPA," n.d.)

Airport:

Add Name of the airport

Input - Buildings

INPUT

Colour-coding:

White cells: Add Input, Grey Cells: Add input if site specific data are available, otherwise leave default values, Orange cells: indicate calculations (do not change)

Input for 1 day

INPUT for A/C		Tankfarm		ITPO		Hydrant	
		buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)
Quantity of A/C units	#	0	30	0	7	0	
Concurrency factor*			0.7		1.0		
Power rating**	kW	3.5	3.5	3.5	3.5	3.5	3.5
Hours used per day	hr		24		24		

*Concurrency factor: No operation: 0, Low Operation: 0.3, High operation:0.7, Full operation: 1

**If no site specific data are available, leave default values

INPUT for ALL sockets and lights		Tankfarm		ITPO		Hydrant	
		buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)
Lump of Sockets, lights	#		446.0		156.0		
Concurrency factor*		0.0	0.7	0.0	0.7		
Power ratng**	kW	25.0	25.0	25.0	25.0	25.0	25.0
Hours used per day	hr		24.0		24.0		

OUTPUT

Calculations for 1 year

Calculations		Tankfarm		ITPO		Hydrant		
		buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	
Energy consumption-A/C	kWh	0	643860	0	214620	0	0	858480
Energy consumption-All sockets/ligh	kWh	0	68371800	0	23914800	0	0	92286600
CO2 emissions-A/C	kgCO2	0	515088	0	171696	0	0	686784
CO2 emissions-All sockets/lights	kgCO2	0	54697440	0	19131840	0	0	73829280

Calculations

Energy consump. = 365 x Quantiry of units x Power rating (kWh) x Hours used per day (hr) x concurrency factor

Emissions = Energy consumption (kWh) x Emission factor (kgCO2/kWh)

Airport:

Add Name of the airport

Input - Vehicle movement

INPUT

Colour-coding:

White cells: Add Input, Grey Cells: Add input if site specific data are available, otherwise leave default values, Orange cells: indicate calculations (do not change)

INPUT ON GENERAL PARAMETERS

			Units
Diesel Fuel Price per lt	:	0.120	$/lt
Gasoline Fuel Price per lt	:	0.480	$/lt

Input for 1 day

INPUT for Vehicle Traffic		Hydrant LP flushing vehicles		ITPO Vehicles				
		Diesel Engines (HD)	Gasoline Engines (HD)	Diesel Engines (HD)	Gasoline Engines (HD)	Diesel Engines (LD)	Gasoline Engines (LD)	HD: Heavy Duty; LD: Light Duty
Total Road length - all vehicles (by type)	km	15		878		201		
Total Idle time - all vehicles (by type)	min	20		3163		1290		
Average consumption during driving	lt/100km	15.0		215.0		15.0		
Average consumption during idling**	lt/min idling	0.063	0.063	0.063	0.063	0.063	0.063	

**If no site specific data are available, leave default values

OUTPUT

Calculations for 1 year

Calculations		Hydrant LP flushing vehicles		ITPO Vehicles				
		Diesel Engines (HD)	Gasoline Engines (HD)	Diesel Engines (HD)	Gasoline Engines (HD)	Diesel Engines (LD)	Gasoline Engines (LD)	HD: Heavy Duty; LD: Light Duty
Fuel consumption	lt	1304	0	761836	0	40711	0	
CO2 emissions	kgCO2	3516.4	0.0	2054822.2	0.0	109804.9	0.0	2168143.5

Calculations

Fuel consumption = Σ all fuel types 365*[Distance driven per day (km) x consumption during driving (lt/100km) + time in idle per day (min) x consumption during idling (lt/min)]

CO2 Emissions = Consumption (Diesel) x Emission factor (Kg CO2/lt Diesel) + Consumption (Gasoline) x Emission factor (Kg CO2/lt Gasoline)

GENERAL PARAMETERS (Default values)		
CO2 emissions per lt consumed (Diesel)	2.7	kg CO2/lt cons.
CO2 emissions per lt consumed (Gasoline)	2.3	kg CO2/lt cons.

Ref: Emission Factors for Greenhouse Gas Inventories, http://www2.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf

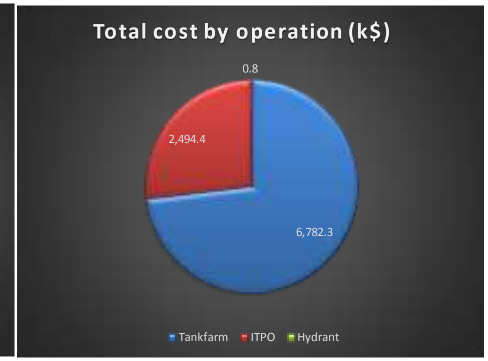
Financial Impact

Airport **PMIA**

Financial impact calculations

Pumps and Instruments	Energy Consumption	Units	Cost of electricity	Units	Cost of CO_2 offset	Units
Pumps-Tankfarm	**43,209.5**	kWh	**3.67**	k$	**0.56**	k$
Instruments-Tankfarm	**193,070.4**	kWh	**16.41**	k$	**2.50**	k$
Pumps-Hydrant	**0.0**	kWh	**0.00**	k$	**0.00**	k$
Instruments-Hydrant	**5,742.2**	kWh	**0.49**	k$	**0.07**	k$
Total	**242,022.1**	kWh	**20.57**	k$	**3.13**	k$
Buildings	Energy Consumption		Cost of electricity		Cost of CO_2 offset	
Tankfarm	**69,015,660.0**	kWh	**5,866.33**	k$	**892.79**	k$
ITPO	**24,129,420.0**	kWh	**2,051.00**	k$	**312.14**	k$
Hydrant	**0.0**	kWh	**0.00**	k$	**0.00**	k$
Total	**93,145,080.0**	kWh	**7,917.33**	k$	**1,204.92**	k$
Vehicles	Fuel consumption		Cost of fuel		Cost of CO_2 offset	
ITPO vehicles (Diesel engines)	**802,547.1**	lt	**96.31**	k$	**35.00**	k$
Hydrant Vehicles (Diesel engines)	**1,303.7**	lt	**0.16**	k$	**0.06**	k$
ITPO vehicles (Gasoline engines)	**0.0**	lt	**0.00**	k$	**0.00**	k$
Hydrant Vehicles (Gasoline engines)	**0.0**	lt	**0.00**	k$	**0.00**	k$
Total		lt	**96.46**	k$	**35.06**	k$

Total Cost of Electricity	**7,937.90**	k$
Total Fuel cost	**96.46**	k$
Total cost to offset CO2 emissions	**1,243.11**	k$
TOTAL	**9,277.48**	k$



	Energy cost	Fuel cost	CO_2 offset	Total
Tankfarm	5,886.4	0.0	895.8	**6,782.3**
ITPO	2,051.0	96.3	347.1	**2,494.4**
Hydrant	0.5	0.2	0.1	**0.8**

Social impact

Airport **PMIA**

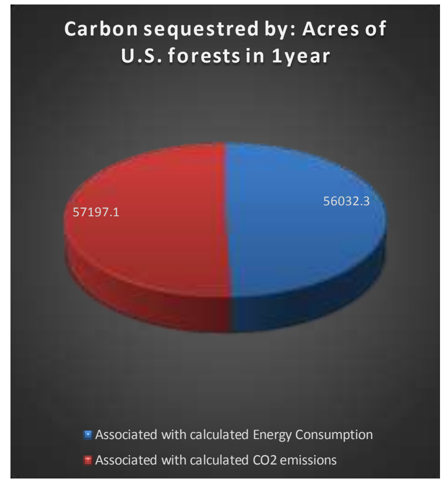
Social Impact of Energy consumption and Motor Vehicle fuel consumption

		Units
Energy Consumption	93,387,102.11	kWh
Fuel Consumption Vehicles (Total)	76,877.83	tn CO_2

Social Impact

Equivalencies of CO2-e emissions

	Associated with calculated Energy Consumption	Associated with calculated CO_2 emissions	Total
Greenhouse gas emissions from			
	9338.7 Passenger vehicles driven for one year	14683.7 Passenger vehicles driven for one year	24022.4 Passenger vehicles driven for one year
Carbon sequestered by			
	1680967.8 tree seedlings grown for 10 years	######## tree seedlings grown for 10 years	3472221.2 tree seedlings grown for 10 years
	56032.3 acres of U.S. forests in one year	57197.1 acres of U.S. forests in one year	113229.4 acres of U.S. forests in one year
CO_2 emissions from			
	9338.7 homes' energy use for one year	6380.9 homes' energy use for one year	15719.6 homes' energy use for one year
	7284194.0 gallons of gasoline consumed	######## gallons of gasoline consumed	15125732.1 gallons of gasoline consumed
	186774.2 barrels of oil consumed	161443.4 barrels of oil consumed	348217.6 barrels of oil consumed



Equivalencies from:
http://www2.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Appendix Q: Case Study 2 - Sample

Alternative 1

Assessment

INPUT

Instructions

> Projected Sales

Year	
Volume (lt)	**2,800,000,000.0**
Sales ($)	**$896,000,000.0**

Note: numbers shown below in the 'Priority' column are for demostration purposes only (examples) - Please edit as described below:

> Define priorities for the 3 sustainability dimensions and the primary/secondary criteria - Use the scale: (1: Not important, 2: Slightly important, 3: Moderately important, 4: Important, 5: Very important)

#	Environmental > Go to Assessment tab	Applicability?	Priority (1-5)
A	Environmental	Applies	4
A1	Administrative procedures	Applies	2
A1.1	Cooperative Sustainability Policy	Applies	2
A1.2	Sustainable Procurement Policy	Applies	2
A1.3	Green Procurement Policy	Applies	2
A1.4	Use of renewable materials	Applies	2
A1.5	Recycle used materials	Applies	3
A1.6	Environmental impact assessment (EIA) study	Applies	1
A1.7	Environmental Certificate	Applies	1
A2	Water efficiency	Applies	3
A2.1	Wastewater generation	Applies	2
A2.2	Water withdrawal	Applies	3
A2.3	Storm water management system	Applies	3
A2.4	Recycle/reuse water	Applies	3
A2.5	Landscaping water use	Applies	1
A2.6	Water use reduction	Applies	4
A3	Indoor environmental quality	Applies	4
A3.1	Indoor ventilation and Air Quality	Applies	4
A4	Energy	Applies	4
A4.1	Energy savings from operation of pumps	Applies	4
A4.2	Energy savings from operation of buildings	Applies	4
A4.3	Use of Renewable Energy	Applies	3
A4.4	Vehicle fuel savings	Applies	3
A5	Emissions	Applies	4
A5.1	Reduction in VOC emissions	Applies	4
A5.2	Vehicle exhaust (GHG) emissions during movement/idling	Applies	4
A5.3	Utilization of environmentally friendly vehicles	Applies	3
A5.4	Reduce GHG emissions associated with energy consumption	Applies	4
A6	Waste	Applies	4
A6.1	Reduce Hazardous Wastes produced from ad-hoc activities (e.g. commissioning procedures) and spills	Applies	4
A6.2	Reduce Hazardous Wastes produced from routine operation and maintenance	Applies	4
A6.3	Reduce Non Hazardous Wastes produced from routine operation and maintenance	Applies	4
A6.4	Pollution of land / waterways	Applies	4
A7	Land Use & Biodiversity	Applies	3
A7.1	Efficiency of land use	Applies	3
A7.2	Impact of location and size of land used for operations in biodiversity	Applies	3
A7.3	Impact of activities in biodiversity	Applies	1
A8	Expenditures	Applies	3
A8.1	Initiatives to monitor Environmental mitigation and protection expenditures	Applies	1
A9	Noise	Applies	2
A9.1	Noise pollution	Applies	2

#	Economic > Go to Assessment tab	Applicability?	Priority (1-5)
B	**Economic**	**Applies**	**5**
B1	Economic performance analysis	Applies	4
B1.1	Life-cycle cost analysis	Applies	3
B1.2	Assessment of Capital projects	Applies	4
B1.3	Land and property value	Applies	3
B1.4	Capital to sales ratio	Applies	4
B1.5	Operating Expenses to Sales	Applies	4
B1.6	Operating Expenses Efficiency Control	Applies	4
B1.7	Maintenance to Assets cost	Applies	3
B1.8	Working Capital To Sales	Applies	4
B2	Economic value retained	Applies	5
B2.1	Direct economic value generated	Applies	5
B2.2	Economic value retained	Applies	3
B2.3	Net Present Value (NPV)	Applies	4
B2.4	Pay back Period	Applies	5
B2.5	Return on Assets (ROA)	Applies	4
B2.6	Financial implications due to emissions of pollutants and climate change substances	Applies	3
B3	Market presence	Applies	3
B3.1	Marketability	Applies	3
B3.2	Standard entry level wage ratio	Applies	4
B3.3	Employment opportunity	Applies	4
B3.4	Affordability	Applies	3
B3.5	Long term plan	Applies	3
B4	Indirect Economic impacts	Applies	3
B4.1	Indirect Economic impacts	Applies	3
B4.2	Non-monetary benefits	Applies	3
B4.3	Finance Leverage	Applies	3

#	Social > Go to Assessment tab	Applicability?	Priority (1-5)
C	Social	Applies	4
C1	Occupational Health and Safety	Applies	5
C1.1	Representation in HSSE committees	Applies	3
C1.2	Reduce Work-related injuries and fatalities	Applies	5
C1.3	Work-related injuries and fatalities	Applies	5
C1.4	Eliminate occupational diseases, lost days, and absenteeism	Applies	4
C1.5	Health and Safety awareness and prevention	Applies	5
C1.6	Education enhancement on HSSSE awareness	Applies	5
C1.7	Health and Safety covered in formal agreements with trade unions	Applies	3
C1.8	Fuelling Vehicles - Tests of safety devices	Applies	5
C1.9	Fuelling Vehicles - safety equipment	Applies	5
C1.10	Fuel Storage - Tests of safety devices	Applies	5
C1.11	Fuel storage - safety equipment	Applies	5
C1.12	Personal Protective Equipment (PPE)	Applies	5
C2	Security	Applies	5
C2.1	Initiatives to improve Security	Applies	5
C2.2	Security breach	Applies	5
C3	Community wellbeing and engagement	Applies	3
C3.1	Community awareness program	Applies	3
C3.2	Complaints	Applies	4
C3.3	Community engagement program	Applies	3
C3.4	Community appreciation	Applies	1
C3.5	Impacts of operations on local communities	Applies	1
C3.6	Prevention and mitigation measures program	Applies	3
C3.7	Initiatives for community	Applies	2
C3.8	Compensations to personnel	Applies	3
C3.9	Contractors with sustainability orientation	Applies	3
C3.10	Diversity	Applies	4
C3.11	Employee wellbeing	Applies	4
C3.12	Business Continuity Plan	Applies	4
C3.13	Local materials	Applies	3
C4	Employment	Applies	4
C4.1	Employee hires and turnover	Applies	4
C4.2	Staff localization	Applies	4
C5	Labor / Management Relations	Applies	2
C5.1	Notices of changes in operations	Applies	2
C5.2	Hygiene standards	Applies	4
C6	Education and Training	Applies	4
C6.1	Training per year per employee	Applies	3
C6.2	Skill management of employees	Applies	1
C6.3	Performance and career development	Applies	4
C6.4	On-Job-Training	Applies	4
C6.5	Sustainability research and development	Applies	2
C7	Quality of services	Applies	4
C7.1	Eliminate customer complaints	Applies	4
C7.2	Improve customer satisfaction	Applies	4
C7.3	Sustainable transportation of employees	Applies	3
C7.4	Improve employee satisfaction	Applies	3
C8	Regulatory Compliance	Applies	3
C8.1	Anti-competitive behavior	Applies	2
C8.2	Fines for non compliances with regulations	Applies	3
C9	Cultural heritage	Applies	1
C9.1	Financial contributions to cultural institutions	Applies	1

Environmental

Instructions

FILL IN ALL ORANGE-COLOURED CELLS

#	Environmental Criteria	Description / Definition	Assessment Standard of measure	Reference	Assessment Select an option from the drop-down list	Utility (0-1)
A	Environmental					
A1	Administrative procedures					
A1.1	Cooperative Sustainability Policy	Adopt an own corporate policy on sustainable standards	Report if Corporate sustainability policy is in place	CDA, Sustainable Airport Manual, 2013	Limited process, program or policy in place to address issues	0.25
A1.2	Sustainable Procurement Policy	Adopt an own sustainable procurement policy	Report if Sustainable procurement policy in place	CDA, Sustainable Airport Manual, 2013	Limited process, program or policy in place to address issues	0.25
A1.3	Green Procurement Policy	Reduce the environmental impact of products and services by developing a Green Purchasing Program.	Refer to SAM Appendix AP-A – Green Product Listing for products and their minimum required content levels. Points for this credit will be awarded based on the number of green products, as defined in Appendix AP-A, procured for general day-to-day office use.	CDA, Sustainable Airport Manual, 2013 (pp. AP-13)	0	0.00
A1.4	Use of renewable materials	Reduce the need for virgin materials , energy, and waste by promoting the use of renewable input materials	Report whether there is a program in place to monitor percentage of recycled input materials used	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	0.25
			The percentage of paper recycled content is calculated as follows; % = (weight of chlorine-free paper/total weight of the paper)× % post-consumer recycled content	CDA, Sustainable Airport Manual, 2013 (pp. AP-16)	30% -	0.00
			Percentage of recycled input materials used, using the formula: (Total recycled input materials used/Input materials used) x 100	Sustainable Airport Manual, Chicago Airport	Less than 10%	0.00
A1.5	Recycle used materials	Reduce the need for virgin materials, energy, and waste by promoting the recycle of used materials	Report if there is a program in place to monitor the percentage of (recyclable) materials recycled	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	0.25
			Percentage of (recyclable) materials recycled, using the formula: (Total used materials recycled /Total used recyclable materials) x 100	Sustainable Airport Manual, Chicago Airport	Less than 10%	0.00
A1.6	Environmental impact assessment (EIA) study	EIA applies to ensure commitment to environmental regulations and standards stated in the General Environmental law of Saudi Arabia.	The requirement is one study for the whole project and this study should be updated if there is any additional facility or upgrading to the project.	CDA, Sustainable Airport Manual (2013), General Environmental Law and Rules for Implementation (15 October 2001)	0	0.00
A1.7	Environmental Certificate	To show that the company is committed to environmental laws and standards of a local or international organizations	Obtain environmental certificates from local (i.e. PME) or international organizations (i.e. LEED, ISO 14001) expressed the company's interest in saving the environment (the law of PME requires an environmental license for companies in petroleum sector)	Best practice	1 local and 1 international certificate	0.50

A2	Water efficiency					
A2.1	Wastewater generation	Eliminate the generation of wastewater use of potable water resources for vehicle washing	Report initiatives to minimize the amount of pollutants and chemicals entering waste water (e.g. vehicle washing monitoring programs)	CDA, Sustainable Airport Manual, 2013	Process, program or policy is well developed and reflects good practice from the industry	0.50
			Report the percentage calculates as follow: % = (total amount of current wastewater / total amount of previous wastewater) × 100	CDA, Sustainable Airport Manual, 2013 Best practise	10% -	0.00
A2.2	Water withdrawal	Monitor and improve the efficient use of water	Implement water use reduction programmes and report annual reduction achieved	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	0.50
			The percentage of water withdrawal production calculates as follow: % = (the total amount of current water use / total amount of previous water use) × 100	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	10% -	0.00
A2.3	Storm water management system	Effective drainage system is critical to minimize the effects of storm water on the environment and the operability of the airport	Implement storm water management programmes	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	0.25
			Measure the quality of storm water in accordance with the applicable regulatory standards	Sustainability Reporting Guidelines & Airport Operators Sector Supplement PME, General Environmental law, 2001	0	0.00
A2.4	Recycle/reuse water	Monitor and improve the water reuse/recycle	Implement reuse/recycled water programmes and report annual reduction achieved	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	0.25
			Total volume of water recycled/reused by the operation in cubic meters per year (%)	Sustainable Airport Manual, Chicago Airport	Less than 10%	0.00
A2.5	Landscaping water use	Water sources significantly affected by withdrawal of water	Identify water sources significantly affected by water withdrawal by the operation (i.e. Withdrawals that account for an average of 5% or more of the annual average volume of the local water body)	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Risks have not been assessed and performance is/will not be monitored	0.00
A2.6	Water use reduction	Efficiency to reduce the use of potable water & waste water	Water saving percentage	Sustainable Airport Manual, Chicago Airport	0	0.00

A3	**Indoor environmental quality**					
A3.1	Indoor ventilation and Air Quality	Improve indoor air quality	Report if ventilation systems have been designed using the Ventilation Rate Procedure or the applicable local code, whichever is more stringent	Sustainable Airport Manual, Chicago Airport	Some awareness of issue inside organization. Policy or program is communicated and enforced. Funding allocation to manage issue established on annual basis	0.50
			Increase outdoor air ventilation rates for all air-handling units serving occupied spaces by at least 30% above the minimum required by ASHRAE Standard 62.1-2007	Sustainable Airport Manual, Chicago Airport	30% -	0.00
			Report if one of the two options mentioned below have been implemented: A. Modify or maintain each outside air intake, supply air fan, and/or ventilation distribution system to supply at least the outdoor air ventilation rate required by ASHRAE 62.1—2010 under all normal operating conditions. OR B. Modify or maintain the system to supply at least ten cubic feet per minute (cfm) of outdoor air per person under all normal operating conditions.	Sustainable Airport Manual, Chicago Airport	Either Option A or B has been implemented	1.00
A4	**Energy**					
A4.1	Energy savings from operation of pumps	Reduce direct energy consumption associated with the operation of pumps	Report the initiatives for energy savings due to conservation and efficiency improvements	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	0.50
			Report the electricity consumption savings* in %, as a result of the energy saving initiatives	Sustainable Airport Manual, Chicago Airport	Less than 15%	0.00
A4.2	Energy savings from operation of buildings	Reduce direct energy consumption associated with the operation of offices and buildings	Report the initiatives for energy savings due to conservation and efficiency improvements	Sustainability Reporting Guidelines & Airport Operators Sector Supplement; CDA, Sustainable Airport Manual, 2013	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75
			Report the electricity consumption savings* in %, as a result of the energy saving initiatives	Sustainable Airport Manual, Chicago Airport	Less than 15%	0.00
A4.3	Use of Renewable Energy	Encourage and recognize increasing levels of on-site and off-site renewable energy to reduce environmental impacts associated with fossil fuel energy use.	Report the utilization of renewable energy for on-site activities	Sustainable Airport Manual, Chicago Airport	Less than 4.5%	0.00
			Report the utilization of renewable energy for off-site activities	Sustainable Airport Manual, Chicago Airport	Less than 37.5%	0.00
A4.4	Vehicle fuel savings	Reduce fuel consumption for refueling, hydrant flushing and passenger due to vehicle movement/idling	Report the initiatives for motor vehicle fuel savings due to utilization of green (LNG/Electric) vehicles and implementation of alternative driving routes	Sustainability Reporting Guidelines & Airport Operators Sector Supplement; International Civil Aviation Organization, 2011	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	0.50
			Report the fuel consumption savings* in %, as a result of the fuel saving initiatives	Sustainable Airport Manual, Chicago Airport	Less than 10%	0.00

A5	Emissions					
A5.1	Reduction in VOC emissions	Reduce VOC emissions from 1) aircraft vents during fueling operations; 2) refueller vents during filling operations, 3) hydrant LP flushing vehicle vents during LP flushing operations; 4) tank vents during routine operation and receipt of product into storage tanks	Report the initiatives to monitor VOC emissions by weight	International Civil Aviation Organization, 2011	Risks have not been assessed and performance is/will not be monitored	0.00
			Report the VOC reduction* in %, as a result of the VOC monitoring and reduction initiatives	UNECE, Decision 2012/2 Amendment of the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, Annexes X and XI, Emission reduction commitments for Volatile Organic Compounds for 2020 and beyond	Less than 10%	0.00
A5.2	Vehicle exhaust (GHG) emissions during movement/idling	Explore options to optimize routes and idling times as a means to reduce VOC and Greenhouse Gases (GHG) emissions from the exhausts of refueling, hydrant flushing and passenger vehicles, during vehicle movement/idling	Report the initiatives to monitor VOC and Greenhouse gases (GHG) emissions by weight and whether the location has considered a plan to optimize routes and idling times	International Civil Aviation Organization, 2011	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	0.50
			Report the CO2 reduction* in %, as a result of the CO2 monitoring and reduction initiatives	United Nations Framework Convention on Climate Change 2011	Less than 15%	0.00
A5.3	Utilization of environmentally friendly vehicles	Explore options to utilize 'green' or 'clean' vehicles (liquefied petroleum gas or electric) as a means to reduce VOC and Greenhouse Gases (GHG) emissions from vehicles' exhausts	Report the initiatives to utilize 'green' or 'clean' vehicles (liquefied petroleum gas or electric) as a means to reduce VOC and Greenhouse Gases (GHG) emissions from vehicles' exhausts	Airport cooperative Research Program, Airport Sustainability Practices	Limited process, program or policy in place to address issues	0.25
A5.4	Reduce GHG emissions associated with energy consumption	Reduce VOC and Greenhouse Gases (GHG) emissions associated with energy savings	Report the initiatives to monitor VOC and GHG emissions by weight by kwWhr of electricity consumption	International Civil Aviation Organization, 2011 US Environmental Protection Agency	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	0.25
			Report the CO2 reduction in %, as a result of the CO2 monitoring and reduction initiatives	United Nations Framework Convention on Climate Change 2011	Less than 15%	0.00

A6	Waste					
A6.1	Reduce Hazardous Wastes produced from ad-hoc activities (e.g. commissioning procedures) and spills	Reduce hazardous wastes produced during ad-hoc activities and spills, e.g. commissioning operations of equipment and facilities (e.g. soaked fuel after soak tests for New storage tanks or refueling vehicles, wastewater after initial pressure strength test of new hydrant systems etc.)	Report the initiatives to monitor and reduce hazardous wastes produced by type and by weight	JIG 1,2,4 and EI/JIG 1530 US Environmental Protection Agency	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75
			Report the % of hazardous wastes reduced* by implementing specific initiatives	Sustainable Airport Manual, Chicago Airport	Less than 10%	0.00
A6.2	Reduce Hazardous Wastes produced from routine operation and maintenance	Reduce hazardous wastes produced over the course of normal/routine operations (tank farm, hydrant and ITPO), e.g. fuel slops, used filter elements, used hoses, vehicle tyres etc.	Report the initiatives to monitor and reduce hazardous wastes produced by type and by weight	JIG 1,2,4 and EI/JIG 1530 US Environmental Protection Agency	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75
			Report the % of hazardous wastes reduced* by implementing specific initiatives	Sustainable Airport Manual, Chicago Airport	Less than 10%	0.00
A6.3	Reduce Non Hazardous Wastes produced from routine operation and maintenance	Reduce non hazardous wastes produced over the course of routine operations (tank farm, hydrant, ITPO and house-hold type of wastes from buildings and offices)	Report the initiatives to monitor and reduce non-hazardous wastes produced by type and by weight	CDA, Sustainable Airport Manual, 2013	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75
			Report the % of non-hazardous wastes reduced* by implementing specific initiatives	Sustainable Airport Manual, Chicago Airport	Less than 10%	0.00
A6.4	Pollution of land / waterways	Reduce emissions of uncontained spills into the ground / waterways	Report the initiatives to monitor uncontained spills into the ground / waterways	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75

A7	**Land Use & Biodiversity**					
A7.1	Efficiency of land use	Efficiency of land use by optimizing site location, land acquisition, future expansion, and visual harmony.	Report the availability of unoccupied land adjacent to the facilities	CDA, Sustainable Airport Manual, 2013	Some awareness of issue inside organization. Policy or program is communicated and enforced. Funding allocation to manage issue established on annual basis	0.50
A7.2	Impact of location and size of land used for operations in biodiversity	Description of significant impacts of land that lies within, contains, or is adjacent to legally protected areas on biodiversity in these areas	Report the initiatives to monitor significant direct and indirect positive and negative impacts of land (location and size) with reference to the following: • Species affected; • Extent of areas impacted; • Duration of impacts; and • Reversibility or irreversibility of the impacts.	CDA, Sustainable Airport Manual, 2013	Issue not on radar screen, relevancy to the organization undetermined. No budget allocation for activity	0.00
A7.3	Impact of activities in biodiversity	Description of significant impacts of activities, products, and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas.	Report the initiatives to monitor significant direct and indirect positive and negative impacts of activities with reference to the following: • Species affected; • Extent of areas impacted; • Duration of impacts; and • Reversibility or irreversibility of the impacts.	CDA, Sustainable Airport Manual, 2013	Issue not on radar screen, relevancy to the organization undetermined. No budget allocation for activity	0.00
A8	**Expenditures**					
A8.1	Initiatives to monitor Environmental mitigation and protection expenditures	Measure environmental mitigation and protection expenditures to allow the assessment of the efficiency of the environmental initiatives	Report process to establish targets and monitor the monetary value of waste disposal, emissions treatment, and remediation costs related to the following items: • Treatment and disposal of waste; • Treatment of emissions (e.g., expenditures for filters, agents); • Expenditures for the purchase and use of emissions certificates; • Depreciation of related equipment, maintenance, and operating material and services, and related personnel costs; Insurance for environmental liability; and • Clean-up costs, including costs for remediation of spills	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	0.50
A9	**Noise**					
A9.1	Noise pollution	Maintain noise levels from machinery and equipment at permissible levels	Report initiatives to monitor noise levels from machinery and equipment used at airport fuel operation facilities (e.g. power generators, air-powered tools, fire fighting pumps etc.) against noise targets or limits applicable to the airport	Sustainability Reporting Guidelines & Airport Operators Sector Supplement; ICAO Annex 16, ACI Noise Rating Index	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	0.25

Economic

Instructions

FILL IN ALL ORANGE-COLOURED CELLS

#	Economic Criteria	Description / Definition	Assessment Standard of measure	Reference	Assessment Select an option from the drop-down list	Utility (0-1)
B	**Economic**					
B1	**Economic performance analysis**					
B1.1	Life-cycle cost analysis	All new projects require life-cycle costing before implementation.	Report whether project has been subjected to a life-cycle cost analysis/assessment before commencement	Airport cooperative Research Program, Airport Sustainability Practices	Risks have been assessed and a baseline established. No plan for ongoing monitoring of performance	0.25
B1.2	Assessment of Capital projects	Capital projects are required to predict operating and maintenance costs	Report whether capital projects have been subjected to analysis to predict operating and maintenance costs	Airport cooperative Research Program, Airport Sustainability Practices	Process, program or policy embedded in airport operations and reflects best practice from the industry	0.75
B1.3	Land and property value	Assessment of land and property value	Report whether land and property value has been assessed	Airport cooperative Research Program, Airport Sustainability Practices	Process, program or policy embedded in airport operations and reflects best practice from the industry	0.75
B1.4	Capital to sales ratio	Assessment of total Capital expenses ($)	Report capex to sales ratio (%)	Industry best practice	Capex to sales ratio is below average industry benchmark by up to 0.25%	0.25

> Calculations

		Fuel System	ITP
B1.4.1	**Fuel Costs**		
	Cost of Initial Jet Fuel in Hydrant System	*$8,320,000.00*	*$0.00*
	Cost of Initial Jet Fuel in Tank Farm	*$1,280,000.00*	*$0.00*
B1.4.2	**Initial Jet fuel transportation costs**	*$0.00*	*$0.00*
B1.4.3	**Civil Works costs**		
	Security fence cost	*$875,520.00*	*$1,800,000.00*
	Gates cost	*$151,464.80*	*$20,800.00*
	Facility roads & pavement cost	*$6,819,425.07*	*$2,550,000.00*
	Tank farm cost	*$6,819,425.07*	*$0.00*
	Administration Building cost	*$3,182,340.00*	*$2,940,000.00*
	Fire fighting cost	*$1,090,897.87*	*$0.00*
	Electrical room cost	*$1,363,841.07*	*$98,000.00*
	Pump & filtration	*$10,910,730.13*	*$0.00*
	Off-Loading office	*$0.00*	*$0.00*
	Security room	*$121,215.73*	*$20,000.00*
	Off-Loading pavement & shed	*$0.00*	*$0.00*
	Loading pavement & Test facility	*$4,261,155.73*	*$656,475.73*
	Demolition Works	*$0.00*	*$1,100,000.00*
	Wash Bay	*$0.00*	*$80,000.00*
	Earthworks (Backfilling)	*$3,866,666.67*	*$7,200,000.00*
	Safety Signs& Branding	*$26,666.67*	*$16,000.00*
	Landscaping & irrigation	*$133,333.33*	*$50,000.00*
	Truck Parking Shed	*$0.00*	*$1,750,000.00*
	Maintenance Building	*$2,600,000.00*	*$1,500,000.00*
	Soil Test	*$133,333.33*	*$10,000.00*
B1.4.4	**Mechanical works**		
	Equipment (Pumps, meters, and Filters)	*$0.00*	*$0.00*
	Transfer Pumps	*$8,478,737.60*	*$0.00*
	Jockey Pumps	*$1,212,300.00*	*$0.00*
	Flow meter- Loading	*$454,635.47*	*$70,000.00*
	Filter vessel	*$6,062,881.60*	*$0.00*
	Off-Loading Skid	*$0.00*	*$0.00*
	De-fueling pump	*$0.00*	*$70,000.00*
	De-fueling filter	*$0.00*	*$39,666.67*
	De-fueling flow meter	*$0.00*	*$21,000.00*
	Oil Water Seperator	*$400,000.00*	*$133,333.33*
	Storm Drainage	*$2,533,333.33*	*$254,666.67*
	Sewer System	*$2,266,666.67*	*$308,617.07*
B1.4.5	**Sampling system**	*$4,547,092.27*	*$0.00*
B1.4.6	**Valves & Fittings**	*$6,820,730.67*	*$0.00*

	Sub-totals ($)
Fuel Costs	***$9,600,000.00***
Initial Jet fuel transportation costs	***$0.00***
Civil Works costs	***$62,147,291.20***
Mechanical works	***$22,305,838.40***
Sampling system	***$4,547,092.27***
Valves & Fittings	***$6,820,730.67***
Storage tanks	***$43,529,898.93***
Pipes	***$12,606,744.80***
Fire fighting system	***$7,052,817.33***
Electrical Works	***$42,942,720.27***
Controls and Instrumentation	***$29,253,540.80***
Engineering consultation Fees/Charges	***$12,159,578.40***
Office equipment & furniture	***$858,666.67***
Service Vehicles	***$320,000.00***
Mobile equipment (refueller, dispensers, hydrant cleaning, etc.)	***$0.00***
Total capital costs ($) >	***$254,144,919.73***
Total capex costs to sales ratio (%) >	**28.4%**

B1.4.7	**Storage tanks**		
	Jet Fuel main Tanks	*$36,377,294.67*	*$0.00*
	De-fueling storage tank	*$1,060,969.60*	*$163,333.33*
	Water Tank	*$2,728,301.33*	*$0.00*
	Fuel Tanks Modification	*$0.00*	*$0.00*
	Platforms & Railings	*$3,200,000.00*	*$0.00*
B1.4.8	**Pipes**		
	Pipes, Pipe Rack & Supports	*$12,606,744.80*	*$0.00*
B1.4.9	**Fire fighting system**	*$5,466,666.67*	*$1,586,150.67*
B1.4.10	**Electrical Works**		
	Transformers	*$4,545,169.07*	*$0.00*
	Wires / Cables	*$4,545,169.07*	*$220,543.20*
	Stand-by Generator	*$7,574,928.80*	*$0.00*
	Electrical panels	*$3,031,384.00*	*$246,022.67*
	HVAC system	*$7,578,460.53*	*$814,820.53*
	Accessories	*$4,243,923.73*	*$1,041,733.33*
	Fire Alarm system	*$1,515,692.00*	*$114,866.13*
	Safety & Security System(CCTV)	*$2,273,538.13*	*$743,080.27*
	Flight Monitoring System	*$0.00*	*$80,000.00*
	Area & Road Lighting	*$578,666.67*	*$1,523,753.07*
	Lightning System	*$613,333.33*	*$40,000.00*
	Grounding System	*$1,393,333.33*	*$224,302.40*
B1.4.11	**Controls and Instrumentation**		
	Tank Gauging System	*$1,818,871.73*	*$0.00*
	Control valves	*$8,488,078.13*	*$0.00*
	Valves and accessories	*$6,820,769.33*	*$0.00*
	Control system/software	*$7,578,642.13*	*$0.00*
	Terminal management system	*$4,547,179.47*	*$0.00*
B1.4.12	**Engineering consultation Fees/Charges**		
	Engineering consultation Fees/Charges & Mobilization (Preliminaries, project Documentation, temporary Facility...)	*$10,666,666.67*	*$1,492,911.73*
B1.4.13	**Office equipment & furniture**	*$666,666.67*	*$192,000.00*
B1.4.14	**Service Vehicles**	*$320,000.00*	*$0.00*
B1.4.15	**Mobile equipment (refueller, dispensers, hydrant cleaning, etc.)**	*$0.00*	*$0.00*

B1.5	**Operating Expenses to Sales**	The measure the performance and effeciency of controlling expenses.	Average Expenses as a Percentage of Sales (%)	https://saibooks.com/index.php?option=com_content&view=article&id=64&Itemid=65	Opex to sales ratio is below average industry benchmark	0.00

> Calculations

		Fuel System	ITP
B1.5.1	**Variable costs**		
	Jet Fuel Evaporation Losses Cost	*$1,792,000.00*	*$896,000.00*
B1.5.2	**Fixed costs**	0	0
	Employee cost (total of salary, wages, be	*$1,803,200.00*	*$6,140,800.00*
	Employee Training Cost	*$54,096.00*	*$184,224.00*
	Utilities Cost	*$224,000.00*	*$40,000.00*
	Employee Uniform	*$13,066.67*	*$53,866.67*
	Licenses Cost	*$0.00*	*$24,800.00*
	Rent Cost	*$520,000.00*	*$2,100,000.00*
	Insurance Cost	*$240,000.00*	*$499,200.00*
	Maintenance and spare parts Cost	*$385,333.33*	*$992,000.00*
	Quality & HSSE equipment cost	*$45,280.00*	*$80,000.00*
	Professional Fees & Inspections Cost	*$64,000.00*	*$128,000.00*
	Contracted Services Cost	*$48,000.00*	*$150,000.00*
	Security Services Cost	*$133,333.33*	*$170,000.00*
	Operating Items Cost	*$113,200.00*	*$240,000.00*
	Mobilization and Pre-operating costs	*$450,800.00*	*$0.00*
B1.5.3	**Depreciation costs**		
	Depreciation of Vehicles	*$106,666.67*	*$2,218,666.67*
	Depreciation of Office Equipment, IT, and Supplies	*$66,666.67*	*$100,000.00*
	Depreciation of equipment and Technical Operating Items	*$21,333.33*	*$32,000.00*
B1.5.4	**Regulatory-driven costs**		
	Taxes	*$0.00*	*$0.00*
	Audit and legal costs	*$0.00*	*$0.00*
	Bank Guarantee Cost	*$0.00*	*$0.00*

	Sub-totals ($)
Variable costs	***$2,688,000.00***
Fixed costs	***$14,897,200.00***
Depreciation costs	***$2,545,333.33***
Regulatory-driven costs	***$0.00***
Total Opex costs ($) >	***$20,130,533.33***
Total Opex costs to sales ratio (%) >	***2.2%***

B1.6	*Operating Expenses Efficiency Control*	*Ability to control and contain Opex to not exceed level of inflation*	Annual monetary agency inflation	Saudi Arabian Monetary Agency (SAMA)	Annual increase in Opex is below the average declared inflation rate by 0.5%	0.25
B1.7	*Maintenance to Assets cost*	*Maintenance to Assets cost indicates the percentage of maintenance cost to total asset cost.*	Measured against maintenance functional benchmark (3%)	http://cleanbayarea.com/recycling-environment/maintenance-cost-vs-asset-replacement-value-rav/	Maintenance to asset cost is 3% or below	1.00
B1.8	*Working Capital To Sales*	*Indicates the firm's ability to finance additional sales without incurring additional debt. Formula: Working capital ÷ sales revenue.*	Assessed against the industry average ratio benchmark . Benchmarked against Saudi Ground services	http://www.tadawul.com.sa/Resources/fsPdf/644_2015-07-07_08-10-57_Arabic.pdf	Working captial is between 34% - 36% to sales revenue	0.75

B2	**Economic value retained**					
B2.1	Direct economic value generated	Direct economic value generated. Net sales plus revenues from financial investments and sales of assets	Report programs in place to monitor direct economic value generated including revenues vs financial targets Note: Finance, treasury, or accounting departments should have the information required by this Indicator.	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Process, program or policy is well developed and reflects good practice from the industry	0.50
B2.2	Economic value retained	Direct economic value retained	Report programs in place to monitor Economic value generated and retained (Investments, equity release etc.) vs financial targets Note: Finance, treasury, or accounting departments should have the information required by this Indicator.	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	0.50
B2.3	Net Present Value (NPV)	A measure of the project's profitability and the amount of value added to the firm	Project NPV	http://capitalbudgeting.tripod.com/id24.html http://www.gulfbase.com/ScheduleReports/250364a2_GCCEquityRiskPremium-October2012.pdf	NPV <0	0.00
B2.4	Pay back Period	The number of years required to recover a project's cost. Pay back period provides a measure of the liquidity of the project.	Average pay back period	ICAO , Emission reduction measure pay back period http://www.icao.int/Meetings/EnvironmentalWorkshops/Documents/2014-Malaysia/9-1_Financing.pdf	Pay back period is 7 to 8 years	0.75
B2.5	Return on Assets (ROA)	A performance measure used to evaluate the efficiency of an investment . A profitability ratio calculated as net income divided by total assets.	Measured against five years average of ROA of oil sector (8.1%)	https://www.stock-analysis-on.net/NYSE/Company/Exxon-Mobil-Corp/Ratios/Profitability	ROA is above five years average of oil & gas industry sectors by 0.75%	0.75
B2.6	Financial implications due to emissions of pollutants and climate change substances	Financial implications due to climate change	Report whether there are programs in place for the quantitatively estimations of the financial implications of climate change for the organization (e.g., cost of offsetting CO2 emissions or VOC emissions)	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Risks have not been assessed and performance is/will not be monitored	0.00
B3	**Market presence**					
B3.1	Marketability	Ability to attract and increase sales volume	Annual growth in Gross domestic product (GDP)	Netherlands Airport Consultants B.V., NACO, Kingdom's Airport Aviation and Logistics. Saudi Arabia, May 2012	Growth in Annual sales volume is above annual GDP Growth by 0.5%	0.25
B3.2	Standard entry level wage ratio	Range of ratios of standard entry level wage compared to local minimum wage at significant locations of operation. Economic well-being is one of the ways in which an organization invests in its employees	Report the organization's entry wage to the local minimum entry wage	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Process, program or policy is well developed and reflects good practice from the industry	0.50
B3.3	Employment opportunity	Employment opportunities generated	Report the organization's plans to generate employment opportunities	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Limited process, program or policy in place to address issues	0.25
B3.4	Affordability	Use sustainability tools to assess mid- and long-term affordability	Report whether there is a process in place which uses a sustainability matrix to assess affordability	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	No process, program or policy in place	0.00
B3.5	Long term plan	The 20-year master plan uses a sustainability matrix to assess possible projects.	Report whether there is a long term business plan in place which uses a sustainability matrix to assess possible projects	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	No process, program or policy in place	0.00

B4	**Indirect Economic impacts**					
B4.1	Indirect Economic impacts	Understanding and describing significant indirect economic impacts, including the extent of impacts. Indirect economic impacts include the additional impacts generated as money circulates through the economy.	Report indirect economic impacts and their significance in the context of external benchmarks and stakeholder priorities, such as national and international standards, protocols, and policy agendas	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Risks have not been assessed and performance is/will not be monitored	0.00
B4.2	Non-monetary benefits	Annual objectives and targets should include quantification of nonmonetary benefits	Report whether annual objectives and targets include quantification of nonmonetary benefits	Airport cooperative Research Program, Airport Sustainability Practices	Risks have not been assessed and performance is/will not be monitored	0.00
B4.3	Finance Leverage	The Debt to Equity (DOE) ratio indicates how much debt is used to finance assets relative to the amount of value represented in shareholders' equity. E = Total Liabilities / (Total Assets - Total Liabilities)	Debt to Equity (DOE)	https://www.stock-analysis-on.net/NYSE/Company/Exxon-Mobil-Corp/Long-Term-Trends/Debt-to-Equity#Comparison-to-Industry	Debt to equity is higher than energy sector benchmark by 0.1%	0.75

Social

FILL IN ALL ORANGE-COLOURED CELLS

Instructions

#	Social Criteria	Description / Definition	Assessment Standard of measure	Reference	Assessment Select an option from the drop-down list	Utility (0-1)
C	Social					
C1	Occupational Health and Safety					
C1.1	Representation in HSSE committees	Workforce represented in formal joint management worker health and safety committees that help monitor and advise on occupational health and safety programs	Report whether workforce is represented in formal joint management-worker health and safety committees	Sustainability Reporting Guidelines & Airport Operators Sector Supplement		
			Internal HSSE Audit - 1 Year External HSSE Audit - 1 / 3 years Safety Walk by Mangement - 2 / Year Safety Meetings- 12/ Year Safety bulletin - 4/ Year KPI (HSSE) - Compilation - 4/ Year Minimum acceptable limit- 85% of Planned Vs. Actual.	Best industry practice	if less than 85%	0.00
C1.2	Reduce Work-related injuries and fatalities	Protective and preventive measures are applied to protect personnel from occupational health hazards associated with hazardous materials, Exposure of personnel to physical hazards (e.g. noise, Air quality and water quality) Personnel undergo medical assessments, including colour blindness, Audiogram and Drug tests at the time of employment and at regular intervals. Employer have to Provide adequate PPE.	Report programs for monitoring and reducing rates of injury and total number of work-related fatalities	JIG HSSE statistics	Includes mechanism for continuous performance improvements. Performance goals aligned with strategic planning (corporate-level goals and targets). Performance is/will be reported externally to stakeholders and general public.	1.00
			Goal is - ZERO Incident 2 minor Incident / year is acceptable.	Best industry practice	> 3	0.00
C1.3	Work-related injuries and fatalities	Reduce rates of injury and total number of work-related fatalities	Report reduction* in work-related injuries and fatalities	JIG HSSE statistics	Reduction in incident rates less than 20%	0.00
			Number of Potential Incidents reported, Annual HSSE Plan activities, Annual HSSE Plan investments, implementation of HSSE audit recommendations and Implementation of HSSE Remedial Action Plan	Best industry practice	> 3 Injuries	0.00

C1.4	Eliminate occupational diseases, lost days, and absenteeism	Reduce rates of occupational diseases, lost days, and absenteeism	Report programs for monitoring and reducing rates of occupational diseases, lost days, and absenteeism	JIG HSSE statistics	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	0.50
			Report absenteeism (%) dues to occupational diseases Absenteeism = 5 days/ year/ employee Sick leave= 8 days/year/emplyee	JIG HSSE statistics	Absenteeism more than 10%	0.00
C1.5	Health and Safety awareness and prevention	Education, training, counseling, prevention, and risk-control programs in place to assist workforce members, their families, or community members regarding serious diseases	Report the programs related to assisting workforce members, their families, or community members regarding serious diseases	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Limited process, program or policy in place to address issues	0.25
C1.6	Education enhancement on HSSSE awareness	Enhancement of education, Risk Assessment, Work Control Permit, Safety Meeting, Fundamental of Safety, Smith Defense Drive, Law and workplace health and safety policies and procedures, Use PPE as required	Education enhancement: Trainings: HSSE Policies: Smith Defense Drive Use PPE as required Minimum Acceptable Limit: 80%	Best industry practice	90-95%	0.50
C1.7	Health and Safety covered in formal agreements with trade unions	Formal agreements can promote the acceptance of responsibilities by both parties and the development of a positive health and safety culture.	Report whether there is a program in place to review whether formal agreements (either local or global) with trade unions cover health and safety.	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Process, program or policy embedded in airport operations and reflects best practice from the industry	0.75
			Acceptable limit 100%.	Business Ethics	if less than 85%	0.00
C1.8	Fuelling Vehicles - Tests of safety devices	The procedure & guidelines for performing the tests and checks to determine that they are functioning adequately	Report whether the Weekly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded e.g. Interlock function, Bonding wire, Elevating platform lowering , Elevating platform wand sensors	AAFQCO Manual	All Weekly checks and records in place (per AAFQCO Manual)	1.00
			Report whether the Monthly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded e.g. Deadman, Fueller high level cut-off devices , Engine emergency stop switches	AAFQCO Manual	All Monthly checks and records in place (per AAFQCO Manual)	1.00
			Report whether the Quarterly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded	AAFQCO Manual	All Quarterly checks and records in place (per AAFQCO Manual)	1.00
			Report whether the Semi-Annual, Annual and less frequent checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded	AAFQCO Manual	All Semi-annual/annual/less freq. checks and records in place (per AAFQCO Manual)	1.00

C1.9	Fuelling Vehicles - safety equipment	Minim required Safety equipment considered / in place	Report whether the min required safety equipment have been considered / are in place: Fire extinguishers: 2x9 kg/vechicle Spill kit: 50 Ltr/vechicle Cones: 3/vechicle First aid box: 1 box/vechicle	AAFQCO Manual	Minimum equipment in place	1.00
C1.10	Fuel Storage - Tests of safety devices	The procedure & guidelines for performing the tests and checks to determine that they are functioning adequately	Report whether the Weekly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded, e.g. bonding wires	AAFQCO Manual	All Weekly checks and records in place (per AAFQCO Manual)	1.00
			Report whether the Monthly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded, e.g. Hydrant Emergency Shut-Down buttons	AAFQCO Manual	All Monthly checks and records in place (per AAFQCO Manual)	1.00
			Report whether the Quarterly checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded, e.g. safe procedures for entry in Valve chambers	AAFQCO Manual	All Quarterly checks and records in place (per AAFQCO Manual)	1.00
			Report whether the Semi-Annual, Annual and less frequent checks (per AAFQCO Manual) of devices critical to safe operations and health of personnel are conducted and recorded, e.g. tank cleaning every 3-5 y, cathodic protection yearly	AAFQCO Manual	All Semi-annual/annual/less freq. checks and records in place (per AAFQCO Manual)	1.00
C1.11	Fuel storage - safety equipment	Minim required Safety equipment considered / in place	Report whether the min required safety equipment have been considered / are in place: Fire extinguishers: Every 20m/ 10kg ; Spill kit: 2 X 120 ltr; Sprinkler system: every 1.5 m /1 nozzle; Fire Alarm syst. each 45 m/per unit; First aid box: 1 box / 3 - 4 min	AAFQCO Manual	Minimum equipment in place	1.00
C1.12	Personal Protective Equipment (PPE)	To ensure the greatest possible protection for employees at workplace, employer have to arrange and pay for required PPE.	Report whether the min standards/specifications for PPEs have been considered / are in place: Eye Protection : •EN166 / UV Protection SPF 15+; Fire Resistant & Antistatic Shirts/ Trousers : •NFPA 2112, •ASTM D6413 ; Fire Resistant & Antistatic Workwear Overalls : •ASTM D6413 •EN470-1•EN11612; QC Gloves ,Hand Gloves : •EN:388 – BS:EN:374; High Visibility Vest : •EN 471:2003 class 3; Safety Helmets : •EN 397; Ear Muffs : •ANSI S3.19-1974; Safety boots : •EN 345:EN ISO20345:2004/20346 •EN ISO2034520347•Height of 13cm •Anti-slip •Shock Absorbent ----- Acceptable limit-100%	NFPA , OSHA ,AAFQCO Manual	All requirements met	1.00

C2	Security					
C2.1	Initiatives to improve Security	Initiatives to improve Rates of security-related incidents	Report programs in place for monitoring rates of security-related incidents	JIG HSSE statistics	Continuous monitoring of performance against goals and targets that are updated regularly is planned. Performance is/will be reported internally within the organization	0.75
			Fence: Height 2 - 3 m	Security Recommended Practice of industry & Best industry practice.	3 meters	1.00
			Gates: 2 – Entry & Exit – 1 Crash Gate	Security Recommended Practice of industry & Best industry practice.	3	1.00
			CCTV camera day/night vision : 100 meter / 1 camera	Security Recommended Practice of industry & Best industry practice.	200 meters	0.50
			Security Guards: Minimum 4 / Shift – 24 Hours Operations	Security Recommended Practice of industry & Best industry practice.	4	1.00
			Patrolling: 2hrs /1 Vehicle	Security Recommended Practice of industry & Best industry practice.	3.5 hours	0.50
C2.2	Security breach	Rates of security-related incidents	Report reduction* in security incident rates, based on initiatives taken	JIG HSSE statistics	Reduction in security incident rates less than 20%	0.00

C3	Community wellbeing and engagement					
C3.1	Community awareness program	Identify opportunities to raise awareness of employees and stakeholders on sustainability (e.g. development of leaflets to inform stakeholders about good environmental practices, websites, social media etc.)	Report whether operations have implemented plans to raise community awareness on sustainability	Airport cooperative Research Program, Airport Sustainability Practices	Limited process, program or policy in place to address issues	0.25
C3.2	Complaints	Number of complaints per year	Number of complaints per year	Industry best practices	8	0.00
C3.3	Community engagement program	Identify areas to improve/implement local community engagement, impact assessments, and development programs	Report whether operations have implemented local community engagement, impact assessments, and development programs (e.g. Environmental impact assessments and ongoing monitoring; Public disclosure of results of environmental and social impact assessments; Local community development programs based on local communities' needs; Works councils, occupational health and safety committees and other employee representation bodies to deal with impacts)	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	No process, program or policy in place	0.00
C3.4	Community appreciation	Community appreciation	Number of times an Appreciation from community members is raised per year	Best industry practice, Work Control Procedures	0	0.00
C3.5	Impacts of operations on local communities	Impacts of operations on local communities	Report Operations and associated communities with significant potential or actual negative impacts	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Issue not on radar screen, relevancy to the organization undetermined. No budget allocation for activity	0.00
			Audit report gaps from Enirnomental Authorities as per (EPA) Acceptal limit gaps = Zero	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	More than 3	0.00
C3.6	Prevention and mitigation measures program	Prevention and mitigation measures implemented in operations with significant potential or actual negative impacts on local communities	Report whether prevention and mitigation measures were implemented and achieved or not	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	No process, program or policy in place	0.00
C3.7	Initiatives for community	Education: Scholarships Environmental: Awareness & Contribution for green products Charity events sponsorships Participation voluntary services by employee to community	Number of initiatives taken: Education: Scholarships Environmental: Awareness & Contribution for green products Charity events sponsorships Participation voluntary services by employee to community	Best industry practice, Work Control Procedures	0	0.00

C3.8	Compensations to personnel	Number of persons physically or economically displaced, either voluntarily or involuntarily, by the airport operator or on its behalf by a governmental or other entity, and compensation provided	Report programs to provide compensations by project and average per person	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Problems identified. Stakeholders take the lead in raising issue. Limited budget allocation for managing issue	0.25
		Number of persons physically or economically displaced, either voluntarily or involuntarily, by the airport operator or on its behalf by a governmental or other entity, and compensation provided	Number of Compensations	Saudi labour laws	4 and more	0.00
C3.9	Contractors with sustainability orientation	Engage contractors who use environmentally friendly practices and are sustainability-oriented	Report whether contractor selection and placement process includes sustainability among the selection/assessment criteria	Airport cooperative Research Program, Airport Sustainability Practices	Limited process, program or policy in place to address issues	0.25
		Engage contractors who use environmentally friendly practices and are sustainability-oriented	Contractors record from previous projects, enhancement since then Audit reports Strenth Vs Gaps 2 Strenth = 1 Gap	Airport cooperative Research Program, Airport Sustainability Practices	0	0.00
C3.10	Diversity	Identify areas to improve contract opportunities for Small/medium enterprises	Report whether contractor selection and placement process has considered diversity among the criteria	Airport cooperative Research Program, Airport Sustainability Practices	Process, program or policy embedded in airport operations and reflects best practice from the industry	0.75
			Preparation of Vendor List - Ethitical Contractors, Safety and qualified & experience staff	Industry best practice	Yes	1.00
C3.11	Employee wellbeing	Identify opportunities to improve the wellbeing of employee working at the facility	Report whether employee wellbeing programs have been developed (e.g. Sport facilities for staff, intercompany day nursery, All airport services can be used by employees, Every staff member has internet access, Planters and open green space etc.)	Airport cooperative Research Program, Airport Sustainability Practices	Process, program or policy is well developed and reflects good practice from the industry	0.50
			Training, PPE, safety at work place, Motivation and employee emoluments. Staff turn over % per Year	Industry best practice	19% & above	0.00
C3.12	Business Continuity Plan	Businesses continuity plan include the Minimum Fuel Storage requirements for the quantity of fuel that needs to be stored in Airport Tanks to cover any interruptions of supply chain. The minimum fuel storage requirements shall be able to cover 5 peak days in term of Airport fuel Uplifts	Measured against industry standard of having 5 peak days for jet fuel stored in the tanks	IATA Guidelines for Minimum Fuel storage requirements https://www.iata.org/policy/Documents/guidance-fuel-storage-may08.pdf	If minimum storage quantity is above 6.5 days	1.00
C3.13	Local materials	The demand of local materials (manufactured, extracted, or recovered locally)	Percentage of local materials	Sustainable Airport Manual, Chicago Airport	15% - 30%	0.50

C4	Employment					
C4.1	Employee hires and turnover	Rate of new employee hires and employee turnover results in changes to the human and intellectual capital of the organization and can impact productivity	Report whether there are programs in place to monitor the rate of new employee hires entering and employees leaving employment during the reporting period	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Process, program or policy is well developed and reflects good practice from the industry	0.50
			Exit Interview feedback, Root cause analysis of staff of resignation.	US Survey 2013 & Industry Best Practice	19% & above	0.00
C4.2	Staff localization	Staff localization is the percentage of the staff that are hired from local area	Measured against labor law minimum requirements	http://www.emol.gov.sa/nitaqat/nitaqat.pdf	Local staff is 50% -60 of total staff	0.75
C5	Labor / Management Relations					
C5.1	Notices of changes in operations	Minimum notice period(s) regarding significant operational changes, including whether it is specified in collective agreements	Report whether there are programs in place to ensure minimum number of weeks notice typically provided to employees and their elected representatives prior to the implementation of significant operational changes that could substantially affect them.	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Process, program or policy embedded in airport operations and reflects best practice from the industry	0.75
C5.2	Hygiene standards	Hygiene standards such providing milk to staff can have positve anti-tumor effect	Measured against probablity of reducing lung cancer	http://www.acsu.buffalo.edu/~andersh/research/milkcancer.asp	one liter or above	1.00

C6	Education and Training					
C6.1	Training per year per employee	Maintaining and improving human capital, particularly through training that expands the knowledge base of employees, is a key element in organizational development	Report whether there are programs to monitor the average number of hours of training per year per employee, by employee category	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Process, program or policy embedded in airport operations and reflects best practice from the industry	0.75
			Planned Vs Actual % Acceptable 90%	Industry Best Practice	less than 75%	0.00
C6.2	Skill management of employees	Programs for skills management and lifelong learning that support the continued employability of employees and assist them in managing career endings	Report whether there are employee training or assistance programs in place to upgrade skills	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Process, program or policy embedded in airport operations and reflects best practice from the industry	0.75
			Acceptable limit 80%	Industry Best Practice	Less than 65%	0.00
C6.3	Performance and career development	Percentage of employees receiving regular performance and career development reviews,	Report whether there are programs in place for employees to receive a formal performance appraisal and review	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Industry leading process, program or policy. Long term planning horizon	1.00
			Limit 100%	Industry Best Practice	Less than 70%	0.00
C6.4	On-Job-Training	On-the-job training describes the process of teaching an employee to complete the key activities needed for their job after they are hired	Mesurd against labor law standard percentage (12% of total manpower)	http://portal.mol.gov.sa/Sites/default.aspx	On job training is between 14 and 15 %	0.75
C6.5	Sustainability research and development	Sustainability research and development is a way for airports to improve existing, environmental, social, and economic practices, and discover new ones. Research and development can also benefit airports through the implementation of new technologies, processes, and ideas.	Report whether the location implements a sustainability research and development program	Airport cooperative Research Program, Airport Sustainability Practices	Limited process, program or policy in place to address issues	0.25

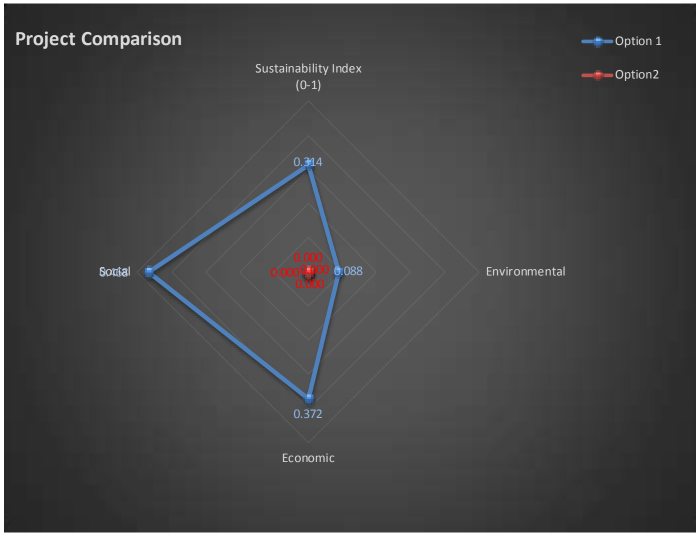
C7	Quality of services					
C7.1	Eliminate customer complaints	Initiatives taken to monitor and eliminate number of substantiated complaints	Report whether there are programs in place to obtain and address customer complaints	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Industry leading process, program or policy. Long term planning horizon	1.00
			Acceptable limit: 2 Complaints / Year	Industry Best Practice	0	0.00
			Total number of substantiated complaints raised per year, relatively to the total number of customers over the assessment period	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	More than 8% of customers	0.00
C7.2	Improve customer satisfaction	Practices related to customer satisfaction, including results of surveys measuring customer satisfaction	Report whether there are programs in place to monitor the satisfaction results or key conclusions of surveys (based on statistically relevant sample sizes) conducted in the reporting period that were related to information about: The organization as a whole; Quality of services	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Goals and targets established. Performance is/will be monitored but there is no plan to be reported either internal or external to the organization	0.50
			Number of Complaints Vs Appreciations : max 2	Industry Best Practice	>5	0.00
C7.3	Sustainable transportation of employees	Practices related to sustainable transportation and alleviating road congestion, i.e. support public transports for employees, enhance cyclist access and facilities for employees, side roads	To what extent is the airport supporting sustainable transportation through initiatives	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Problems identified. Stakeholders take the lead in raising issue. Limited budget allocation for managing issue	0.25
			Measure of Employees Timely Attendance Acceptable 95% on time	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Less than 80 %	0.00
C7.4	Improve employee satisfaction	Practices related to satisfaction of employees at the fuel facility, quality of emergency response services, fire brigade response etc.	Initiatives to improve the extent at which the airport employees are satisfied by the quality of airport services	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Some awareness of issue inside organization. Policy or program is communicated and enforced. Funding allocation to manage issue established on annual basis	0.50
			To what extent are the airport employees satisfied by the quality of airport services based on HR surveys	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Less than 10%	0.00
C8	Regulatory Compliance					
C8.1	Anti-competitive behavior	Total number of legal actions for anti-competitive behavior, anti-trust, and monopoly practices and their outcomes.	Report the number of occurrences of legal actions for anticompetitive behavior, anti-trust, and monopoly practices	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Has occurred at least once	0.00
C8.2	Fines for non compliances with regulations	Significant fines from sanctions for non-compliance with laws and regulations	Report monetary value of significant fines and sanctions for non-compliance with laws and regulations	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Fines more than $50K	0.00
C9	Cultural heritage					
C9.1	Financial contributions to cultural institutions	Participation in initiatives for financial support contributions (donations, sponsorships, etc.) to cultural-related institutions	Report whether there is a program in place for financial support contributions (donations, sponsorships, etc.) to cultural-related institutions	Sustainability Reporting Guidelines & Airport Operators Sector Supplement	Process, program or policy is well developed and reflects good practice from the industry	0.50

OUTPUT

Instructions

Sustainability Index

		Option 1	Option2
		do not edit these cells- automatic calcs	manually add values here
	Sustainability Index (0-1)	**0.314**	**0.000**
Utility	**Environmental**	0.088	0.000
Utility	**Economic**	0.372	0.000
Utility	**Social**	0.468	0.000



NOTE:

Option1 = The sustainability index and the utility for each of the e sustainability factors are **automatically** calculated based on input provided in this sheet - **DO NOT EDIT THE CELLS UNDER OPTION 1**

Option2 = For comparison purposes, **manually enter the values under Option 2**, from separate calculations for a different project alternative - (i.e. add the other alternative's sustainability index and the utility for each of the 3 sustainability dimensions)

Aggregation Analysis

#	Environmental > Go to Assessment tab	Priority (1-5)	Utility (0-1)	
A	**Environmental**	4	**0.088**	
A1	Administrative procedures	2	**0.138**	0
A1.1	Cooperative Sustainability Policy	2	0.250	1
A1.2	Sustainable Procurement Policy	2	0.250	1
A1.3	Green Procurement Policy	2	0.000	0
A1.4	Use of renewable materials	2	0.250	1
		2	0.000	0
		2	0.000	0
A1.5	Recycle used materials	3	0.250	1
		3	0.000	0
A1.6	Environmental impact assessment (EIA) study	1	0.000	0
A1.7	Environmental Certificate	1	0.500	1
A2	Water efficiency	3	**0.148**	0
A2.1	Wastewater generation	2	0.500	1
		2	0.000	0
A2.2	Water withdrawal	3	0.500	2
		3	0.000	0
A2.3	Storm water management system	3	0.250	1

#	Economic > Go to Assessment tab	Priority (1-5)	Utility (0-1)	
B	**Economic**	5	**0.372**	
B1	Economic performance analysis	4	**0.483**	2
B1.1	Life-cycle cost analysis	3	0.250	1
B1.2	Assessment of Capital projects	4	0.750	3
B1.3	Land and property value	3	0.750	2
B1.4	Capital to sales ratio	4	0.250	1
B1.5	Operating Expenses to Sales	4	0.000	0
B1.6	Operating Expenses Efficiency Control	4	0.250	1
B1.7	Maintenance to Assets cost	3	1.000	3
B1.8	Working Capital To Sales	4	0.750	3
B2	Economic value retained	5	**0.448**	2
B2.1	Direct economic value generated	5	0.500	3
B2.2	Economic value retained	3	0.500	2
B2.3	Net Present Value (NPV)	4	0.000	0
B2.4	Pay back Period	5	0.750	4
B2.5	Return on Assets (ROA)	4	0.750	3
B2.6	Financial implications due to emissions of pollutants and climate change substances	3	0.000	0
B3	Market presence	3	**0.221**	1

#	Social > Go to Assessment tab	Priority (1-5)	Utility (0-1)
C	**Social**	4	**0.468**
C1	Occupational Health and Safety	5	**0.648**
C1.1	Representation in HSSE committees	3	0.000
		3	0.000
C1.2	Reduce Work-related injuries and fatalities	5	1.000
		5	0.000
C1.3	Work-related injuries and fatalities	5	0.000
		5	0.000
C1.4	Eliminate occupational diseases, lost days, and absenteeism	4	0.500
		4	0.000
C1.5	Health and Safety awareness and prevention	5	0.250
C1.6	Education enhancement on HSSSE awareness	5	0.500
C1.7	Health and Safety covered in formal agreements with trade unions	3	0.750
		3	0.000
C1.8	Fuelling Vehicles - Tests of safety devices	5	1.000
		5	1.000
		5	1.000
		5	1.000

		3	0.000	0
A2.4	Recycle/reuse water	3	0.250	1
		3	0.000	0
A2.5	Landscaping water use	1	0.000	0
A2.6	Water use reduction	4	0.000	0
A3	Indoor environmental quality	4	**0.500**	2
A3.1	Indoor ventilation and Air Quality	4	0.500	2
		4	0.000	0
		4	1.000	4
A4	Energy	4	**0.232**	1
A4.1	Energy savings from operation of pumps	4	0.500	2
		4	0.000	0
A4.2	Energy savings from operation of buildings	4	0.750	3
		4	0.000	0
A4.3	Use of Renewable Energy	3	0.000	0
		3	0.000	0
A4.4	Vehicle fuel savings	3	0.500	2
		3	0.000	0
A5	Emissions	4	**0.139**	1
A5.1	Reduction in VOC emissions	4	0.000	0
		4	0.000	0
A5.2	Vehicle exhaust (GHG) emissions during movement/idling	4	0.500	2
		4	0.000	0

B3.1	Marketability	3	0.250	1
B3.2	Standard entry level wage ratio	4	0.500	2
B3.3	Employment opportunity	4	0.250	1
B3.4	Affordability	3	0.000	0
B3.5	Long term plan	3	0.000	0
B4	Indirect Economic impacts	3	**0.250**	1
B4.1	Indirect Economic impacts	3	0.000	0
B4.2	Non-monetary benefits	3	0.000	0
B4.3	Finance Leverage	3	0.750	2

C1.9	Fuelling Vehicles - safety equipment	5	1.000
C1.10	Fuel Storage - Tests of safety devices	5	1.000
		5	1.000
		5	1.000
		5	1.000
C1.11	Fuel storage - safety equipment	5	1.000
C1.12	Personal Protective Equipment (PPE)	5	1.000
C2	Security	5	**0.679**
C2.1	Initiatives to improve Security	5	0.750
		5	1.000
		5	1.000
		5	0.500
		5	1.000
		5	0.500
C2.2	Security breach	5	0.000
C3	Community wellbeing and engagement	3	**0.316**
C3.1	Community awareness program	3	0.250
C3.2	Complaints	4	0.000
C3.3	Community engagement program	3	0.000
C3.4	Community appreciation	1	0.000
C3.5	Impacts of operations on local communities	1	0.000
		1	0.000
C3.6	Prevention and mitigation measures program	3	0.000

A5. 3	Utilization of environmentally friendly vehicles	3	0.250	1
A5. 4	Reduce GHG emissions associated with energy consumption	4	0.250	1
		4	0.000	0
A6	Waste	4	**0.429**	2
A6. 1	Reduce Hazardous Wastes produced from ad-hoc activities (e.g. commissioning procedures) and spills	4	0.750	3
		4	0.000	0
A6. 2	Reduce Hazardous Wastes produced from routine operation and maintenance	4	0.750	3
		4	0.000	0
A6. 3	Reduce Non Hazardous Wastes produced from routine operation and maintenance	4	0.750	3
		4	0.000	0
A6. 4	Pollution of land / waterways	4	0.750	3
A7	Land Use & Biodiversity	3	**0.214**	1
A7. 1	Efficiency of land use	3	0.500	2
A7. 2	Impact of location and size of land used for operations in biodiversity	3	0.000	0
A7. 3	Impact of activities in biodiversity	1	0.000	0
A8	Expenditures	3	**0.500**	2
A8. 1	Initiatives to monitor Environmental mitigation and protection expenditures	1	0.500	1
A9	Noise	2	**0.250**	1
A9. 1	Noise pollution	2	0.250	1

C3.7	Initiatives for community	2	0.000
C3.8	Compensations to personnel	3	0.250
		3	0.000
C3.9	Contractors with sustainability orientation	3	0.250
		3	0.000
C3.1 0	Diversity	4	0.750
		4	1.000
C3.1 1	Employee wellbeing	4	0.500
		4	0.000
C3.1 2	Business Continuity Plan	4	1.000
C3.1 3	Local materials	3	0.500
C4	Employment	4	**0.417**
C4.1	Employee hires and turnover	4	0.500
		4	0.000
C4.2	Staff localization	4	0.750
C5	Labor / Management Relations	2	**0.917**
C5.1	Notices of changes in operations	2	0.750
C5.2	Hygiene standards	4	1.000
C6	Education and Training	4	**0.477**
C6.1	Training per year per employee	3	0.750
		3	0.000

C6.2	Skill management of employees	1	0.750
		1	0.000
C6.3	Performance and career development	4	1.000
		4	0.000
C6.4	On-Job-Training	4	0.750
C6.5	Sustainability research and development	2	0.250
C7	Quality of services	4	**0.258**
C7.1	Eliminate customer complaints	4	1.000
		4	0.000
		4	0.000
C7.2	Improve customer satisfaction	4	0.500
		4	0.000
C7.3	Sustainable transportation of employees	3	0.250
		3	0.000
C7.4	Improve employee satisfaction	3	0.500
		3	0.000
C8	Regulatory Compliance	3	**0.000**
C8.1	Anti-competitive behavior	2	0.000
C8.2	Fines for non compliances with regulations	3	0.000
C9	Cultural heritage	1	**0.500**
C9.1	Financial contributions to cultural institutions	1	0.500

Emission Calculator

Input tab

Reported values should correspond to 1 day

Airport: KAIA - NEW DEPOT

Aircraft Fuelling

	Daily	Units
Jet Fuel delivered	4,900,000.0	lt
Jet fuel by Hydrant System	76.0%	%
Jet Fuel density	0.80	kg/lt
Jet fuel by Refueller	24.0%	%
Jet fuel defuelled into Refueller	19,000.0	lt
Avgas delivered by Refueller		lt
Avgas density	0.75	kg/lt

Airport Area

Total area of the airport	5.8	sq. miles

Hydrant operation

Number of low points flushed daily		# low points
Average quantity flushed per low point		lt

Tank Farm

Basic Input Data	JET A1 Tanks (Daily)	Avgas Tanks (Daily)	Units
Vapor recovery system present?	No		Yes/No
Tank Data			
Diameter	33.0		m
Capacity	10,000,000.0		lt
(C)onical or **(D)**ome roof?	C		"C" or "D"
Shell height	13.0		m
Liquid Data			
Maximum daily throughput	1,717,250.0		lt/day/tank
Number of tanks in tankfarm	8.0		

Vehicle Movement - ITPO vehicles

	HDDV (Daily)	HDGV (Daily)	LDDV (Daily)	LDGV (Daily)	Units
Total Road length - all vehicles (by type)	9,016.9		1,188.0		Km
Total Idle time - all vehicles (by type)	11,557.5		18,470.0		min
Average consumption, lt/100km	670.0		72.0		lt/100km driven

HDDV *Heavy-Duty Diesel Vehicles*
HDGV *Heavy-Duty Gasoline Vehicles*
LDDV *Light-Duty Diesel Vehicles*
LDGV *Light-Duty Gasoline Vehicles*

Hydrant Low Point (LP) flushing Vehicle

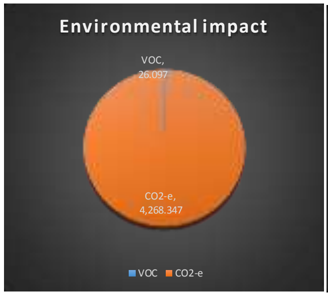
	HDDV	Units
Total Road length - all LP flushing vehicles		Km
Total Idle time - all LP flushing vehicles		min
Average consumption, lt/100km		lt/100km driven

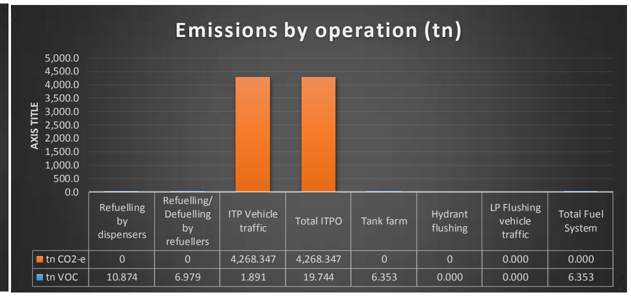
Environmental Impact

KAIA - NEV Airport

Total Emission calculations

Environmental impact - Emissions		per year	Units
Total emissions, VOC	VOC	**26.097**	tn
Total emissions, CO2-e	CO2-e	**4,268.347**	tn
Total emissions, Other Vehicle Exhaust	Other	38.398	tn
Total emissions, THC	THC	1.908	tn
Total emissions, CO	CO	9.268	tn
Total emissions, NOx	NOx	26.549	tn
Total emissions, $PM_{2.5}+PM_{10}$	PM	0.6419	tn
Total emissions, CH4	CH4	0.0178	tn
Total emissions, N2O	N2O	0.0140	tn





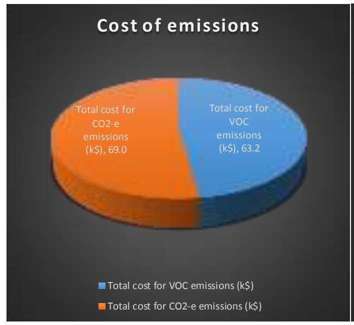
	ITPO				**Fuel System**				
	Refuelling by dispensers	Refuelling/Defuelling by ref	ITP Vehicle traffic	**Total ITPO**	Tank farm	Hydrant flushing	LP Flushing vehicle t	**Total Fuel System**	
tn VOC	10.874	6.979	1.891	**19.744**	6.353	0.000	0.000	**6.353**	tn VOC
tn CO2-e	0	0	4,268.347	**4,268.347**	0	0	0.000	**0.000**	tn CO2
				4,288.092				**6.353**	tn

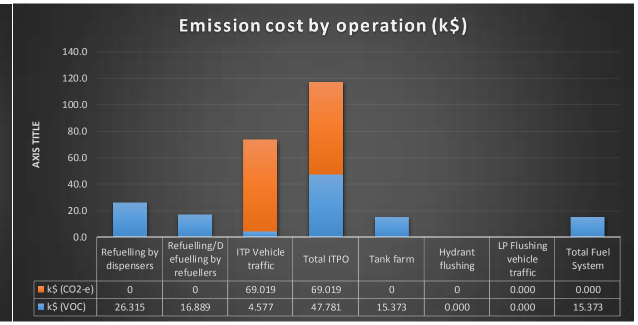
Financial Impact

KAIA - N Airport

Total Financial calculations

Financial Impact	per year	Units
Unit cost to recover VOC [2]	2,420.0	$/tn VOC reduced
Total cost for VOC emissions (k$)	63.2	k$
Unit cost for to off-set CO2-e [4], [5]	16.2	$/tn CO2 offset
Total cost for CO2-e emissions (k$)	69.0	k$
Total cost	132.2	k$





	ITPO				**Fuel System**				
	Refuelling by dispensers	Refuelling/Defuelling b	ITP Vehicle traffic	**Total ITPO**	Tank farm	Hydrant flushing	LP Flushing vehicle traf	**Total Fuel System**	
k$ (VOC)	26.315	16.889	4.577	**47.781**	15.373	0.000	0.000	**15.373**	k$
k$ (CO2-e)	0	0	69.019	**69.019**	0	0	0.000	**0.000**	k$
				116.800				**15.373**	k$

Social impact

KAIA - NEV Airport

> Social impact of VOC emissions [15]
Health effect of VOC emissions

		Units
Brain and nervous system cancer incidence rate	**7.318**	new cancers occurring per 100,000 people per year

>Social impact of CO2-e emissions [18]

Total CO2-e emissions	4268.35	tn CO2

Equivalencies of CO2-e emissions

Greenhouse gas emissions from

815.3 Passenger vehicles driven for one year

Carbon sequestered by

99,452.5 tree seedlings grown for 10 years

3,175.7 acres of U.S. forests in one year

CO_2 emissions from

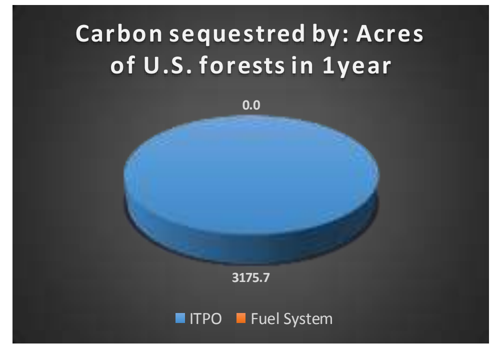
354.3 homes' energy use for one year

435371.4 gallons of gasoline consumed

8963.5 barrels of oil consumed

	ITPO	Fuel System
CO2-e (tn)	4268.34740	0.00000
Carobon sequestered by acres of U.S. forests in one year	**3175.7**	**0.0**

Equivalencies from:
http://www2.epa.gov/energy/greenhouse-gas-equivalencies-calculator



Calculations

		Units
VOC emissions		
VOC concentration at t	**9,934.096**	pounds VOC/sq. mile

Equations for cancer incedence rates as a function of VOC emissions

Linear model : Y = mX + b,
Y is the cancer incidence rate
X the pounds of emissions/square mile,
b is a constant, and
m is a coefficient

Linear model for VOC	m (x 10-4)	b
Brain and nervous system	7.367	5.877

Correlation with Nonchlorinated VOC emissions

Calculation Sheet: Emissions from Aircraft and Refueller Vents

KAIA - NEV Airport

Emissions from aircraft fuel tank vents during aircraft refuelling and Emissions from tank truck vent during loading

Data below correspond to:	1	days	**Calculations correspond to**	365	days

Input		Units	**Emission Calculations**	per year	Units	**Financial Impact**		Units
Jet Fuel delivered	4,900,000.0	lt	Total emissions, Jet fuel	17,852.880	kg VOC	Unit cost for reducing VOC [2]	2,420.0	$/tn VOC reduced
Jet fuel by Hydrant System	76.0%	%	Total emissions, Avgas	0.000	kg VOC	**Total cost for VOC emissions**	43.204	k$
Jet Fuel density	0.80	kg/lt	**A. Total emissions**	**17,852.880**	kg VOC			
Jet fuel by Refueller	24.0%	%	A1. By Dispensers	10,874.080	kg VOC			
Jet fuel defuelled into Refueller	19,000.0	lt	A2. By Refuellers	6,978.800	kg VOC			
Avgas delivered by Refueller	0.0	lt						
Avgas density	0.75	kg/lt						

Factors [1]

Jet fuel Emission factor	0.01	gr VOC/kg fuel
Avgas Emission factor	1.27	gr VOC/kg fuel

Equations

Equation used for the above calculation

Emissions [g VOC] = Σfuel types ((fuelhydrant delivered [kg] + 2 × fueltanker delivered [kg]) × emission factor [g/kg]) + (2 × fueltanker defuelled [kg]) × emission factor [g/kg])

Calculation Sheet: Emissions from Hydrant operations

KAIA - NEV Airport

Emissions from low point flushing vehicle, during hydrant low point flushing activity

Data below correspond to:	1	days	**Calculations correspond to**	365	days			
Input			**Emission Calculations**	per year		**Financial Impact**		
		Units			Units			Units
Number of low points flushed daily	0.0	# low points	Total emissions, Jet fuel	0.000	kg VOC	Unit cost for reducing VOC [2]	2,420.0	$/tn VOC reduced
Average quantity flushed per low point	0.0	lt	Note: The Hydrant LP Vehicle exhaust emissions are calculated in the "Vehicle Trafiic" tab			**Total cost for VOC emissions**	0.000	k$
Jet Fuel density	0.8	kg/lt	Link to LP Vehicle exhaust emissions					

Factors [1]

Jet fuel Emission factor	0.01	gr VOC/kg fuel

Equations

Equation used for the above calculation
Emissions [g VOC] = (fuel flushed per low point [kg]) × emission factor [g/kg])

Calculation Sheet: Emissions from Storage Tanks

KAIA - NI Airport

Emissions from handling aviation fuels into storage tanks

Data below correspond to:	1	days		**Calculations correspond to**	365	days				
Input				**Emission Calculations**	per year			**Financial Impact**		
	JET A1 Tanks	**Avgas Tanks**				Units				Units
Basic Input Data			Units	Total emissions, Jet fuel	6,352.584	kg VOC		Unit cost for reducing VOC [2]	2,420.0	$/tn VOC reduced
Vapor recovery system present?	No	No	Yes/No	Total emissions, Avgas	0.000	kg VOC		**Total cost for VOC emissions**	15.373	k$
Tank Data				**Total emissions**	**6,352.584**	kg VOC				
Diameter	33.0	0.0	m							
Capacity	10,000,000.0		lt							
(C)onical or **(D)**ome roof?	C	C	"C" or "D"							
Shell height	13.0	0.0	m							
Liquid Data										
Maximum daily throughput	1,320,000.0	0.0	lt/day/tank							
Number of tanks in tankfarm	3.0	0.0								

Equations [1],[3]

Equation used for the above calculation

Emissions [kg VOC] = SL + WL

Calculation Sheet: Emissions from vehicle traffic

KAIA - NEVAirport

Emissions from vehicle traffic of refuelling and servicing vehicles

Data correspond to: 1 days

Input	Hydrant flushing vehicle	ITPO vehicles				
	Heavy-Duty Diesel Vehicles	Heavy-Duty Diesel Vehicles	Heavy-Duty Gasoline Vehicles	Light-Duty Diesel Vehicles	Light-Duty Gasoline Vehicles	
	HDDV	HDDV	HDGV	LDDV	LDGV	Units
Total Road length - all vehicles (by type)	0.0	9,016.9	0.0	1,188.0	0.0	Km
Total Idle time - all vehicles (by type)	0.0	11,557.5	0.0	18,470.0	0.0	min
Average consumption, lt/100km	0.0	670.0	0.0	72.0	0.0	lt/100km driven
Average consumption, lt/min idling	0.063	0.063	0.063	0.063	0.063	lt/min idling
Calculation of total consumption						
Corresponding fuel consumption per year	0.0	22,316,974.2	0.0	737,532.1	0.0	lt

Calculations correspond to 365 days

Emission Calculations	Hydrant flushing vehicle per year	ITPO vehicles per year	Units
Total emissions, VOC	0.000	1,891.375	kg
Total emissions, THC	0.000	1,908.397	kg
Total emissions, CO	0.000	9,267.649	kg
Total emissions, NOx	0.000	26,548.705	kg
Total emissions, $PM_{2.5}$	0.000	641.938	kg
Total emissions, PM_{10}	0.000	698.636	kg
Total emissions, CH4	0.000	17.763	kg
Converted CH4 emissions to CO2-e	0.000	444.082	kg
Total emissions, N2O	0.000	13.993	kg
Converted N2O emissions to CO2-e	0.000	4,128.074	kg
Total emissions, CO2-e	0.000	4,268,347.396	kg

Financial Impact		Units
Unit cost for reducing VOC [2]	2,420.0	$/tn VOC reduced
Total cost for VOC emissions	4.577	k$
Unit cost for CO2 [4], [5]	16.17	$/tn CO2 offset
Total cost for CO2 emissions	69.019	k$
Total cost for all emissions	73.596	k$

Emission Factors [6], [7], [17]	**HDDV**	**HDGV**	**LDDV**	**LDGV**	
VOC Emission factor (driving)	0.347	1.232	0.147	1.051	gr/Km driven
VOC Emission factor (idle)	0.073	0.135	0.056	0.084	gr/min
THC Emission factor (driving)	0.352	1.270	0.151	1.087	gr/Km driven
THC Emission factor (idle)	0.073	0.151	0.056	0.101	gr/min
CO Emission factor (driving)	1.795	10.198	0.652	8.715	gr/Km driven
CO Emission factor (idle)	0.534	3.165	0.123	1.515	gr/min
NOx Emission factor (driving)	6.690	2.263	2.398	2.124	gr/Km driven
NOx Emission factor (idle)	0.704	0.111	0.078	0.085	gr/min
$PM_{2.5}$ Emission factor (driving)	0.157	0.034	0.071	0.033	gr/Km driven
$PM_{2.5}$ Emission factor (idle)	0.023	0.000	0.000	0.000	gr/min
PM_{10} Emission factor (driving)	0.170	0.040	0.077	0.038	gr/Km driven
PM_{10} Emission factor (idle)	0.025	0.000	0.000	0.000	gr/min
CH4 Emission factor (driving)	0.004	0.038	0.001	0.027	gr/Km driven
CH4 Emission factor (idle*)	0.001	0.008	0.000	0.005	gr/min
N2O Emission factor (driving)	0.003	0.068	0.001	0.039	gr/Km driven
N2O Emission factor (idle*)	0.001	0.014	0.000	0.008	gr/min
CO2 Emission factor (driving)	870.000	924.000	374.000	400.000	gr/Km driven
CO2 Emission factor (idle*)	174.000	184.800	74.800	80.000	gr/min

*Due to lack of data, emission rates for idling are given as estimations, considering idling factors are 20% of emission factors during driving

Equations

Equation used for the above VOC calculations

$E = RL \times EF$,
E=Emissions (grams),
RL=road length (km),
EF=emission factor, grams/vehicle-km driven

$E = T \times EF1$,
E=Emissions (grams),
T=idle time (mins),
EF1=idle emission factor

Energy Calculator

Airport: KAIA

Input - Pumps

INPUT

Colour-coding:

White cells: Add Input, Grey Cells: Add input if site specific data are available, otherwise leave default values, Orange cells: indicate calculations (do not change)

INPUT ON GENERAL PARAMETERS			Units
Electricity Average Unit Price	:	0.085	$/kWh

Input for 1 day

INPUT for Pumps		Tankfarm											Hydrant
	Name pump>	Jet Pump	Slop	Tank transfer/recovery	Unloading	Other Depot	Other Depot	Other Depot	Other Depot	Other Depot	Foam	Fire water	Hydrant
# of pumps working concurrently	Units	1	1	1	1								
Concurrency factor*													
Operating Hrs per day	Hrs												
Density**	kg/m³										1200.00	1000.00	
Output	m³/h												
Delivery height	m												
Efficiency of pump**		0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.80	0.80	0.75
Efficiency of motor**		0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.80	0.80	0.95
Overall efficiency		0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.64	0.64	0.71

*Concurrency factor: No operation: 0, Low Operation: 0.3, High operation:0.7, Full operation: 1

**If no site specific data are available, leave default values

Input for 1 day

INPUT for Instruments		Tankfarm				Hydrant			
		Number	Concurrency factor*	Estimated energy consumption (kW)**	Operating hrs (per day)	Number	Concurrency factor	Estimated energy consumption (kW)**	Operating hrs (per day)
Electrical actuators	#			1.2				1.2	
Instruments	#			0.04				0.04	
Outdoor spotlights on poles	#			0.4				0.4	
Outdoor fluorescent light fittings	#			0.12				0.12	
Cathodic protection	#			0.4				0.4	

OUTPUT

Calculations for 1 year

Pumps		Pumps - Tankfarm											Pumps - hydrant
		Jet Pump	Slop	Tank transfer/recovery	Unloading	Other Depot	Other Depot	Other Depot	Other Depot	Other Depot	Foam	Fire water	Hydrant
Energy consumption	kWh	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Total		Tankfarm	**0.0**	kWh	Hydrant	**0.0**	kWh						
		CO_2 emissions:	**0.0**	kgCO2	CO_2 emissions:	**0.0**	kgCO2						

Calculations

Energy cons. = 365 (days) x Number of pumps working concurrently x Concurrency factor x Operating hrs per day x Pump Output flowrate (m3/hr) x Delivery height (m) x Density (kg/m3) x gravity (g=9.81m2/s) / (Overall efficiency x 3.6*10^6)

CO2 emissions = Energy consumption (kWh) x Emission factor (kgCO2/kWh)

Calculations for 1 year

Instruments	Tankfarm		Hydrant	
Energy consumption	kWhr	CO2 emissions (kg CO2)	kWhr	CO2 emissions (kg CO2)
Electrical actuators	0	0	0	0
Instruments	0	0	0	0
Outdoor spotlights on poles	0	0	0	0
Outdoor fluorescent light fittings	0	0	0	0
Cathodic protection	0	0	0	0
Total	**0.0**	**0.0**	**0.0**	**0.0**

Calculations

Energy consumption = 365 (days) x Number of instruments working concurrently x Concurrency factor x Operating hrs per day x Estimated energy consumption

CO2 emissions = Energy consumption (kWh) x Emission factor (kgCO2/kWh)

GENERAL PARAMETERS (Default values)			Ref:
Unit cost for CO_2 offset	16.17	$/tn CO_2	("Carbon Portal," n.d.)
CO_2 Emission Factor (Electricity)	0.8	$kgCO_2/kWh$	("US Environmental Protection Agency | US EPA," n.d.)

Airport:

KAIA

Input - Buildings

INPUT

Colour-coding:

White cells: Add Input, Grey Cells: Add input if site specific data are available, otherwise leave default values, Orange cells: indicate calculations (do not change)

Input for 1 day

INPUT for A/C		Tankfarm		ITPO		Hydrant	
		buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)
Quantity of A/C units	#	0			50	0	
Concurrency factor*					1.0		
Power rating**	kW	3.5	3.5	3.5	3.5	3.5	3.5
Hours used per day	hr				24		

*Concurrency factor: No operation: 0, Low Operation: 0.3, High operation:0.7, Full operation: 1

**If no site specific data are available, leave default values

INPUT for ALL sockets and lights		Tankfarm		ITPO		Hydrant	
		buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)
Lump of Sockets, lights	#				1445.0		
Concurrency factor*					1.0		
Power ratng**	kW	25.0	25.0	25.0	25.0	25.0	25.0
Hours used per day	hr				24.0		

OUTPUT

Calculations for 1 year

Calculations		Tankfarm		ITPO		Hydrant		
		buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	buidling with low energy consumption (no A/C)	buidling with high energy consumption (>1 A/C)	
Energy consumption-A/C	kWh	0	0	0	1533000	0	0	1533000
Energy consumption-All sockets/ligh	kWh	0	0	0	316455000	0	0	316455000
CO2 emissions-A/C	kgCO2	0	0	0	1226400	0	0	1226400
CO2 emissions-All sockets/lights	kgCO2	0	0	0	253164000	0	0	253164000

Calculations

Energy consump. = 365 x Quantiry of units x Power rating (kWh) x Hours used per day (hr) x concurrency factor

Emissions = Energy consumption (kWh) x Emission factor (kgCO2/kWh)

Airport: **KAIA**

Input - Vehicle movement

INPUT

Colour-coding:

White cells: Add Input, Grey Cells: Add input if site specific data are available, otherwise leave default values, Orange cells: indicate calculations (do not change)

INPUT ON GENERAL PARAMETERS			Units
Diesel Fuel Price per lt	:	0.120	$/lt
Gasoline Fuel Price per lt	:	0.480	$/lt

Input for 1 day

INPUT for Vehicle Traffic		Hydrant LP flushing vehicles		ITPO Vehicles				
		Diesel Engines (HD)	Gasoline Engines (HD)	Diesel Engines (HD)	Gasoline Engines (HD)	Diesel Engines (LD)	Gasoline Engines (LD)	HD: Heavy Duty; LD: Light Duty
Total Road length - all vehicles (by type)	km			9017		1188		
Total Idle time - all vehicles (by type)	min			11558		18470		
Average consumption during driving	lt/100km			670.0		72.0		
Average consumption during idling**	lt/min idling	0.063	0.063	0.063	0.063	0.063	0.063	

**If no site specific data are available, leave default values

OUTPUT

Calculations for 1 year

Calculations		Hydrant LP flushing vehicles		ITPO Vehicles				
		Diesel Engines (HD)	Gasoline Engines (HD)	Diesel Engines (HD)	Gasoline Engines (HD)	Diesel Engines (LD)	Gasoline Engines (LD)	HD: Heavy Duty; LD: Light Duty
Fuel consumption	lt	0	0	22317219	0	737532	0	
CO2 emissions	kgCO2	0.0	0.0	60193924.2	0.0	1989269.1	0.0	62183193.3

Calculations

Fuel consumption = Σ all fuel types 365*[Distance driven per day (km) x consumption during driving (lt/100km) + time in idle per day (min) x consumption during idling (lt/min)]

CO2 Emissions = Consumption (Diesel) x Emission factor (Kg CO2/lt Diesel) + Consumption (Gasoline) x Emission factor (Kg CO2/lt Gasoline)

GENERAL PARAMETERS (Default values)		
CO2 emissions per lt consumed (Diesel)	2.7	kg CO2/lt cons.
CO2 emissions per lt consumed (Gasoline)	2.3	kg CO2/lt cons.

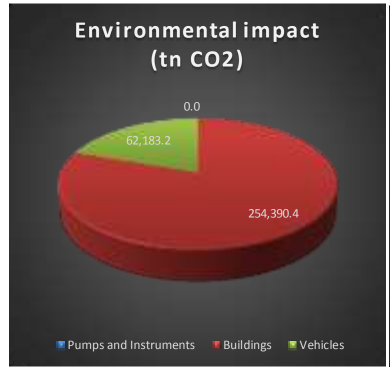
Ref: Emission Factors for Greenhouse Gas Inventories, http://www2.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf

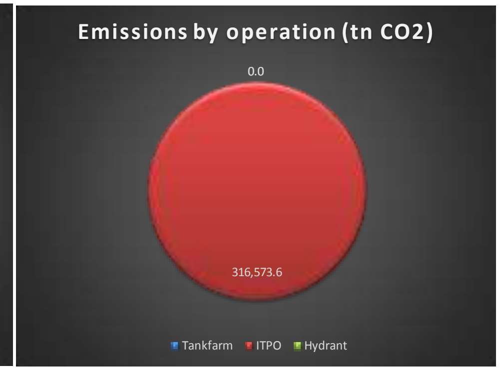
Environmental Impact

Airport **KAIA**

Energy Consumption and CO_2 Emission calculations

Pumps and Instruments	Energy Consumption	Units	CO_2 emissions	Units
Pumps-Tankfarm	**0.0**	kWh	**0.0**	tn CO_2
Instruments-Tankfarm	**0.0**	kWh	**0.0**	tn CO_2
Pumps-Hydrant	**0.0**	kWh	**0.0**	tn CO_2
Instruments-Hydrant	**0.0**	kWh	**0.0**	tn CO_2
Total	**0.0**	kWh	**0.0**	tn CO_2
Buildings	Energy Consumption		CO_2 emissions	
Tankfarm	**0.0**	kWh	**0.0**	tn CO_2
ITPO	**317,988,000.0**	kWh	**254,390.4**	tn CO_2
Hydrant	**0.0**	kWh	**0.0**	tn CO_2
Total	**317,988,000.0**	kWh	**254,390.4**	tn CO_2
Vehicles	Fuel consumption		CO_2 emissions	
ITPO vehicles (Diesel engines)	**23,054,750.9**	lt	**62,183.2**	tn CO_2
Hydrant Vehicles (Diesel engines)	**0.0**	lt	**0.0**	tn CO_2
ITPO vehicles (Gasoline engines)	**0.0**	lt	**0.0**	tn CO_2
Hydrant Vehicles (Gasoline engines)	**0.0**	lt	**0.0**	tn CO_2
Total		lt	**62,183.2**	tn CO_2
TOTAL	**317,988,000.0**	kWh	**316,573.6**	tn CO_2
	23,054,750.9	lt Diesel	**0.0**	lt Gasoline





	CO_2 emissions
Tankfarm	0.0
ITPO	316,573.6
Hydrant	0.0

Financial Impact

Airport **KAIA**

Financial impact calculations

Pumps and Instruments	Energy Consumption	Units	Cost of electricity	Units	Cost of CO_2 offset	Units
Pumps-Tankfarm	**0.0**	kWh	**0.00**	k$	**0.00**	k$
Instruments-Tankfarm	**0.0**	kWh	**0.00**	k$	**0.00**	k$
Pumps-Hydrant	**0.0**	kWh	**0.00**	k$	**0.00**	k$
Instruments-Hydrant	**0.0**	kWh	**0.00**	k$	**0.00**	k$
Total	**0.0**	kWh	**0.00**	k$	**0.00**	k$

Buildings	Energy Consumption		Cost of electricity		Cost of CO_2 offset	
Tankfarm	**0.0**	kWh	**0.00**	k$	**0.00**	k$
ITPO	**317,988,000.0**	kWh	**27,028.98**	k$	**4,113.49**	k$
Hydrant	**0.0**	kWh	**0.00**	k$	**0.00**	k$
Total	**317,988,000.0**	kWh	**27,028.98**	k$	**4,113.49**	k$

Vehicles	Fuel consumption		Cost of fuel		Cost of CO_2 offset	
ITPO vehicles (Diesel engines)	**23,054,750.9**	lt	**2,766.57**	k$	**1,005.50**	k$
Hydrant Vehicles (Diesel engines)	**0.0**	lt	**0.00**	k$	**0.00**	k$
ITPO vehicles (Gasoline engines)	**0.0**	lt	**0.00**	k$	**0.00**	k$
Hydrant Vehicles (Gasoline engines)	**0.0**	lt	**0.00**	k$	**0.00**	k$
Total		lt	**2,766.57**	k$	**1,005.50**	k$

Total Cost of Electricity	**27,028.98**	k$
Total Fuel cost	**2,766.57**	k$
Total cost to offset CO2 emissions	**5,119.00**	k$
TOTAL	**34,914.55**	k$

	Energy cost	Fuel cost	CO_2 offset	Total
Tankfarm	0.0	0.0	0.0	**0.0**
ITPO	27,029.0	2,766.6	5,119.0	**34,914.5**
Hydrant	0.0	0.0	0.0	**0.0**

Social impact

Airport **KAIA**

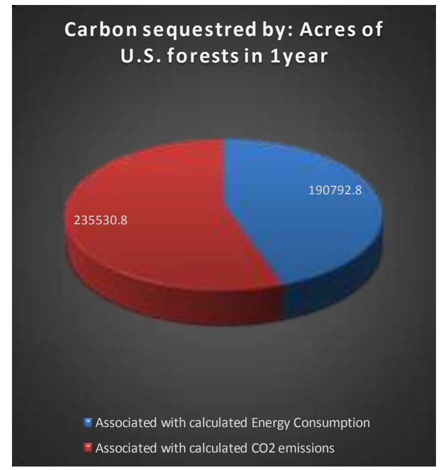
Social Impact of Energy consumption and Motor Vehicle fuel consumption

		Units
Energy Consumption	317,988,000.00	kWh
Fuel Consumption Vehicles (Total)	316,573.59	tn CO_2

Social Impact

Equivalencies of CO2-e emissions

	Associated with calculated Energy Consumption	Associated with calculated CO_2 emissions	Total
Greenhouse gas emissions from			
	31798.8 Passenger vehicles driven for one year	60465.6 Passenger vehicles driven for one year	92264.4 Passenger vehicles driven for one year
Carbon sequestered by			
	5723784.0 tree seedlings grown for 10 years	7376164.7 tree seedlings grown for 10 years	13099948.7 tree seedlings grown for 10 years
	190792.8 acres of U.S. forests in one year	235530.8 acres of U.S. forests in one year	426323.6 acres of U.S. forests in one year
CO_2 emissions from			
	31798.8 homes' energy use for one year	26275.6 homes' energy use for one year	58074.4 homes' energy use for one year
	24803064.0 gallons of gasoline consumed	32290506.5 gallons of gasoline consumed	57093570.5 gallons of gasoline consumed
	635976.0 barrels of oil consumed	664804.5 barrels of oil consumed	1300780.5 barrels of oil consumed



Equivalencies from:
http://www2.epa.gov/energy/greenhouse-gas-equivalencies-calculator