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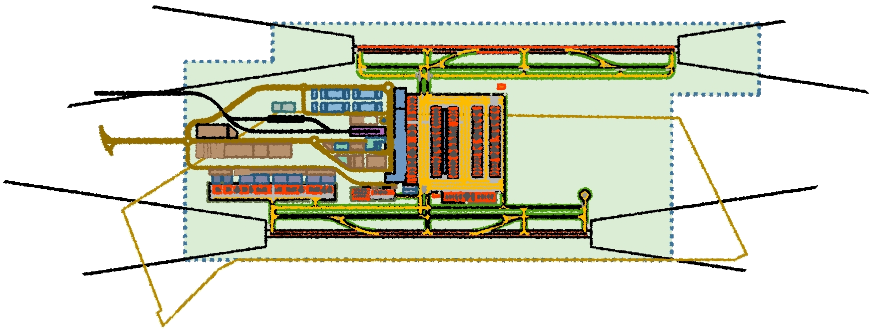

Power Supply

Telecommunications

Fuel Supply

Technical Report and Appendices

DRAFT

February 4, 2011

Dorsch Gruppe
Dorsch
International
Consultants

I Executive Summary

This report presents the concept for power supply, telecommunications and aviation fuel supply which Dorsch International Consultants ("Dorsch") has prepared for the new Gateway International Airport project, in parallel and in coordination with the preparation of the Airport Land-Use Plan.

During preliminary investigations and contacts with Nigerian officials as well as international experts with local knowledge, it has been found that the Nigerian national power grid is insufficient to provide a reliable power supply as required for the operation of an international airport. An airport gas turbine power plant, sufficiently sized to serve as GIA's prime power supply of about 20 megawatt, is deemed necessary for the initial airport development phase. This plant shall consist of two turbines on duty and a third-one used as a back-up / emergency turbine. Based on on-site discussions, it is expected that ongoing governmental projects to improve the national power grid will be implemented latest as of beginning of Phase 3, so that the airport's power supply can be provided via a connection to the national high-voltage grid. If this cannot be achieved, the airport gas-turbine power plan will need to be expanded up to 40 megawatts, and five gas-turbines, to cater for all needs according to the current air traffic forecasts.

The natural gas supply required for power plant operation is proposed via a spur high-pressure connection to the nearest Escravos-Lagos-Pipeline-System (ELPS).

As for power supply, the national telecommunication network is greatly insufficient or even not available at all, as it is the case in the rural areas near the planned airport site. As a result, airport telecommunication has to be provided via aerial satellite and radio systems. Nowadays, these systems provide acceptable reliability and safety and are thought to be an efficient and economical option for GIA. Nevertheless, capital investments in a land line network appear necessary to enhance national development. Once land-based telecommunication systems are available, which could be the case for airport development as of Phase 3, the airport should be connected to these, in order to maximize systems' reliability.

A further key aspect studied is the aviation fuel supply for GIA. Fuel supply is crucial for airport operations. Although Nigeria is an OPEC member state, the infrastructure for fuel products, including all kinds of aviation fuel, is insufficient. All aviation fuel is imported from abroad, since the country does not have refining facilities adapted for aviation fuel products. The amount of aviation fuel currently distributed nationally will hardly be sufficient for the first years of airport operation Moreover, following the expected growth of air-transport, the amount of fuel required for GIA will rapidly (and significantly) exceed the maximum amounts of fuel currently distributed nationwide. Thus, significant capital investments on the governmental level are necessary to ensure and maintain a sufficient and reliable fuel supply at GIA.

In addition to refining and distribution issues, the transport infrastructure to ensure a sufficient supply past development Phase 1 is insufficient. After approximately three years of airport operation, the number of fuel tank trucks necessary to deliver aviation fuel to the airport is expected to exceed the hourly volumes that can be realistically unloaded at an airport tank farm site. Rail infrastructure currently consists of a narrow gauge track, insufficient and excluded as feasible option for any fuel supply. Moreover, as indicated by the Consultant planning the future railway connection, the proposed normal gauge railway is not expected to be operating for the initial airport development phase.

Finally, only a dedicated aviation fuel pipeline, constructed parallel to existing product pipeline systems and operating the latest three years after airport opening (i.e. during initial Phase 1), is a feasible option to deliver the required amounts of aircraft turbine kerosene needed for daily aircraft operations as forecasted for GIA.

The airport fuel farm has to provide jet fuel (Jet A-1) for airline operations and aviation gas (avgas) for General Aviation aircraft. The size of storage tanks proposed as part of this concept considers the important refining and supply issues in Nigeria, and provides sufficient fuel storage capacity accordingly, for one week (7 days) of operation during the first years of operation.

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II Power, Communications and Fuel Requirements

II.1 Introduction

This report provides information about power supply, telecommunications and aviation fuel supply for the new Gateway International Airport (GIA, also referred to as "the Airport") project in the Ogun State, Nigeria. This report has been prepared by consulting engineers Jan Wilke and Harald Alexander Wolf for Dorsch International Consultants GmbH, Airports Division, for the GHS Heritage GmbH, acting on behalf of GH Transport Solutions & HAM Management Solutions.

It is part of a larger scope of technical services provided by Dorsch International Consultants for the GIA project, and is intended to provide specific information about the mentioned systems to develop the Airport. This report must not be read as a design report for these systems, but to provide general guidance to be considered in the design.

II.2 General Provisions

II.2.1 Data Collection

The present study has been prepared based on the information made available during fall and winter 2010.

- Consultant's personal impressions during a visit to Nigeria in December 2010,
- Meetings with governmental agencies during the December visit in Nigeria,
- Meetings with power systems providers during the December visit in Nigeria,
- Different telephone calls with power system providers and manufactures,
- Different meetings of Dorsch design team in Munich,
- Meetings with Dr Gaines the secretary of the Nigerian German Energy Partnership, Frankfurt, a bi-national cooperation of German energy industries and Nigerian stakeholders,
- Publications and information disclosed to the public as cited where applicable.

II.2.2 Systems Considered

The present study addresses the following infrastructural systems required for airport operation:

- Electrical power supply,
- Telecommunication systems,
- Natural gas supply,
- Aviation fuel supply to the airport.

Further infrastructure, utilities and systems are required for proper airport operation, but not part of this study. Building systems are not included in the present study, as well as airport fuel distribution concepts, e.g. hydrant fueling or fuel bowsers, serving the aircraft on the airport. Finally, wherever relevant several options have been identified and cross-compared.

II.3 Power Supply

The present report provides information of how to ensure sufficient power supply to GIA. It further includes basic considerations of possible electrical utilities and electrical supply schemes at the airport.

II.3.1 National Electrical Power Supply

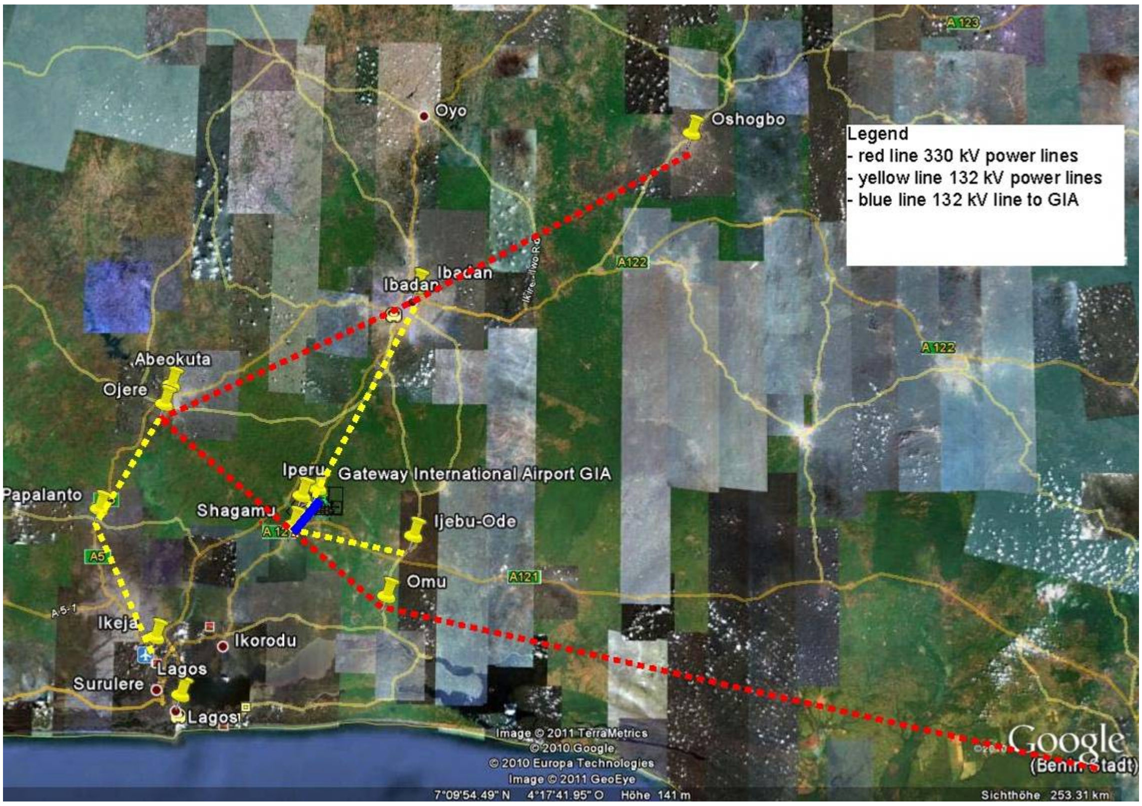

Figure II.3-1 Regional High-Voltage Transmission System

Figure II.3-1 gives an overview of the regional high voltage transmission systems in Lagos, Abeokuta and Ibadan counties. In Abeokuta county, two 330 kV transmission lines are available. The one serves the cities of Ojere, Ibadan, and Oshogbo and the other links the cities of Ojere, Shagamu, Omu and Benin. A further 330 kV transmission line links the cities Benin and Orita. An electric power transformer substation working at 330 kV to 132 kV voltage level has been identified in Ojere. The larger cities in the airport vicinity are supplied from this substation and another 132 kV transmission operates from the city of Ojere to the cities of Ikeja, Sango and Paplanto. A high voltage transmission line at 132 kV level is available from Ijebu to Ode. Furthermore, in this area also exists a 132 kV transmission line, which leads to the transformer substation in Sagamu.

The installed and available capacity of the Ijebo-Ode transmission line, connected to substations, is 60 MVA, divided into two transformers (30 MVA each) that work on 132/33 kV level.

To cater for the future airport power demand, the airport power supply should be provided from the 132 kV-system, via using the Sagamu electric transformer substation, located about 20 to 25 kilometer away from the new airport. However, it should be noted that the currently installed capacity of the national power grid and of the available lines in the Shagamu area are insufficient in terms of generation and transmission capacities to ensure the expected airport power supply. This is mainly due to large consumers in the area, e.g. cement plants using approximately 60 MVA. Several generation and distribution improvement projects have been launched to increase the available capacity.

GIA power needs have been estimated in the range of 15 to 20 MVA for development phases 1 and 2 (i.e. until 2029). It is expected that from 2019 on the additional electrical power demand cannot be realized from the existing Shagamu transformer substation or the corresponding transmission lines.

To implement reliable power supply for GIA, extensive discussions with the power suppliers in Nigeria are necessary during the upcoming planning and design stages.

II.3.2 GIA Airport Power Supply

II.3.2.1 Feeder System

As explained above, the possibility to supply the airport using a 132 kV network has been considered. This would require capital investments for the Samagu transformer substation, the existing 132 kV transmission system and an airport feeder line to GIA. This 132 kV feeder line would have be to be laid underground for approximately two to three kilometer from the airport perimeter because aerial transmission systems are not allowed in airport vicinity. The end point of this airport feeder line is the airport main station located within the airport perimeter. Two oil-insulated transformers with a step-down capacity of 31.5 MW each are planned, rated for 132/33 kV. All transformers are to be specified for tropical conditions.

Figure II.3-2 Example 132/33 kV Oil Transformer, Courtesy of AEG

II.3.2.2 Electrical Power Demand

The power demand estimate is based on the facilities requirements described in the Airport Land-Use Plan, for the four airport development phases, as well as on professional experience from other airports with similar size and annual passenger / cargo throughput. During airport development phase 1, various basic installations are needed, which can be then used and extended during the following airport development phases.

	Phase 1	Phase 2	Phase 3	Phase 4
installed electrical capacity of the airport in MW	34	39,5	58,5	69,5
diversity factor	0,4	0,45	0,5	0,55
electrical capacity of the airport in MW	13,6	17,8	29,2	38,2
power factor (cos φ)	0,95	0,95	0,95	0,95
electrical capacity of the airport in MVA	14,3	18,7	30,8	40,2

Table II-1 GIA Airport Power Demand

Table II-1 shows the expected power demand for GIA during the four development phases. The calculated demand does not include any allowance for near commercial areas and communities located outside airport area boundaries (as shown in the Land-Use Plan). For information only, Table III-2 shows estimations of the additional power needs for surrounding commercial areas and communities.

	Phase 1	Phase 2	Phase 3	Vision
installed electrical capacity of the airport in MW	13,6	17,8	29,2	38,2
installed electrical capacity of the communities in MVA	1	1	2	2
installed electrical capacity of the commercial areas in MW	3	3	7	10
electrical load of the airport incl. communities and commercial areas in MW	17,5	21,8	37,2	49,1
diversity factor	0,9	0,9	0,9	0,9
electrical load of the airport incl. communities and commercial areas in MW	15,75	19,6	33,5	44,2
power factor (cos φ)	0,95	0,95	0,95	0,95
electrical load of the airport incl. communities and commercial areas in MW	**16,6**	**20,7**	**35,25**	**46,5**

Table II-2 Power Demand including GIA and Neighboring Areas

For the individual airport development phases, spare capacities have been considered, as well as diversity factors.

For planning purpose, the following estimated order of magnitude energy consumption is expected:

- Phase 1: approx. 100-125 MWh_{el} per day
- Phase 2: approx. 125-150 MWh_{el} per day
- Phase 3: approx. 175 MWh_{el} per day
- Phase 4: approx. 200 MWh_{el} per day.

II.3.2.3 Power Plant

As outlined above, the national power system is not sufficient to provide reliable power supply to GIA, due to:

- The lack of network reliability and high failure ratio of the national power supply
- The lack of appropriate infrastructure
- The required spare capacity for airport development.

Figure II.3-3 Example Gas Turbine Package, Courtesy of Siemens

The construction of a dedicated airport baseload power plant within the airport area is recommended as the best (if not only) workable alternative to supply GIA. Considering Nigeria's natural gas resources and existing natural gas transmission infrastructure, a gas turbine power plant is recommended as primary option. This power plant should be equipped with three (2+1) gas turbines, with an electrical capacity of 10 MW each. Thus, for airport development phases 1 and 2, a plant configuration of two identical gas-turbine-generator-sets, packages, and one additional spare package as back-up unit (n+1-configuration) is currently considered as the most convenient.

It is expected that by the end of phase 2 (around 2030), the initiated high-voltage generation and transmission projects will have already led to significant improvements of the national system's reliability. If this can be achieved, no additional gas-turbine-packages would be required for Phase 3. The additional electrical power load could indeed be provided by the already existing spare gas-turbine and via a feeder line from the upgraded national transmission system. If the above mentioned improvements to national power grid cannot be achieved by the beginning of Phase 3, two additional 10-MW-gas-turbine-packages would be required to satisfy Airport needs, thereby totaling five turbine "packages", of which four on-duty turbines and an additional backup one (following the n+1-configuration). This configuration would meet Airport power supply requirements until the end of Phase 4 (30 million annual passengers).

The proposed power plant will contain include periphery electrical equipments, such as royalty metering, transformers, switchgears on its premises.

II.3.2.4 Natural Gas Supply

Considering the utmost importance of reliable power supply for airport operations, early contact with national natural gas providers are still necessary to obtain reliable information on natural gas amounts and prices. This should be done during further infrastructure planning and design stages.

II.3.3 Airport Power Distribution

II.3.3.1 Medium Voltage System

The proposed design is governed by following design goals:

- High reliability
- Simple design of the switchgear
- Simple design of the protection concept.

Power distribution is planned on a medium voltage level to provide the required capacities. For the medium voltage configuration, different voltage levels are available, i.e.:

- Option 1 – 10 kV-voltage level: This option should not be considered since this voltage level is insufficient to distribute the requested capacities with acceptable number of medium voltage rings.
- Option 2 – 20/24 kV-voltage level: Power distribution on 20/24 kV voltage level provides sufficient distribution capacity with acceptable number of medium voltage distribution rings. Future system additions can be realized easily, adding further medium voltage stations into the respective rings.
- Option 3 - 33/36 kV-voltage level: Power distribution at 33/36 kV voltage level provides sufficient distribution capacity with acceptable number of medium voltage distribution rings. Future system additions can be realized easily, adding further medium voltage stations into the respective rings.

Taking into account the possibility of supplying surrounding communities (possibly accommodating airport workers) and commercial sites from the airport's power plant during a transitional period, it is recommended to choose the higher 33 kV voltage level. At a later date the infrastructure, including cable network or transmission lines, transformers, switchgear etc. can be sold to an energy supply company. Communities and commercial areas would thus be no longer connected to the airport from the beginning of airport development phase 3.

Attached Appendix 3 includes a concept of the single line diagram showing the overall structure of the medium voltage distribution network and integrating power generation as well as the possible extension of the power plant in phases 3 and 4.

The main station no. 1 and 2 should be designed physically separated, gas-insulated switchgear with coupler for high reliability and local tropical conditions. The recommended location for one of the main stations is close to the power plant to reduce power loss. Five medium voltage rings are to be provided for the airport medium voltage distribution system.

Depicted equipment of the substation such as transformers, circuit breakers etc. is only given as an example and shall be chosen during further design. During the first airport development phases, sufficient spare space must be considered to allow for posterior connections of additional buildings and facilities.

High importance is given to design and equipment standardization in order to facilitate future system additions. 2 to 3 standard stations are to be installed inside container as compact stations, which are generally more economical than individually manufactured units.

To protect the medium voltage equipment and to provide cost-efficient medium power distribution, the medium voltage rings operate openly. As a result, the respective distributions are supplied from only one direction. This also means that the electrical protection concept allows an easy separation of the overcurrent relay and no differential protection device etc. are needed.

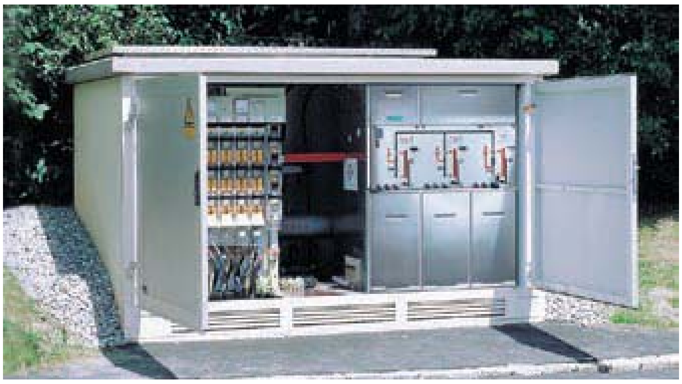

Figure II.3-4 Example of Gas Insulated Compact Switch Gear, Courtesy of Siemens

Figure II.3-5 Example of Gas Insulated Building Switch Gear, Courtesy of Siemens

II.3.3.2 33/0.4 kV Transformer

Standardized transformers offer financial and operational advantages. Three standard transformer sizes are generally used:

- 630 kVA

- 1000 kVA
- 1600 kVA

Cast resin transformers are easy to install inside buildings. Associated with technical support equipment, cast resin transformers can be operated with up to 140% of nominal power. Therefore it is recommended to use cast resin transformers for GIA.

Figure II.3-6 Example of Cast Resin Transformer, Courtesy of Siemens

II.3.3.3 0.4 kV Low-Voltage Switchgear

Regarding the low-voltage switchgear, we also recommend to work with standardized equipment. The following two options are possible:

- Option 1 - switchgear compact station: This involves the possibility to combine the compact station with the gas insulated medium voltage switchgear.
- Option 2 - switchgear for indoor installation: The following guidance should be considered: 1-2 variants for incoming feeder, 2-3 variants for outgoing feeder, 1-2 variants for coupler panels e.g. for the connection of the emergency power systems.

The 0.4 kV incoming feeder should be equipped with circuit breakers, while the 0.4 kV outgoing feeders should be equipped with fuse switch disconnectors.

Figure II.3-7 Example of 0.4 kV Switchgear with Incoming and Outgoing Feeder Lines, Courtesy of ABB

II.3.3.4 Renewable Energy

Green building approaches include intelligent building and system design. When integrated early into the design process green building allows better design with no or only little additional costs, but permits to reduce operational costs significantly.

Photovoltaic generators provide interesting options for onsite green power generation. For solar-thermal power generation, the necessary free spaces are not available and therefore excluded as feasible option for onsite power generation. However solar-thermal systems may be interesting when considering cold generation for building air-conditioning, which required special attention during design.

Considering the available building and shaded structures, the available surfaces on GIA allow installation of photovoltaic systems for an electrical generation capacity of about 2 to 4 MW_{peak}.

Finally, such installations need to be in line with the architecture and in compliance with aviation safety and security requirements.

Figure II.3-8 Example of Architectonic Solar Modules, Courtesy of Würth Solar

Figure II.3-9 Example of Solar Modules on Industrial Facility, Courtesy of Würth Solar

In the current costs there are no costs for possible photovoltaic systems included.

II.4 Telecommunications

The goal, as described in the Scope of Services, is to investigate the needs and options to provide a safe and efficient external telecommunication system for GIA. Furthermore, there are fundamental considerations of internal development in the telecommunications sector to be made.

II.4.1 National Telecommunication Services

The telecommunication service in Nigeria does not have the service density and coverage, compared to western and required international standards. Essentially, the national telecommunication system consists of individual telecommunication lines that connect and service major cities.

According to available information, these lines consist of fiber optic cables and high-pair copper telephone lines. In rural areas and in smaller cities and villages, land-based telecommunications service is generally not available. In particular, the Consultant verified during the December 2010 site visit of the airport site and environs that no land-based telecommunication service is available in the neighborhood of the future airport.

II.4.2 Airport Telecommunications Service

The improvement of the national cable telecommunication infrastructure and the implementation of land-based telecommunications infrastructure in rural and remote areas are required for Nigeria's development. However, the implementation of such infrastructure projects will surely take decades, and for the initial GIA development stages, it is assumed that land-based communications infrastructure will not be available.

Therefore, the airport telecommunications infrastructure during the initial airport development stages should be provided by:

- new construction of satellite receiving systems
- new construction of radio relay system.

Modern satellite and radio-based communications infrastructure can provide the necessary service reliability and safety for international airport operation. Further advantages of radio relay systems are the quick installation and operational readiness. The capital expenditures of radio relay equipment are generally lower than for leased telecommunications circuits. The availability of radio relay service is generally more than 99.99% and without weather-related losses. With radio relay systems, a wide range with data rates from 2Mbps up to 1000Mbps can be guaranteed.

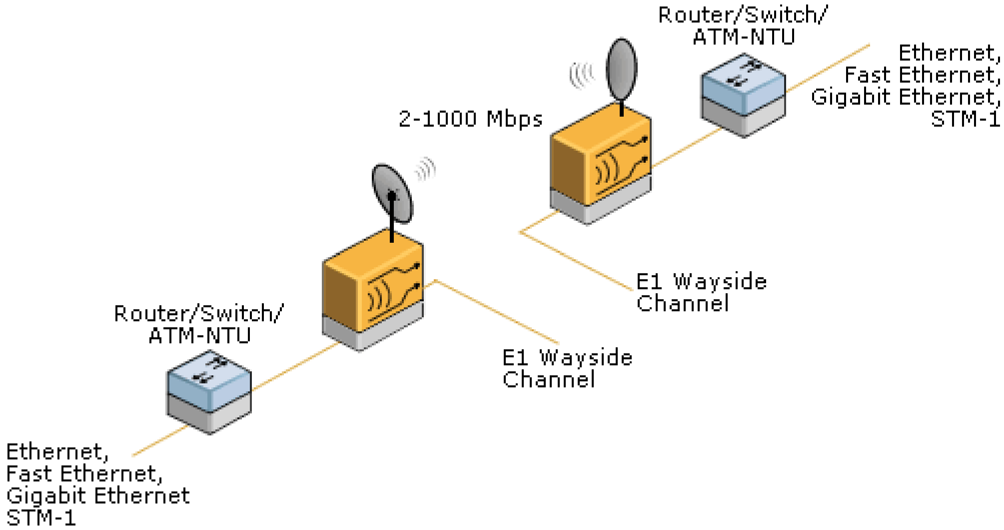

Figure II.4-1 Typical Radio Relay System Design

Nevertheless, the implementation of a land-based telecommunications service is advised once regional land-based telecommunications infrastructure is available, which is not expected earlier than during phase 3. Mainly due to systems' reliability, three independent means of communications infrastructure are advised for international airports to minimize the risks of losing communications.

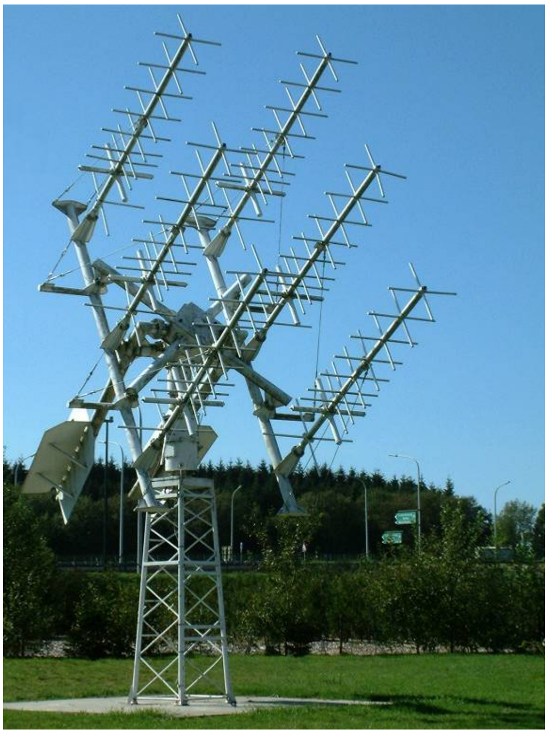

Figure II.4-2 Typical Radio Relay Antenna

To develop the final solution for airport telecommunications infrastructure during the upcoming design phases, the national service providers will have to be contacted.

II.4.3 Airport Telecommunications Infrastructure

In addition to pure telecommunication systems, various individual systems and services are required on international airports. These use the airport telecommunication infrastructure for transmittal of data, voice and images. The most common systems and services are:

- Radio Systems for Airport Operational Communications
- User Neutral Data Network
- Display and Passenger Information Systems
- Antenna Systems for the supply CCTE
- Telephone Systems
- Intercoms
- Clock Systems
- Emergency Call Systems
- Airline data network System.

Further safety and security relevant data, voice and image systems require dedicated and independent infrastructure, separated from the above telecommunications infrastructure.

II.4.3.1 Aviation and Airport Specific Data Voice and Image Systems

Aviation and airport specific data, voice and image systems are required further, which are beyond of the scope of the present report. Separated infrastructure is required for these systems.

II.4.3.2 Network Typologies

For the data, voice & image network infrastructure, different network topologies are applied, as shown in the following figure:

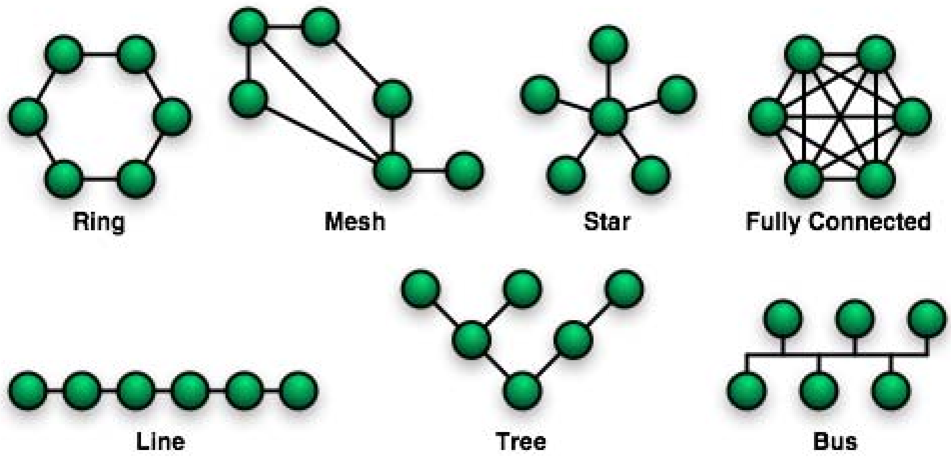

Figure II.4-3 Basic Data Topologies

- Ring topology: A ring network is a network topology in which each node connects to exactly two other nodes and forms a single continuous path for signals from each node, thus forming a ring. If the connection of a node to a neighboring node is disturbed, each node in the network still remains and is still supplied.
- Star topology: Star topology is one of the most common type of network topology that is used in industries and offices. In the star topology there is a central connection point called the hub which is a computer hub or sometimes just a switch. The advantage of a star topology is that when there is a failure in a cable then only one computer might get affected and not the entire network.
- Tree typology: Among all the network topologies we can derive that the tree topology is a combination of the bus topology and the star topology. The tree-like structure allows you to have many servers on the network and you can branch out the network in many ways. This is particularly helpful for buildings which are offside so that each of the branches can identify the relevant systems in their own network and yet connect to the big network in some way. A tree structure suits best when the network is widely spread and vastly divided into many branches.

For the project a combination of the above network topologies is applied to obtain the required system reliability efficiently and economically.

- ring topology for the airport-wide network infrastructure
- star topology for the in-building infrastructure
- tree topology for remote buildings.

For the service to the airport, two areal distribution switching units are considered which are overlaid by two power switching units.

II.4.3.3 Internal Service

The airport telecommunications infrastructure includes both high-pair telecommunications copper cable as well as fiber optic cables. Due to length restrictions, both multi-mode and single-mode fiber optic cable are used. The design of the internal data network should be modular. For each building, one area switching unit (ASU) and different tertiary switching units (SU) as required for individual floors and operational areas will be foreseen and installed in dedicated technical spaces. The technical spaces have specific building and space requirements for, but not limited to: fire safety and fire protection, room climate control, room lighting, grounding and bonding, electrical prime power supply, back-up and break load free power supply, cooling of IT devices, rack and space alarm and surveillance, and IT infrastructure management. The design services specify these requirements according applicable codes and standards and agreed with responsible authorities.

For the wiring structures, following recommendations are given:

- From Areal Distribution Switching Units (ADSU) to Area Switching Unit (ASU) multi-mode fiber optic cable, single mode fiber optic cable and telecommunications copper cable,
- From ASU to SU multi mode fiber optic cable and telecommunications copper cable,
- From SU fiber optic cable for special use and CAT6/class data network cable.

Based on the system's data traffic the appropriate active and passive data, voice and image components will need to be sized and selected during the later design as well as the corresponding infrastructure.

II.4.3.4 Security Systems

Particular attention must be given to the security systems at GIA, which are "standalone" systems and must not be part of the general data, voice and image infrastructure, but instead require dedicated and independent infrastructure. These systems include the following main elements:

- Access Control, Burglar Alarms, Video Surveillance
- Fire Alarm System
- Sound & Public Address System
- Governmental Agencies Radio System.

Separate technical rooms are to be provided that have individual space requirements for, but not limited to: fire safety and fire protection, room climate control, room lighting, grounding and bonding, electrical prime power supply, back-up and break load free power supply, rack and space alarm and surveillance. During future design services these requirements are to be specified according to applicable codes and standards and in coordination with authorities.

II.4.3.4.1 Access Control, Burglar Alarms, Video Surveillance

It is very important to ensure that an integral system is used. Furthermore, it is essential to develop a security concept together with the responsible authorities during the next design phases. Such a security concept shall address, among others:

- Security areas, including separation of landside and airside areas
- Zone concept for access areas
- Technical requirements for video monitoring & recording technology (CCTV)
- Security center.

II.4.3.4.2 Fire Alarm System

The fire alarm system is an essential part of the airport safety system and a system required by international regulations. All buildings are to be equipped with fire alarm systems. The fire alarm system should be designed and built either in compliance with U.S. standards (NFPA) or European standards.

Building fire alarm systems must be designed as separate systems. A central fire alarm system will be provided, while individual subsystems will be connected with the main system to increase reliability.

II.4.3.4.3 Sound & Public Address System

The Sound & Public Address system generally provides the following functions:

- Transmitting voice announcements with informal character
- Transmission of alarm announcements to protect passengers

All buildings are to be equipped with a public address system. The public address system should be designed and built either according to U.S. standard e.g. NFPA or to European standard.

II.4.3.4.3.1 Dedicated Governmental Agencies Radio System

The Dedicated Governmental Agencies Radio (DGAR) system serves the goal of regulating and ensuring a trouble-free communication between governmental agencies.

The relevant governmental agencies that require dedicated communication channels are generally:

- National police forces
- Customs
- Local firefighters and airport fire service,
- Disaster protection authorities and organizations
- Carriers and service providers of the emergency services.

This DGAR system is a non-public mobile FM radio. The TETRA standard, which has been developed in the mid-1990s, is used countrywide or locally in several European and non-European countries. In addition, a second digital radio standard named

Tetrapol (initially developed by EADS for the French governmental agencies) is currently used in parallel to the TETRA standard.

The following figure presents the network architecture of DGAR.

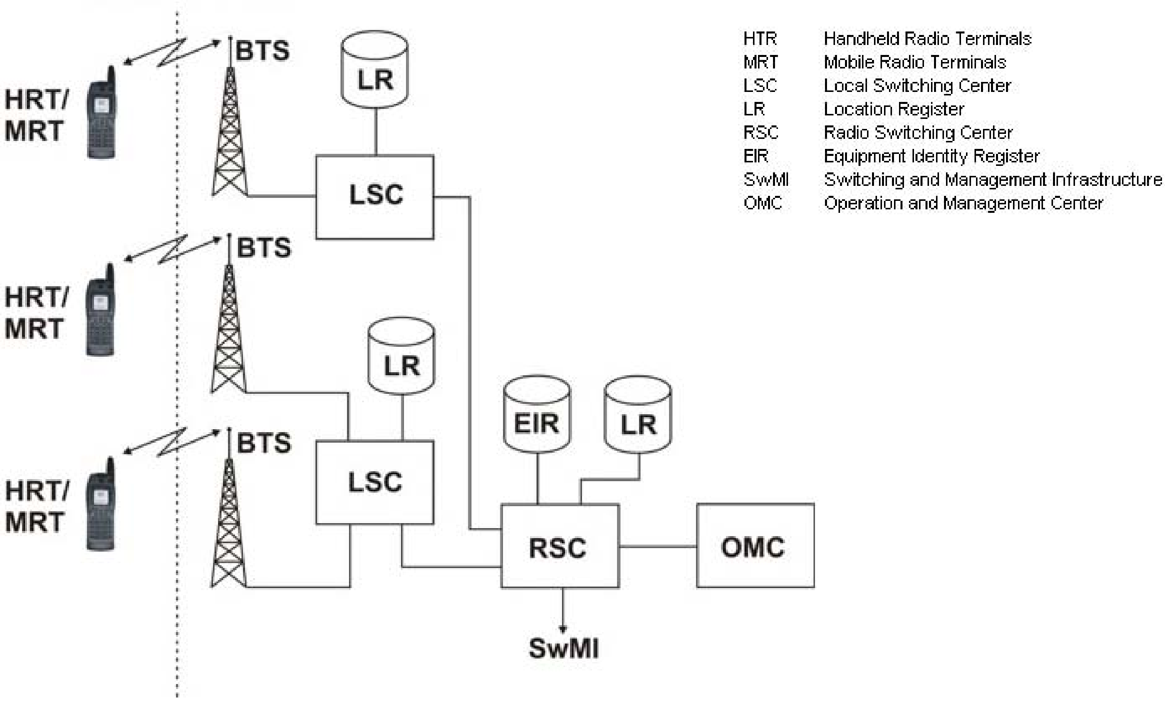

Figure II.4-4 Network Architecture of DGAR-like systems

II.5 Natural Gas Supply

As previously detailed, reliable natural gas supply is required for onsite power generation,. Nigeria's national gas resources are abundant.

II.5.1 Natural Gas Demand

Following the above figures of the expected airport electrical demand, the airport power plant magnitude natural gas consumption is as follows:

- Phase 1 and 2: approx. 204,000 kWh_{th} / day, equivalent to 18,800 normal m^3
- Phase 3 and 4: approx. 340,000 kWh_{th} / day, equivalent to 31,400 normal m^3.

Further natural gas demand may be expected for cooking equipment inside of the catering facility. However, the natural gas consumption of the catering facility is negligible when compared with the demand for power generation and is therefore not considered.

District chilled water systems possibly convenient for space air conditioning may represent a further natural gas consumer. Gas-operated district chilled water systems replace electrical refrigeration systems and the gas demand for power generation is reduced consequently. For the purpose of the present study the airport natural gas demand is expected identical if gas-operated district chilled water systems are present or not. This has to be addressed during design.

II.5.2 Natural Gas Transmission Systems

The Figure II.5-1 gives an overview of natural gas transmission systems. Some 20 km south of proposed airport site, the Escravos-Lagos–Pipeline-System (ELPS) links Lagos region with the Escravos gas fields over a length of 340 kilometer and 36 inches, DN900 respectively, pipe size.

At Escravos natural gas fields, NNPC develops a large Gas-To-Liquid (GTL) facility, but reliable information about ELPS's natural gas throughput or pressure rating couldn't be obtained. Based on the Escavos natural gas production, ELPS pipe size and system length, and expert assertions that sufficient natural gas can be provided without limitations[1],the Consultant expects that ELPS will be able to provide the required amount of natural gas to the airport. A direct spur line from the ELPS to the airport at system's high pressure without additional compressor station is considered as a feasible option.

The high pressure spur line is expected to operate on a minimum working pressure of five MPa_{gauge} and over, and is made from steel pipe spools.

Figure II.5-1 Pipeline Transmission Systems, F40 Lagos – Escravos Natural Gas Transmission System

[1] Based on discussion with Dr Gaines G held in October 2010

II.5.3 Airport Natural Gas Supply

The natural gas spur line includes the necessary isolation devices, royalty metering, and pressure reduction at the airport power station. Gas supply to the gas turbine takes place at medium pressure level, say 0.2 to 0.5 MPa_{gauge}, according to manufacturers' recommendations.

For other natural gas consumers, e.g. canteen and catering facilities, and, if economically convenient, gas-operated district chilled water facility, a low-pressure airport natural gas distribution system, with working pressures of 0.1 MPa_{gauge} and under, will be implemented. While all medium-pressure natural gas systems are made of steel pipes, the low-pressure distribution system is made of HDPE, plastic pipe spools.

If economically convenient, pressure reduction shall include micro turbines with power generation to effectively use the pressure drop from the high pressure spur line to the medium- and low-pressure distribution system and to optimize the airport's energy performance.

II.6 Fuel Farm, Petrol Station and Supply System

The safe and continuous supply of on-time and economically delivered jet fuel is a critical component of airport operations, this is especially true for airports with an elevated number of long haul operations, such as the GIA. Any disruption to the fuel supply chain can have significant flow-on effects to all aircraft movements and passengers.

II.6.1 Aviation Fuel Types

Aviation fuel for modern passenger and cargo jet airplanes is internationally Jet A-1, a kerosene-type jet fuel. Jet A-1 is the standard specification fuel used worldwide, whereas Jet A specification fuel is only available in the United States. Jet B fuel grades are rarely used, except in very cold climates, and will not be used at GIA. Since military operations won't take place military fuel grades are not required.

Two per cent of greenhouse gas emissions due to human activity are generated by the aviation industry. With an increasing focus on reducing fossil fuel use to minimize climate change aircraft manufacturers are investigating the use of biofuels to power the aircraft. Biofuels are seen as the only hope for economic survival of the aviation industry as a means of achieving sustainability. Peak Oil and increasing oil prices are also a threat to the future of aviation.

Since 2008 various international airlines and manufactures have tested blends of Jet A-1 with biofuels. In June 2010 the German Airbus manufacturer EADS performed tests with an engine powered solely by algae-derived biofuel.[2] IATA, in its environmental vision to mitigate greenhouse gas emissions from aviation, set a target

[2] Morris, John (2010-06-07). "EADS Sets First Public Algae-Biofuel Flight At ILA Berlin". Aviation Week, accessed January 20, 2011

to be using 10% alternative fuels by 2017.[3] There are strong indicators that biofuels would become cost-comparable with traditional jet fuel, Jet A-1 by around 2020.[4]

Considering the situation of Nigeria as OPEC member state with strong crude oil resources, however lacking refining capacities in general and for jet fuel specifically, strongly dependent on product fuel imports on one hand side, and rich vegetation and precipitations on the other hand side, a significant production of aviation biofuels seems possible. Nigeria is appropriate for aviation fuel production from jatropha.[5] Given the right incentives and impulses a larger portion than above mentioned IATA target of 10% should be possible for the GIA fuel supply.

To impulse sustainable development, for 2017, when aviation biofuels become cost-comparable, a target portion of 10 to 20 % of GIA's jet fuel supply should be aviation biofuel.

Jet fuel is very similar to diesel fuel. In contrast, avgas is a high-octane aviation fuel used to power many piston and Wankel engine aircraft as commonly used for general aviation engines. Avgas is a portmanteau for aviation gasoline, as distinguished from mogas (motor gasoline), which is the everyday gasoline used in cars. The most commonly used aviation fuel is one hundred octane 100LL avgas grade, spoken as "100 low lead". It contains a small amount of tetra-ethyl lead (TEL), a lead compound that reduces gasoline's tendency to spontaneously explode (detonation or "knock") under high loads, high temperatures and high pressures.[6]

100LL grade is expensive because it can't be produced without taking the refinery off-line afterwards for a cleaning, and the fuel must be moved in different trucks from unleaded fuels[7] that requires separate supply chains for mogas and avgas. 2010 in the USA, the average nationwide price difference between mogas/autogas and avgas was about $1.30 per gallon ($0.34 per liter).

Currently, the use of 100LL avgas is under discussion because of its lead content and phase-out is discussed. The 100LL phase-out has been called "one of modern general aviation's most pressing problems", because 70% of 100LL aviation fuel is used by the 30% of the aircraft in the general aviation fleet that cannot use any of the existing alternatives.[8]

The industry is testing alternative aviation fuels to replace 100LL, but the results are contradictory. In February industry announced a 100LL replacement to be called G100UL, indicating "unleaded".

The possibility of environmental legislation banning the use of leaded avgas, and the lack of a replacement fuel with similar performance, has left aircraft designers and pilot's organizations searching for alternative engines for use in small aircraft. As a result, a few aircraft engine manufacturers have begun offering diesel aircraft

[3] IATA, 2009, A global approach to reducing aviation emissions, downloaded from www.iata.com
[4] ATAG Air Transport Action Group (May 2009). Beginner's Guide to Aviation Biofuels.
[5] ATAG Air Transport Action Group (May 2009). Beginner's Guide to Aviation Biofuels.
[6] Avgas, www.wikipedia.org, accessed January 20, 2011
[7] Dolph, G. (2008, August). Fuels for tomorrow's aviation. General Aviation, 24-25. Retrieved from http://www.iaopa.eu/mediaServlet/storage/gamag/aug08/GA_p24-25.pdf
[8] Avgas, www.wikipedia.org, accessed January 20, 2011

engines which run on jet fuel. This technology has potential to simplify airport logistics by reducing the number of fuel types required. Jet fuel is available in most places in the world, whereas avgas is only widely available in a few countries which have a large number of general aviation aircraft. A diesel engine may also potentially be more environmentally friendly and fuel-efficient than an avgas engine. However, very few diesel aircraft engines have been certified by aviation authorities, and widespread use of diesel aircraft engines is still years in the future.[9]

Autogas, or mogas as it is commonly referred to among pilots, is a viable unleaded solution for airplanes for more than 28 years[10], and has the potential of covering nearly 70 percent of the total piston-powered, spark-ignition reciprocating engine fleet, there is a general stigma for this type of fuel for a number of technical reasons[11], FAA's objection using mogas when transporting passengers and the need of Supplemental Type Certificates (STC), an official document authorizing an aircraft to be modified from its original design.[12]

In the USA, 2008, 92 percent of fixed-wing general aviation piston aircraft use 100LL avgas or 100 octane fuel compared to two percent mogas and six percent Jet A fuel. Other fuels are used only to less than 0.5%.[13]

At GIA mogas can be made available over the airport filling station, for general aviation fueling both 100LL and G100UL are considered and dedicated fueling facilities are to be provided.

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[9] Jet fuel, www.wikipedia.org, accessed January 20, 2011

[10] Who we are. (2010). Experimental Aircraft Association: Autofuel. Retrieved from http://www.eaa.org/autofuel/whoweare/

[11] Cloche, M. (2010, March). Hot Topics in General Aviation: Sustainable Aviation Gasoline Alternatives. Masters in Business Administration Thesis. International School of Management in Paris, France

[12] Cloche, M. (2010, March). Hot Topics in General Aviation: Sustainable Aviation Gasoline Alternatives. Masters in Business Administration Thesis. International School of Management in Paris, France

[13] General Aviation Manufacturers Association. (2009). 2009 general aviation statistical databook & industry outlook. Retrieved from http://www.gama.aero/files/documents/GA_Statistical_Databook_and_Industry_Outlo ok.pdf

Fuel types

Fuel Type / ICAO Aircraft Code	A	B	small C	C	D	E	F
Jet Fuels							
Jet A	not used - only regional usage in USA						
Jet A-1	very little	yes	yes	yes	yes	yes	yes
aviation biofuel	very little²	yes²	yes²	yes²	yes²	yes²	yes²
Jet B	not used - only for cold climates						
JP-1	not used - military grade						
JP-4 thru 8	not used - military grade						
JPTS	not used - military grade						
Aviation Fuels							
100LL	yes	not used - for this aircaft type					
G100UL	yes[4]	not used - for this aircaft type					
Mogas	very little³	not used - for this aircaft type					
82UL	not used, not produced any more						
80/87	not used, very little availability						
100/130	not used, only regional usage in New Zealand and Australia						
91/96 & 115/145	[1]	not used - for this aircaft type					

[1]91/96 & 115/145 are produced for special events such as unlimited air races an may be made available on such events
²Aviation biofuels to replace 10 to 20% of jet fuel by 2020
³Mogas to be provided via airport filling station
[4]Unleaded drop-in replacement for 100LL

Table II-3 Aviation fuels types used at GIA

II.6.2 Aviation Fuel Availability

According to the Nigerian constitution, all minerals, gas, and oil the country possesses are legally the property of the Nigerian federal government. The Nigerian National Petroleum Corporation (NNPC) is the state oil corporation through which the federal government of Nigeria regulates and participates in the country's petroleum industry. NNPC by law manages the joint venture between the Nigerian federal government and a number of foreign multinational corporations. Through collaboration with these companies, the Nigerian government conducts petroleum development. NNPC has sole responsibility for upstream and downstream developments, covering the entire spectrum of oil industry operations: exploration and production, gas development, refining, distribution, petrochemicals, engineering, and commercial investments.[14]

Nigeria possesses three refining facilities, all operated by NNPC: In Kaduna, half way between Kano and Abudja, Warri and Port Harcourt in the delta area, Kaduna Refinery and Petrochemical Co. Limited (KRPC), Warri Refinery and Petrochemical Co. Limited (WRPC), Port Harcourt Refining Co. Limited (PHRC). Nigeria's refineries have a nameplate capacity of 445,000 barrels per day (70,749 cubic meters) but have never operated at that level.[15] The Monthly Petroleum Information (MPI) is a monthly summary of Nigerian oil and gas industry activities featuring data on all aspects of upstream and downstream operations disclosed to the public on the corporation's homepage. During the last three years, highest monthly production did not even reach 500,000 cubic meters, 499,091 cubic meters in February 2009.[16] For

[14] Nigerian National Petroleum Corporation (NNPC), www.wikipedia.org, accessed January 20, 2011
[15] Nigeria Reassures Investors on New Lekki Greenfield Oil Refinery, www. http://www.chairmanking.com/nigeria-reassures-investors-new-lekki-greenfield-oil-refinery-20091211/, accessed January 20, 2011
[16] Nigerian National Petroleum Corporation (NNPC), Monthly Petroleum Information 2009 February Highlights

months, production is even nil at all three refineries. KRPC and WRPC had remained unavailable during the entire year 2007 due to lack of crude oil supply caused by the vandalism of the Escravos-Warri pipeline.[17]

MPI provides information about Aviation Turbine Kerosene (Jet A-1) distribution. Highest monthly distribution during the last years has been registered in February 2009, 170,000 cubic meters, 6,100 cubic meters per day respectively.[18] Throughout 2008, Aviation Turbine Kerosene (ATK – Jet A-1) came third in the petroleum products distribution slate with a total figure of 1,050.43 million liters giving an average daily figure of 2.87 million liters.[19] 2007, the total figure for Aviation Turbine Kerosene (ATK – Jet A-1) distribution averaged 0.94 million liters per day.[20] The average daily Aviation Turbine Kerosene distribution between December 2004 and May 2010 reached 1.5 million liters. Latest figure of Aviation Turbine Kerosene distribution disclosed by NNPC corresponds to March 2010. In this month the daily distribution did not reach 0.8 million liters.[21]

NNPC does not provide any figure about domestic refining of aviation fuels in any of the refineries. This coincides with information received from Nigerian German Energy Partnership, Frankfurt, a bi-national cooperation of German energy industries and Nigerian stakeholders that Nigerian national aviation fuel production is nil and all aviation fuel commercialized in Nigeria is imported, mainly from Ivory Coast.[22] Landing facilities for aviation fuel are expected to be located near Lagos terminal.

As a result of national petroleum shortcomings and lacking refining capacities, China is to build an oil refinery in Nigeria, worth of 8 bn $. It will be the first of three refineries covered by a contract signed in May 2010 between Nigeria's state oil company, NNPC, and the China State Construction Engineering Corporation (CSCEC). The refinery will be built in the Lekki free trade zone of Lagos. Under the 23 bn $ framework agreement between NNPC and CSEC, two other refineries will be built. One in Bayelsa in the Niger delta area and the other one in Kogi, near to the Niger bifurcation as well as a fuel complex.[23] Despite of the project's magnitude no information about the current status of the project is available. However, once implemented, it seems realistic that Aviation Turbine Kerosene (ATK – Jet A-1) is included in the refining portfolio.

One 259 kilometer long product pipeline system from Lagos terminal to near Warri exists. System's pipe sizes are 6, 12 and 16 inch, DN150, DN300 and DN400, respectively. General fuel transport takes place with cargo tank motor vehicles (CTMV). In the area of GIA in Ogun, currently only one narrow gauge railway line links Lagos with the cities of Abeokuta, Ibadan and further to Nguru, near the Niger-Nigeria border which is mainly used for passenger transport.

[17] Nigerian National Petroleum Corporation (NNPC), 2008 Annual Statistical Bulletin
[18] Nigerian National Petroleum Corporation (NNPC), Monthly Petroleum Information 2009 February Highlights
[19] Nigerian National Petroleum Corporation (NNPC), 2008 Annual Statistical Bulletin
[20] Nigerian National Petroleum Corporation (NNPC), 2007 Annual Statistical Bulletin
[21] Nigerian National Petroleum Corporation (NNPC), Monthly Petroleum Information 2010 April Highlights
[22] Dr Gaines G., personal information, October 2010
[23] Scott, C, China to build oil refinery in Nigeria. Retrieved January 22, 2011 from http://www.one.org/blog/2010/07/09/china-to-build-oil-refinery-in-nigeria/

Nigeria experiences an elevated degree of fuel robbery, from all means of transmission. Fatal road accidents with fuel CTMV involved are reported regularly. As well various fatal accidents occurred due to puncture by thieves.

Concluding, reliable aviation fuel supply for the operation of a new major international airport cannot be provided under the given conditions.

Figure II.6-1 National rail network

Figure II.6-2 Pipeline transmission systems, F14 Warri – Lagos product transmission system

II.6.3 GIA Aviation Fuel Demand

Multiple factors govern the aviation fuel demand on airports, number and destinations of air movements, fleet composition and airlines' fueling policy that in turn is governed by criteria of fuel price, availability and available quality. As fleet composition, destinations and policies varies throughout the years, as well the aviation fuel demand is variable. At the present planning stage any prediction of aviation fuel demand figures must be vague, and subject of posterior variation.

The aviation fuel demand is based on various assumptions for refueling operations of the different aircraft types: Individual amount of fuel to be refueled, refueling operation, either en-route station or turnaround station and flee composition.

Unit Fuel consumption										
			turnaround station					en route station		
AC Category	Dist.	Avg. Dist. (km)	typical fuel supply			utiliz-ation	design demand	fuel supply	utiliz-ation	design demand
Code letter A/B	Short	600	1,826 l	19,442 l	28,156 l	70%	**11,200 l**	0 l	70%	**0 l**
Code letter C	Short	600	13,000 l	36,340 l	26,022 l	70%	**17,500 l**	0 l	70%	**0 l**
	Medium	1,200	39,530 l	40,485 l	29,663 l	70%	**25,900 l**	0 l	70%	**0 l**
Code letter D	Medium	2,000	30,945 l	36,340 l		70%	**23,800 l**	0 l	70%	**0 l**
	Inter	7,000								
Code letter E	Medium	5,000	179,807 l	227,125 l	167,315 l	60%	**114,600 l**	68,173 l	80%	**54,400 l**
	Inter	9,000								
Code letter F	Medium	5,500								
	Inter	11,000			229,975 l	60%	**138,000 l**	75,708 l	80%	**60,800 l**

Table II-4 Unit fuel demand

For fueling only the number of take-offs is relevant, therefore the number of air-traffic movements for airfield design has to be divided by two.

Table II-5 gives information about the number of starts considered for fuel demand estimate. To obtain the maximum number of daily aircraft movements a daily peaking factor of 1.3 has been applied to the average number (annual movements divided by 365 days). In order to obtain a number of refueling operations at GIA, the daily number of aircraft starts has been distributed into enroute station that does not ask for any refueling or for reduced amounts of fuel and turnaround station, see table. With the unit fuel demand, the total daily fuel demand at GIA is depicted in Table II-7 year by year. Stating with approximately 740 thousand liter per day in 2015, the final fuel demand is expected to reach 9.6 million liter by 2040.

The average amount of approximately 27,000 liter of fuel consumed per commercial aircraft departure during a peak day in the peak month is relatively high. This is due to the elevated number of long haul destinations and of large aircrafts.

Year / ICAO Aircraft Code	Max. Daily Aircraft Starts																	
	A/B/small C			C			D			E			F			Σ total		
	turn around station	turn around station	enroute station	turn around station	turn around station	enroute station	turn around station	turn around station	enroute station	turn around station	turn around station	enroute station	turn around station	turn around station	enroute station	turn around station	enroute station	total
2015	50%	2	2	50%	9	9	50%	0	0	60%	3	2	60%	0	0	15	13	28
2016	50%	3	3	50%	14	14	50%	0	0	60%	5	4	60%	1	0	23	21	45
2017	50%	5	5	50%	21	21	50%	1	1	60%	8	6	60%	1	1	36	33	69
2018	50%	7	7	50%	29	29	50%	1	1	60%	11	8	60%	1	1	49	44	93
2019	50%	7	7	50%	31	31	50%	1	1	60%	12	8	60%	1	1	52	48	100
2020	50%	8	8	50%	33	33	50%	1	1	60%	13	9	60%	2	1	56	51	107
2021	50%	8	8	50%	35	35	50%	1	1	60%	14	9	60%	2	1	59	54	113
2022	50%	9	9	50%	37	37	50%	1	1	60%	15	10	60%	2	1	62	57	119
2023	50%	9	9	50%	39	39	50%	1	1	60%	16	10	60%	2	1	66	60	126
2024	50%	10	10	50%	41	41	50%	1	1	60%	16	11	60%	2	1	69	63	132
2025	50%	10	10	50%	43	43	50%	1	1	60%	17	11	60%	2	1	73	66	139
2026	50%	11	11	50%	45	45	50%	1	1	60%	18	12	60%	2	1	76	70	146
2027	50%	11	11	50%	47	47	50%	1	1	60%	19	13	60%	2	1	80	73	154
2028	50%	12	12	50%	50	50	50%	1	1	60%	20	13	60%	2	1	84	77	161
2029	50%	12	12	50%	52	52	50%	1	1	60%	21	14	60%	2	1	88	80	169
2030	50%	13	13	50%	54	54	50%	1	1	60%	22	14	60%	2	2	92	84	176
2031	50%	13	13	50%	57	57	50%	1	1	60%	23	15	60%	2	2	96	88	185
2032	50%	14	14	50%	60	60	50%	1	1	60%	24	16	60%	2	2	101	92	193
2033	50%	15	15	50%	62	62	50%	1	1	60%	25	17	60%	3	2	106	96	202
2034	50%	15	15	50%	65	65	50%	1	1	60%	26	17	60%	3	2	110	100	210
2035	50%	16	16	50%	68	68	50%	1	1	60%	27	18	60%	3	2	115	105	220
2036	50%	17	17	50%	71	71	50%	1	1	60%	28	19	60%	3	2	120	109	229
2037	50%	17	17	50%	74	74	50%	2	2	60%	29	20	60%	3	2	125	114	239
2038	50%	18	18	50%	77	77	50%	2	2	60%	31	20	60%	3	2	130	119	249
2039	50%	19	19	50%	80	80	50%	2	2	60%	32	21	60%	3	2	135	124	259
2040	50%	20	20	50%	83	83	50%	2	2	60%	33	22	60%	4	2	141	129	270
Vision 2040	50%	25	25	50%	108	108	50%	2	2	60%	43	29	60%	5	3	183	167	351

Table II-5 Estimated Maximum number of daily take-offs

Year / ICAO Aircraft Code	Max. Daily Aircraft Fueling Operations																	
	A/B/small C			C			D			E			F			Σ total		
	enroute fuel	turn around station	enroute station	enroute fuel	turn around station	enroute station	enroute fuel	turn around station	enroute station	enroute fuel	turn around station	enroute station	enroute fuel	turn around station	enroute station	turn around fuel	enroute fuel	total
2015	no	2	0	no	9	0	no	0	0	yes	3	2	yes	0	0	15	2	17
2016	no	3	0	no	14	0	no	0	0	yes	5	4	yes	1	0	23	4	27
2017	no	5	0	no	21	0	no	1	0	yes	8	6	yes	1	1	36	6	42
2018	no	7	0	no	29	0	no	1	0	yes	11	8	yes	1	1	49	8	57
2019	no	7	0	no	31	0	no	1	0	yes	12	8	yes	1	1	52	9	61
2020	no	8	0	no	33	0	no	1	0	yes	13	9	yes	2	1	56	10	66
2021	no	8	0	no	35	0	no	1	0	yes	14	9	yes	2	1	59	10	69
2022	no	9	0	no	37	0	no	1	0	yes	15	10	yes	2	1	62	11	73
2023	no	9	0	no	39	0	no	1	0	yes	16	10	yes	2	1	66	12	78
2024	no	10	0	no	41	0	no	1	0	yes	16	11	yes	2	1	69	12	81
2025	no	10	0	no	43	0	no	1	0	yes	17	11	yes	2	1	73	13	85
2026	no	11	0	no	45	0	no	1	0	yes	18	12	yes	2	1	76	13	90
2027	no	11	0	no	47	0	no	1	0	yes	19	13	yes	2	1	80	14	94
2028	no	12	0	no	50	0	no	1	0	yes	20	13	yes	2	1	84	15	99
2029	no	12	0	no	52	0	no	1	0	yes	21	14	yes	2	1	88	15	103
2030	no	13	0	no	54	0	no	1	0	yes	22	14	yes	2	2	92	16	108
2031	no	13	0	no	57	0	no	1	0	yes	23	15	yes	2	2	96	17	113
2032	no	14	0	no	60	0	no	1	0	yes	24	16	yes	2	2	101	17	118
2033	no	15	0	no	62	0	no	1	0	yes	25	17	yes	3	2	106	18	124
2034	no	15	0	no	65	0	no	1	0	yes	26	17	yes	3	2	110	19	129
2035	no	16	0	no	68	0	no	1	0	yes	27	18	yes	3	2	115	20	135
2036	no	17	0	no	71	0	no	1	0	yes	28	19	yes	3	2	120	21	141
2037	no	17	0	no	74	0	no	2	0	yes	29	20	yes	3	2	125	22	147
2038	no	18	0	no	77	0	no	2	0	yes	31	20	yes	3	2	130	23	153
2039	no	19	0	no	80	0	no	2	0	yes	32	21	yes	3	2	135	23	159
2040	no	20	0	no	83	0	no	2	0	yes	33	22	yes	4	2	141	25	166
Vision 2040	no	25	0	no	108	0	no	2	0	yes	43	29	yes	5	3	183	32	215

Table II-6 Estimated number of daily refueling operations

Year / ICAO Aircraft Code	Max. Daily Fuel Demand										
	A/B/small C		C		D		E		F		Σ total
	turn around station	enroute station	turn around station	enroute station	turn around station	enroute station	turn around station	enroute station	turn around station	enroute station	total
2015	22.400 l	0 l	153.125 l	0 l	5.950 l	0 l	378.180 l	119.680 l	41.400 l	12.160 l	732.895 l
2016	36.400 l	0 l	240.625 l	0 l	5.950 l	0 l	618.840 l	195.840 l	82.800 l	24.320 l	1.204.775 l
2017	56.000 l	0 l	371.875 l	0 l	11.900 l	0 l	962.640 l	304.640 l	124.200 l	36.480 l	1.867.735 l
2018	75.600 l	0 l	503.125 l	0 l	11.900 l	0 l	1.306.440 l	413.440 l	165.600 l	48.640 l	2.524.745 l
2019	81.200 l	0 l	542.500 l	0 l	11.900 l	0 l	1.409.580 l	446.080 l	165.600 l	48.640 l	2.705.500 l
2020	86.800 l	0 l	573.125 l	0 l	17.850 l	0 l	1.512.720 l	478.720 l	207.000 l	60.800 l	2.937.015 l
2021	92.400 l	0 l	608.125 l	0 l	17.850 l	0 l	1.581.480 l	500.480 l	207.000 l	60.800 l	3.068.135 l
2022	95.200 l	0 l	643.125 l	0 l	17.850 l	0 l	1.684.620 l	533.120 l	207.000 l	60.800 l	3.241.715 l
2023	100.800 l	0 l	678.125 l	0 l	17.850 l	0 l	1.787.760 l	565.760 l	248.400 l	72.960 l	3.471.655 l
2024	106.400 l	0 l	713.125 l	0 l	17.850 l	0 l	1.856.520 l	587.520 l	248.400 l	72.960 l	3.602.775 l
2025	112.000 l	0 l	752.500 l	0 l	17.850 l	0 l	1.959.660 l	620.160 l	248.400 l	72.960 l	3.783.530 l
2026	117.600 l	0 l	791.875 l	0 l	17.850 l	0 l	2.062.800 l	652.800 l	248.400 l	72.960 l	3.964.285 l
2027	123.200 l	0 l	826.875 l	0 l	23.800 l	0 l	2.165.940 l	685.440 l	289.800 l	85.120 l	4.200.175 l
2028	128.800 l	0 l	866.250 l	0 l	23.800 l	0 l	2.269.080 l	718.080 l	289.800 l	85.120 l	4.380.930 l
2029	137.200 l	0 l	910.000 l	0 l	23.800 l	0 l	2.372.220 l	750.720 l	289.800 l	85.120 l	4.568.860 l
2030	142.800 l	0 l	949.375 l	0 l	23.800 l	0 l	2.475.360 l	783.360 l	331.200 l	97.280 l	4.803.175 l
2031	148.400 l	0 l	997.500 l	0 l	23.800 l	0 l	2.612.880 l	826.880 l	331.200 l	97.280 l	5.037.940 l
2032	156.800 l	0 l	1.041.250 l	0 l	29.750 l	0 l	2.716.020 l	859.520 l	331.200 l	97.280 l	5.231.820 l
2033	162.400 l	0 l	1.089.375 l	0 l	29.750 l	0 l	2.853.540 l	903.040 l	372.600 l	109.440 l	5.520.145 l
2034	170.800 l	0 l	1.133.125 l	0 l	29.750 l	0 l	2.956.680 l	935.680 l	372.600 l	109.440 l	5.708.075 l
2035	176.400 l	0 l	1.185.625 l	0 l	29.750 l	0 l	3.094.200 l	979.200 l	414.000 l	121.600 l	6.000.775 l
2036	184.800 l	0 l	1.238.125 l	0 l	29.750 l	0 l	3.231.720 l	1.022.720 l	414.000 l	121.600 l	6.242.715 l
2037	193.200 l	0 l	1.290.625 l	0 l	35.700 l	0 l	3.369.240 l	1.066.240 l	414.000 l	121.600 l	6.490.605 l
2038	201.600 l	0 l	1.343.125 l	0 l	35.700 l	0 l	3.506.760 l	1.109.760 l	455.400 l	133.760 l	6.786.105 l
2039	210.000 l	0 l	1.400.000 l	0 l	35.700 l	0 l	3.644.280 l	1.153.280 l	455.400 l	133.760 l	7.032.420 l
2040	218.400 l	0 l	1.456.875 l	0 l	35.700 l	0 l	3.816.180 l	1.207.680 l	496.800 l	145.920 l	7.377.555 l
Vision 2040	282.800 l	0 l	1.894.375 l	0 l	47.600 l	0 l	4.950.720 l	1.566.720 l	621.000 l	182.400 l	9.545.615 l

Table II-7 Estimated daily aviation fuel demand

The estimated Jet A-1 demand during the first year of GIA airport operation represents half of the average daily amount of Aviation Turbine Kerosene distributed nation-wide (1.5 million liter), respectively 90% of the latest nation-wide daily distribution during March 2010. During the third year of GIA operation the estimated daily Jet A-1 demand at GIA is expected to exceed the average nation-wide amount of distributed Aviation Turbine Kerosene. By the year 2040 the estimated aviation fuel demand at GIA is expected to reach 630% of the current average nation-wide Aviation Turbine Kerosene distribution, 9.5 million liter against 1.5 million liter, respectively 1,190% of the daily Aviation Turbine Kerosene distribution of March 2010.

The estimated daily fuel demand includes Jet A-1 and avgas. Avgas is used exclusively for smaller general aviation aircrafts, ICAO code A and B, only this, all other aircraft types are operated with Jet A-1. Exact figures for general aviation are currently not available. To estimate the demanded amount of avgas the following has been assumed:

- aircrafts included in the column “A, B, small C” are mainly general aviation aircrafts,
- 50 % of the fuel demand shown in the column “A, B, small C” corresponds to class A and B aircrafts,

- of these class A and B aircrafts, 92 % are operated with avgas, 6 % with Jet A-1 and 2 % with mogas,
- the remaining “small C” aircrafts are fueled with Jet A-1.

Year / ICAO Aircraft Code	Max. Daily Jet A-1 Demand										
	A/B/small C		C		D		E		F		Σ total
	turn around station	enroute station	turn around station	enroute station	turn around station	enroute station	turn around station	enroute station	turn around station	enroute station	total
2015	12.096 l	0 l	153.125 l	0 l	5.950 l	0 l	378.180 l	119.680 l	41.400 l	12.160 l	722.591 l
2016	19.656 l	0 l	240.625 l	0 l	5.950 l	0 l	618.840 l	195.840 l	82.800 l	24.320 l	1.188.031 l
2017	30.240 l	0 l	371.875 l	0 l	11.900 l	0 l	962.640 l	304.640 l	124.200 l	36.480 l	1.841.975 l
2018	40.824 l	0 l	503.125 l	0 l	11.900 l	0 l	1.306.440 l	413.440 l	165.600 l	48.640 l	2.489.969 l
2019	43.848 l	0 l	542.500 l	0 l	11.900 l	0 l	1.409.580 l	446.080 l	165.600 l	48.640 l	2.668.148 l
2020	46.872 l	0 l	573.125 l	0 l	17.850 l	0 l	1.512.720 l	478.720 l	207.000 l	60.800 l	2.897.087 l
2021	49.896 l	0 l	608.125 l	0 l	17.850 l	0 l	1.581.480 l	500.480 l	207.000 l	60.800 l	3.025.631 l
2022	51.408 l	0 l	643.125 l	0 l	17.850 l	0 l	1.684.620 l	533.120 l	207.000 l	60.800 l	3.197.923 l
2023	54.432 l	0 l	678.125 l	0 l	17.850 l	0 l	1.787.760 l	565.760 l	248.400 l	72.960 l	3.425.287 l
2024	57.456 l	0 l	713.125 l	0 l	17.850 l	0 l	1.856.520 l	587.520 l	248.400 l	72.960 l	3.553.831 l
2025	60.480 l	0 l	752.500 l	0 l	17.850 l	0 l	1.959.660 l	620.160 l	248.400 l	72.960 l	3.732.010 l
2026	63.504 l	0 l	791.875 l	0 l	17.850 l	0 l	2.062.800 l	652.800 l	248.400 l	72.960 l	3.910.189 l
2027	66.528 l	0 l	826.875 l	0 l	23.800 l	0 l	2.165.940 l	685.440 l	289.800 l	85.120 l	4.143.503 l
2028	69.552 l	0 l	866.250 l	0 l	23.800 l	0 l	2.269.080 l	718.080 l	289.800 l	85.120 l	4.321.682 l
2029	74.088 l	0 l	910.000 l	0 l	23.800 l	0 l	2.372.220 l	750.720 l	289.800 l	85.120 l	4.505.748 l
2030	77.112 l	0 l	949.375 l	0 l	23.800 l	0 l	2.475.360 l	783.360 l	331.200 l	97.280 l	4.737.487 l
2031	80.136 l	0 l	997.500 l	0 l	23.800 l	0 l	2.612.880 l	826.880 l	331.200 l	97.280 l	4.969.676 l
2032	84.672 l	0 l	1.041.250 l	0 l	29.750 l	0 l	2.716.020 l	859.520 l	331.200 l	97.280 l	5.159.692 l
2033	87.696 l	0 l	1.089.375 l	0 l	29.750 l	0 l	2.853.540 l	903.040 l	372.600 l	109.440 l	5.445.441 l
2034	92.232 l	0 l	1.133.125 l	0 l	29.750 l	0 l	2.956.680 l	935.680 l	372.600 l	109.440 l	5.629.507 l
2035	95.256 l	0 l	1.185.625 l	0 l	29.750 l	0 l	3.094.200 l	979.200 l	414.000 l	121.600 l	5.919.631 l
2036	99.792 l	0 l	1.238.125 l	0 l	29.750 l	0 l	3.231.720 l	1.022.720 l	414.000 l	121.600 l	6.157.707 l
2037	104.328 l	0 l	1.290.625 l	0 l	35.700 l	0 l	3.369.240 l	1.066.240 l	414.000 l	121.600 l	6.401.733 l
2038	108.864 l	0 l	1.343.125 l	0 l	35.700 l	0 l	3.506.760 l	1.109.760 l	455.400 l	133.760 l	6.693.369 l
2039	113.400 l	0 l	1.400.000 l	0 l	35.700 l	0 l	3.644.280 l	1.153.280 l	455.400 l	133.760 l	6.935.820 l
2040	117.936 l	0 l	1.456.875 l	0 l	35.700 l	0 l	3.816.180 l	1.207.680 l	496.800 l	145.920 l	7.277.091 l
Vision 2040	152.712 l	0 l	1.894.375 l	0 l	47.600 l	0 l	4.950.720 l	1.566.720 l	621.000 l	182.400 l	9.415.527 l

Table II-8 Estimated daily Jet A-1 demand

Year / ICAO Aircraft Code	Max. Daily AVGAS Demand										
	A/B/small C		C		D		E		F		Σ total
	turn around station	enroute station	turn around station	enroute station	turn around station	enroute station	turn around station	enroute station	turn around station	enroute station	total
2015	10.304 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	10.304 l
2016	16.744 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	16.744 l
2017	25.760 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	25.760 l
2018	34.776 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	34.776 l
2019	37.352 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	37.352 l
2020	39.928 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	39.928 l
2021	42.504 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	42.504 l
2022	43.792 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	43.792 l
2023	46.368 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	46.368 l
2024	48.944 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	48.944 l
2025	51.520 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	51.520 l
2026	54.096 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	54.096 l
2027	56.672 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	56.672 l
2028	59.248 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	59.248 l
2029	63.112 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	63.112 l
2030	65.688 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	65.688 l
2031	68.264 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	68.264 l
2032	72.128 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	72.128 l
2033	74.704 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	74.704 l
2034	78.568 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	78.568 l
2035	81.144 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	81.144 l
2036	85.008 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	85.008 l
2037	88.872 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	88.872 l
2038	92.736 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	92.736 l
2039	96.600 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	96.600 l
2040	100.464 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	100.464 l
Vision 2040	130.088 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	0 l	130.088 l

Table II-9 Estimated daily avgas demand

The avgas demand is expected less than 1.5 % of the total aviation fuel demand.

II.6.4 Aviation Tank Farm

II.6.4.1 Evaluation of Existing Aviation Fuel Facilities

Following the information about Nigerian aviation fuel quantities, heaviest investments in fuel and aviation fuel infrastructure are of utmost importance for any airport development. These investments shall include all refining, terminal and landing facilities, transport, and transmission systems. Currently, Nigeria’s aviation fuel supply is far from being sufficient or reliable. The existing facilities don’t allow the implementation of refueling operation at GIA.

II.6.4.1.1.1 Aviation Fuel Farm Storage Capacity

Airport aviation fuel storage facilities may provide sufficient fuel for 1.5 to ten days of airport operation. Storage capacity of aviation fuel farms at airports is generally a function of fuel supply availability, location and capacities of refining facilities and location and size of bulk aviation fuel storage facilities. Longer airport autonomy than 10 days is not common for Aviation Turbine Kerosene, because larger storage tanks ask for larger supply facilities for initial filling.

For design purposes, initial fuel storage for seven days of operation should suffice for operational and strategic fuel storage. It is expected that GIA's fuel supply autonomy for Jet A-1 aviation fuel can be reduced to four days for the final development stage, since capital investments are expected to improve nation's energy and transport infrastructure by that time.

In order to achieve improvements in operation and maintenance, tanks of identical size are proposed. Further and in order to adjust the storage capacity to the real demand, we propose a higher number of smaller tanks instead of fewer larger ones. For the initial years of operation, two tanks of 5,300,000 liter capacity each are necessary. The number of storage tanks is expected to increase up to 6 for the final development phase. Tank dimensions are approximately 17 meter in height and 20 meter in diameter.

	Max. day Jet A-1 demand	Avg. day Jet A-1 demand	AP oparation	autonomy	total storage capacity	individual tank capacity	No. storage tanks
2015	722.591 l	555.839 l	24 h/d	7 d	3.890.875 l	5.300.000 l	1
2016	1.188.031 l	913.870 l	24 h/d	7 d	6.397.090 l	5.300.000 l	2
2017	1.841.975 l	1.416.904 l	24 h/d	7 d	9.918.327 l	5.300.000 l	2
2018	2.489.969 l	1.915.361 l	24 h/d	7 d	13.407.525 l	5.300.000 l	3
2019	2.668.148 l	2.052.422 l	24 h/d	7 d	14.366.951 l	5.300.000 l	3
2020	2.897.087 l	2.228.528 l	24 h/d	6 d	13.371.171 l	5.300.000 l	3
2021	3.025.631 l	2.327.408 l	24 h/d	6 d	13.964.451 l	5.300.000 l	3
2022	3.197.923 l	2.459.941 l	24 h/d	6 d	14.759.645 l	5.300.000 l	3
2023	3.425.287 l	2.634.836 l	24 h/d	6 d	15.809.017 l	5.300.000 l	3
2024	3.553.831 l	2.733.716 l	24 h/d	6 d	16.402.297 l	5.300.000 l	4
2025	3.732.010 l	2.870.777 l	24 h/d	6 d	17.224.662 l	5.300.000 l	4
2026	3.910.189 l	3.007.838 l	24 h/d	6 d	18.047.026 l	5.300.000 l	4
2027	4.143.503 l	3.187.310 l	24 h/d	6 d	19.123.860 l	5.300.000 l	4
2028	4.321.682 l	3.324.371 l	24 h/d	6 d	19.946.225 l	5.300.000 l	4
2029	4.505.748 l	3.465.960 l	24 h/d	5 d	17.329.800 l	5.300.000 l	4
2030	4.737.487 l	3.644.221 l	24 h/d	5 d	18.221.104 l	5.300.000 l	4
2031	4.969.676 l	3.822.828 l	24 h/d	5 d	19.114.138 l	5.300.000 l	4
2032	5.159.692 l	3.968.994 l	24 h/d	5 d	19.844.969 l	5.300.000 l	4
2033	5.445.441 l	4.188.801 l	24 h/d	5 d	20.944.004 l	5.300.000 l	4
2034	5.629.507 l	4.330.390 l	24 h/d	5 d	21.651.950 l	5.300.000 l	5
2035	5.919.631 l	4.553.562 l	24 h/d	5 d	22.767.812 l	5.300.000 l	5
2036	6.157.707 l	4.736.698 l	24 h/d	5 d	23.683.488 l	5.300.000 l	5
2037	6.401.733 l	4.924.410 l	24 h/d	4 d	19.697.640 l	5.300.000 l	4
2038	6.693.369 l	5.148.745 l	24 h/d	4 d	20.594.982 l	5.300.000 l	4
2039	6.935.820 l	5.335.246 l	24 h/d	4 d	21.340.985 l	5.300.000 l	5
2040	7.277.091 l	5.597.762 l	24 h/d	4 d	22.391.049 l	5.300.000 l	5
Vision 2040	9.415.527 l	7.242.713 l	24 h/d	4 d	28.970.852 l	5.300.000 l	6

Table II-10 Airport Jet A-1 fuel farm

The lower number of tanks in 2037 is due to the reduction of airport's fuel autonomy from 5 to 4 days.

Once aviation biofuel is available, one or two storage tanks can be used for biofuel.

As outlined above, availability of avgas is limited worldwide. In Nigeria avgas availability is considered even worse. Major investments to increase avgas production are not expected. Consequently, the storage capacity has been adapted to two weeks, 14 days throughout. As well as for Jet A-1 tank farm we recommend identical tanks of smaller size to adjust to the real storage requirements. Tanks of 3 hundred thousand liter with approximate size of 6 meter in diameter and ten meter in height fit best to the requirements. Initially one avgas storage tank is sufficient. This number will increase to five tanks for the final development stage.

	Max. day AVGAS demand	Avg. day AVGAS demand	AP oparation	autonomy	total storage capacity	individual tank capacity	No. storage tanks
2015	10.304 l	7.926 l	24 h/d	14 d	110.966 l	300.000 l	1
2016	16.744 l	12.880 l	24 h/d	14 d	180.320 l	300.000 l	1
2017	25.760 l	19.815 l	24 h/d	14 d	277.415 l	300.000 l	1
2018	34.776 l	26.751 l	24 h/d	14 d	374.511 l	300.000 l	2
2019	37.352 l	28.732 l	24 h/d	14 d	402.252 l	300.000 l	2
2020	39.928 l	30.714 l	24 h/d	14 d	429.994 l	300.000 l	2
2021	42.504 l	32.695 l	24 h/d	14 d	457.735 l	300.000 l	2
2022	43.792 l	33.686 l	24 h/d	14 d	471.606 l	300.000 l	2
2023	46.368 l	35.668 l	24 h/d	14 d	499.348 l	300.000 l	2
2024	48.944 l	37.649 l	24 h/d	14 d	527.089 l	300.000 l	2
2025	51.520 l	39.631 l	24 h/d	14 d	554.831 l	300.000 l	2
2026	54.096 l	41.612 l	24 h/d	14 d	582.572 l	300.000 l	2
2027	56.672 l	43.594 l	24 h/d	14 d	610.314 l	300.000 l	3
2028	59.248 l	45.575 l	24 h/d	14 d	638.055 l	300.000 l	3
2029	63.112 l	48.548 l	24 h/d	14 d	679.668 l	300.000 l	3
2030	65.688 l	50.529 l	24 h/d	14 d	707.409 l	300.000 l	3
2031	68.264 l	52.511 l	24 h/d	14 d	735.151 l	300.000 l	3
2032	72.128 l	55.483 l	24 h/d	14 d	776.763 l	300.000 l	3
2033	74.704 l	57.465 l	24 h/d	14 d	804.505 l	300.000 l	3
2034	78.568 l	60.437 l	24 h/d	14 d	846.117 l	300.000 l	3
2035	81.144 l	62.418 l	24 h/d	14 d	873.858 l	300.000 l	3
2036	85.008 l	65.391 l	24 h/d	14 d	915.471 l	300.000 l	4
2037	88.872 l	68.363 l	24 h/d	14 d	957.083 l	300.000 l	4
2038	92.736 l	71.335 l	24 h/d	14 d	998.695 l	300.000 l	4
2039	96.600 l	74.308 l	24 h/d	14 d	1.040.308 l	300.000 l	4
2040	100.464 l	77.280 l	24 h/d	14 d	1.081.920 l	300.000 l	4
Vision 2040	130.088 l	100.068 l	24 h/d	14 d	1.400.948 l	300.000 l	5

Table II-11 Airport avgas storage

Jet A-1 as well as avgas storage tanks shall comply with API 650 specifications and tank farm periphery shall comply with the stimulated in NFPA 230 Standard for the Fire Protection of Storage, NFPA 407 Standard for Aircraft Fuel Servicing and codes referenced to therein.

II.6.4.2 Aviation Fuel Farm Location

The factors that govern the selection of the best location for an airport fuel farm include:

- allocation of land for other airport uses,
- safety rules regarding the storage of fuel,
- relationship with aircraft parking apron,
- fuel supply method,
- delivery method to the aircraft,
- size of facilities needed, and
- visual impact of storage tanks.

The proposed fuel farm location is depicted on GIA land-use plans.

II.6.4.3 Fuel Farm Airport Location Requirements

Applicable codes and standards don't give detail requirements of fuel farm location on airports. The American Petroleum Institute prepared 1988 the standard 1500 Storage and Handling of Aviation Fuel at Airports, which is partly superseded but not withdrawn.

FM Global as one of world-wide leading insurance companies provides comprehensive global commercial and industrial property insurance, engineering-driven underwriting and risk management solutions, property loss prevention research and prompt, professional claims handling. As such FM Global discloses Property Loss Prevention Data Sheets (PLODS), covering most of the industrial sectors. PLODS FMDS0788[24] covers aviation fuel storage facilities, too.

	Liquid Flash Point (1)(2)	
	≤ 140°F (60°C)	> 140°F (60°C)
Stable liquids, dike wall to buildings of noncombustible or better construction (See Appendix A) or open process structures (3)	1 D (min 75 ft; 23 m; max. 200 ft, 61 m)	0.5 D (min 50 ft; 15 m; max. 200 ft, 61 m)
Stable liquids, dike wall to buildings of combustible construction (See Appendix A)	2 D (min 125 ft, 38 m; 300 ft, 91 m)	1 D (min 75 ft, 23 m; 300 ft, 91 m)
Unstable liquids, dike wall to buildings any construction	2 D (min 125 ft, 38 m; 300 ft, 91 m)	1 D (min 75 ft, 23 m; 300 ft, 91 m)

Table II-12 Spacing for Flammable Liquid Tank Containment Dikes

Further requirements for fuel storage on airports are given in NFPA 407 Standard for Aircraft Fuel Servicing25. Following NFPA 407, the authority having jurisdiction shall determine the distances required from runways, taxiways, and other aircraft movement and servicing areas to any aboveground fuel storage structure or fuel transfer equipment. Fuel storage tanks shall conform to NFPA 30 Flammable and Combustible Liquids Code. The authority having jurisdiction is an organization, office, or individual responsible for enforcing the requirements.

The Federal Aviation Administration (FAA) of the USA published 1997 the order 1050.15A - Fuel Storage Tanks at FAA Facilities26, where various requirements are formulated, but minimum clearance of fuel tank farms to aircraft movement areas is not provided.

Following clear recommendations and requirements, aviation fuel storage tanks are as close as 20 meter from aircraft movement areas as in Frankfurt, or 60 meter as in Munich, both Germany. However, clearance between tank farm and runway center line is 500 m in Frankfurt, and 750 in Munich, respectively. On New York's JFK airport, clearance to aircraft movement areas is about 170 meter and 1.2 kilometer to runway threshold.

[24] FM Global FMDS0788 FLAMMABLE LIQUID STORAGE TANKS, revised September 2010
[25] NFPA 407 Standard for Airport Fuel Servicing, 2007 Edition
[26] Federal Aviation Administration (FAA), 1050.15A - Fuel Storage Tanks at FAA Facilities, 1997

To define the risks of a specific airport tank farm location, the preparation of an Outside Disaster Management Plan, Hazard and Operation Study, and Risk and Consequence Study for the individual location and the traffic on one specific airport is recommended, and generally conduced as part of an Environmental Impact Assessment.

II.6.4.4 Fuel Farm Impact Assessment

An identified potential hazard associated with the airport tank farm which could result in 100% instantaneous tank failure is an aircraft impact with the facility. In the event that an aircraft crashed onto the tank farm, the number of tanks affected would depend on the dimensions of the aircraft, the impact point and whether the aircraft had significant horizontal momentum at the time of impact.

The main potential aircraft impact hazard to the tank farm comes from the volume of aircraft activity from GIA. The chances of an aircraft crashing from flight at a given location in the vicinity of an airport, depends on the lateral orientation and displacement of the location from the runway centerline. Phillips[27] suggests the following expression for the distribution of aircraft crashes from flight in the vicinity of airports:

$$f(R,\theta) = 0.23\exp(-R/5)\exp(-\theta/5)$$

Where, R is the radial distance in kilometers from the runway end, and θ is the angle in degrees between the vector R and the runway centerline. Both R and θ are measured from the threshold at the departure end of the runway for aircraft taking off, and from the threshold at the arrival end of the runway for landing aircraft.

The aircraft crash frequency at the airport fuel tank farm can then be estimated using the following equation:

$$F = CrashRate \cdot N \cdot f(R,\theta) \cdot Fl(x) \cdot Fl(RW) \cdot A(T)$$

Where, N is the number of aircraft movements per year at the airport, Fl(x) the proportion of flights in specified direction, Fl(RW) the proportion of flights using the specified runway and A(T) the target area. The Table II-13 gives the estimated frequency of aircraft crash onto the airport fuel farm during landings, based on an approach crash frequency of 2.4×10^{-8} per movement per year. This number is higher than for other international airports, which reflects the generally poor conditions of aviation on the African continent.

The aircraft crash risk was found to be dominated by landings rather than take-offs.

[27] Phillips in Ove Arup & Partners Hong Kong Ltd (2009), Appendix 13B Aircraft Impact Frequency. Retrieved from http://www.epd.gov.hk/eia/register/report/eiareport/eia_1722009/html/Section%2013%20(Hazard%20to%20Life)/Appendix%2013B%20.pdf

Runway	Direction	R	θ	f(R,θ)	impact fequency /a							
				Aircraft Movement	15.717		67.037		113.135		197.239	
				Target Area		0,02 km²		0,02 km²		0,03 km²		0,03 km²
Northwest	from Southwest	1,05 km	45 °	2,30E-05	50%	*1,41E-06*	50%	*6,03E-06*	25%	*8,49E-06*	25%	*1,48E-05*
	from Northeast	4,40 km	10 °	1,29E-02	50%	1,33E-10	50%	2,43E-09	25%	2,88E-09	25%	8,75E-09
Southeast	from Southwest	1,40 km	90 °	2,65E-09	0%	0,00E+00	0%	0,00E+00	25%	9,77E-13	25%	5,18E-12
	from Northeast	3,70 km	20 °	2,01E-03	0%	0,00E+00	0%	0,00E+00	25%	3,32E-16	25%	3,06E-15
Total						**1,41E-06**		**6,04E-06**		**8,49E-06**		**1,48E-05**

Approach Crah Rate 2,40E-08

Table II-13 Estimated Frequency of Aircraft Crash onto airport fuel farm

The risk of an aircraft impact is dominated by landings from southwest on the Northwest runway. The total estimated frequency of aircraft crash onto the airport fuel farm is 1.5 x 10^{-5} per year. It should be noted that the estimates in Table II-13 are based on the distribution suggested by Phillips which may be cautious.

II.6.4.5 Aviation Fuel Farm Functions

Following are some of the many procedures and trainings that are performed at a tank farm. However, each tank farm operator will go through a great deal of functions in addition to what is listed below.

- Pump Motor Shutdown
- Filter Changes
- Water Slug Test
- Pumping Station Inspections
- Loading Rack PM
- Installing Flexipolics
- Use Truck Sheets and Fuel Tickets
- Procedure for Returning Recyclable Fuel
- Fuel Samples
- Deactivating Recycle System
- Pump Seal Replacement
- Monitoring Storm Water Facility
- Rebuilding Water Slug Control Valve
- Sump Fuel
- Drop Pressure on Filter Vessel

Fuel receipt

- Gauging Procedure
- Types of Fuel
- Tank Truck Procedure
- Pipeline Receiving
- Fuel Spills

Fuel testing

- Sumping White Bucket Test - Storage Tank - Filter Separator
- Hydrokit
- Filter Differential Readings

- Aqua-Glo Test

Fire protection

- Fire Extinguisher Check - Instructions for Use
- Foam System - Types of Foam - Instructions for Use

II.6.4.6 Preliminary Fuel Farm Layout

The preliminary fuel farm layout reflects the above functions and requirements, and provides a clear separation between airside and landside areas. It includes the required fuel storage tanks for Jet A-1 and avgas for the final airport development, an aviation fuel pipeline receiving and metering facility, and circulation areas. Whereas the CTMV circulation area is a landside facility, the apron fuel distribution vehicle (browser) circulation area corresponds to the airside. On circulation areas, the necessary loading and unloading facilities are to be located, best with roof to protect workers and facilities from weather. A service building provides shelter for fuel laboratory, maintenance, spare parts storage, and dispatch operations as well as offers social spaces for workers. Sufficient space for a posterior hydrant fueling system is available. The entire fuel farm requires frencing.

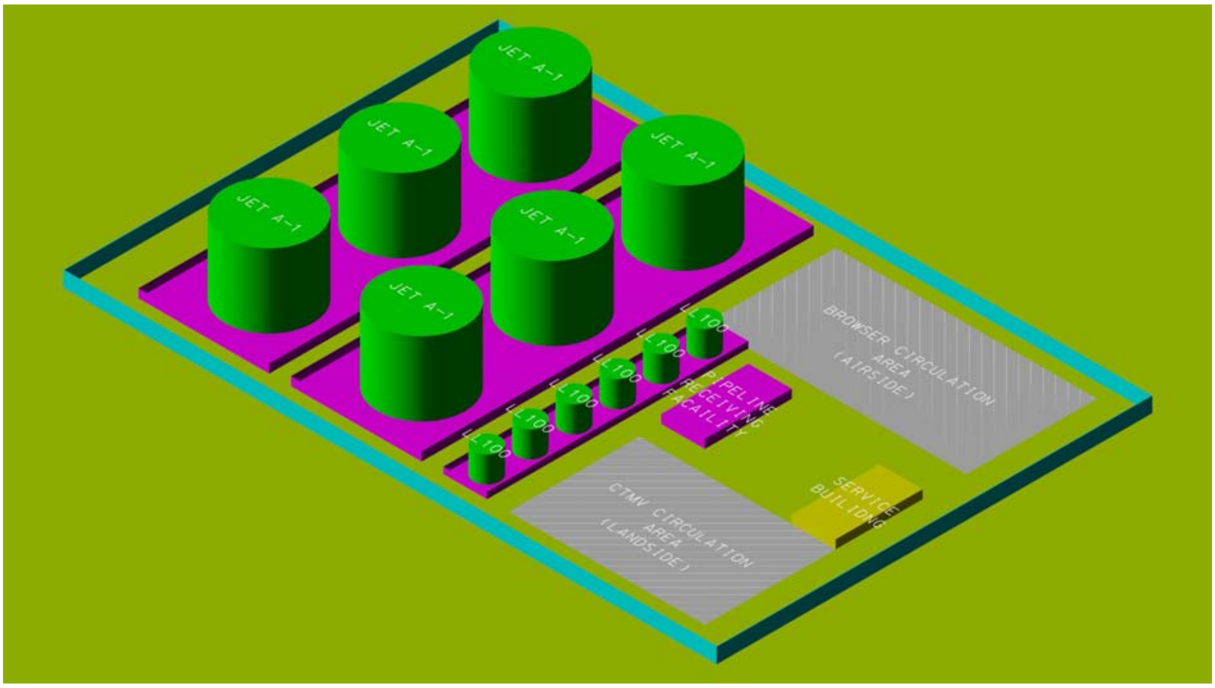

Figure II.6-3 Proposed design fuel farm

A rail fuel unloading facility is not shown on the above proposed fuel farm design, but has to be located alongside from the perimeter.

II.6.4.7 Fuel Load Rack

The fuel load rack provides fuel to airfield vehicles (e.g., belt loaders, push back tugs, and bag cart tugs) that cannot refuel at other fueling stations, and is also the location where jet fuel can be loaded into airfield tankers and driven to individual aircraft.

II.6.5 Aviation Fuel Supply

The comparison of the following options is done under the assumption that aviation fuel can be made available without limitations, which currently is not the case.

Reliable delivery from any source to the airport is of utmost importance for the aviation fuel chain. The following three means of transport for aviation fuel are options for GIA:

- product pipeline
- railway with tank wagon,
- cargo tank motorized vehicles (CTMV).

Ship delivery can be excluded beforehand, since navigable water ways are not available close to GIA. Supply reliability of a product pipeline is generally the highest, and of CTMV lowest.

Without an exception at all major airports aviation fuel supply is realized by means of aviation fuel pipelines and generally two or more transmission pipelines are available. To smaller airports aviation fuel is delivered by cargo CTMV. Railway delivery is only used very rarely, e.g. Franz-Josef-Strauss-Airport in Munich, Germany or Zurich International, Switzerland. The latter does not possess pipeline delivery. Several airports located at seashore are equipped with ship tanker unloading facilities.

Rail aviation fuel supply is not common due to

- the high costs of the necessary countywide rail infrastructure and
- the high number of tank wagons required,
- the high costs of rail delivery and unloading facilities at the airport site,
- the limited increase in supply reliability compared to CTMV transport, considering the high costs for rail fuel supply facilities.

The following table gives information about aviation fuel supply of selected major airports worldwide.

Airport	Country	Size	Aviation Fuel Supply			
		MPAX	CTMV	rail	pipe-line	ship
Los Angeles (LAX)	USA		no	no	yes	no
Munich (MUC)	Germany	35	yes	yes	yes	no
Frankfurt (FRA)	Germany	40	no	no	yes	no
New York (JFK)	USA		yes	no	yes	yes
Bangkok	Thailand		yes	no	yes	no
Sidney	Australia		yes	no	yes	no
San Diego	USA		yes	no	yes	no
London Heathrow airport	England		no	no	yes	no
London Heathrow vicinity	England		yes	no	yes	no
London Stenstead	England		yes	no	yes	no
Denver	USA		yes	no	yes	no
Washington Dulles	USA		yes	no	yes	no
Johannisburg	South Africa		yes	no	yes	no
Houdson	USA		no	no	yes	no
Birmingham	England	12	yes	no	yes	no
Edinburgh	Scottland	10	yes	no	no	no
Paris Charles de Gaulle	France		yes	no	yes	no
Nuremberg	Germany		yes	no	no	no
Stuttgart	Germany		yes	no	no	no
Hamburg	Germany		yes	no	no	no
Cairo	Egypt		yes	no	yes	no
Dubai	UAE		yes	no	yes	no
Milano	Italy		yes	no	yes	no
Madrid	Spain		yes	no	yes	no
Barcelona	Spain		no	no	yes	no
Zurich	Swizzerland		yes	yes	no	no
Vienna	Austria		yes	no	yes	no
Amsterdam Schipol	Netherlands		yes	no	yes	no
Brussels	Belgium		yes	no	yes	no

Table II-14 Aviation fuel supply other airports

Figure II.6-4 Nigerian CTMV with fuel storage tanks

For initial assessment of the most recommended means of transport, available capacities have been considered. For product pipeline transmission systems no capacity limitation can be identified beforehand. Transmission capacity is a function of the pipe diameter. Normal gauge tank wagons are generally manufactured for 75 to 114 cubic meters, an average size of 95 cubic meters has been considered.

Figure II.6-5 Typical fuel tank wagon as operated by Nigerian railways (l), typical US tank wagon (r)

The typical CTMV tank size varies between 33 and 45 cubic meters, an average tank size of 33 cubic meters seems realistic.

Figure II.6-6 Typical CTMV semitrailer

The before mentioned unit capacities have been used to develop different fuel supply scenarios:

- scenario 1: only CTMV supply
- scenario 2: only train tank wagon supply
- scenario 3: 50 % CTMV supply, 50 % train tank wagon supply
- scenario 4: only pipeline supply
- scenario 5: 1/3 CTMV supply, 1/3 train tank wagon supply, 1/3 pipeline supply
- scenario 6: 25 % CTMV supply, 25 % train tank wagon supply, 50 % pipeline supply
- scenario 7: 1/8 CTMV supply, 1/8 train tank wagon supply, 3/4 pipeline supply
- scenario 9: 1% CTMV supply, 4% train tank wagon supply, 95 % pipeline supply.

These scenarios have been assessed for three operational cases:

- case 1: restoring fuel storage capacity after maximum number of days of supply shortage, i.e. refilling of empty storage facility in maximum 5 days and simultaneous daily demand,
- case 2: supply at maximum daily demand rate and
- case 3: supply at average daily demand rate.

For all cases and scenarios the necessary number of CTMV, tank wagons and pipeline size as well as the number of loading facilities has been studied, considering the average unloading time as follows,

- 45 minutes for CTMV
- 75 minutes for train car and
- 225 minutes for an entire tank train.

Unloading time includes approach to unloading facility, connection to fuel pantographs, unloading, disconnecting the pantograph and removal of vehicles from unloading facility. The unloading rate of commercial fuel pantographs for CTMV is between 25 and 36 liters per second while the unloading rate for train cars is between 25 and 42 liters per second.

II.6.5.1 Scenario 1

Scenario 1 considers CTMV transport as only means of aviation fuel supply to the airport.

An initial number of 17 CTMV round trips every day are expected to maintain normal airport operation (case 3). For individual days, when fuel demand is maximum (case 2), this number may increase to 22 CTMV round trips every day. At final development stage 223 daily CTMV trips are expected necessary for normal airport operation (case 3) and may increase to 289 CTMV daily trips when the fuel demand is maximum (case 2). However it's important to highlight that above figures only consider continuous airport operation but not simultaneous filling of empty aviation fuel storage tanks and airport operation (case 1). Considering restoration of fuel storage capacity within five days, 46 CTMV trips are required at the beginning or 465 CTMV trips by the year 2040.

From operational point of view, a maximum number of nine CTMV to be unloaded simultaneously is realistic. Given the unlikely assumption that nine CTMV can be unloaded simultaneously throughout the entire working day and for five days continuously without interruption, scenario 1 reaches operational limits latest by the year 2022, i.e. after seven years of airport operation. However it is more likely that operational limits are reached much earlier. More realistic operational limits are reached by the year 2018, after three years of airport operation, when three CTMV are required to be unloaded simultaneously, summarizing 59 CTMV every day of normal airport operation (case 3), or 77 CTMV during days of maximum demand (case 2), or 158 CTMV for five days to refill empty storage tanks (case 1).

The ecological impact of scenario 1 is illustrated in Table II-15. The flue gas emissions have been estimated based on a typical CTMV engine capacity of 250 kilowatt, which is low when compared with modern trucks that reach 400 kilowatt and more, but reflects the older national vehicle fleet. Further the flue gas emissions estimate consider an average travel and return time from Lagos region to GIA of ten hours, this time is expected to decrease to four hours until 2040. Unit flue gas figures correspond to EURO 1 requirements in the beginning and EURO 3 requirements by 2040. This reflects the supposed renewal of the national vehicle fleet.

Flue gas emissions from aviation fuel transport									
	avg. travel time	avg. unit CO emissions	avg. unit NO_x emissions	avg. unit PM emissions	avg. unit CO_2 emissions	avg. CO emissions	avg. NOx emissions	avg. PM emissions	avg. CO_2 emissions
2015	10,0 h	4,5 g/kWh	8,0 g/kWh	0,4 g/kWh	249,2 g/kWh	28 t/a	50 t/a	2 t/a	1.554 t/a
2016	9,8 h	4,4 g/kWh	7,9 g/kWh	0,4 g/kWh	249,2 g/kWh	44 t/a	79 t/a	4 t/a	2.495 t/a
2017	9,5 h	4,3 g/kWh	7,8 g/kWh	0,3 g/kWh	249,2 g/kWh	65 t/a	118 t/a	5 t/a	3.777 t/a
2018	9,3 h	4,2 g/kWh	7,7 g/kWh	0,3 g/kWh	249,2 g/kWh	84 t/a	153 t/a	7 t/a	4.982 t/a
2019	9,1 h	4,1 g/kWh	7,5 g/kWh	0,3 g/kWh	249,2 g/kWh	86 t/a	158 t/a	7 t/a	5.207 t/a
2020	8,8 h	4,0 g/kWh	7,4 g/kWh	0,3 g/kWh	249,2 g/kWh	89 t/a	164 t/a	7 t/a	5.508 t/a
2021	8,6 h	3,9 g/kWh	7,3 g/kWh	0,3 g/kWh	249,2 g/kWh	89 t/a	164 t/a	7 t/a	5.604 t/a
2022	8,4 h	3,9 g/kWh	7,2 g/kWh	0,3 g/kWh	249,2 g/kWh	89 t/a	166 t/a	7 t/a	5.763 t/a
2023	8,2 h	3,8 g/kWh	7,1 g/kWh	0,3 g/kWh	249,2 g/kWh	91 t/a	170 t/a	7 t/a	6.002 t/a
2024	7,9 h	3,7 g/kWh	7,0 g/kWh	0,3 g/kWh	249,2 g/kWh	89 t/a	169 t/a	7 t/a	6.052 t/a
2025	7,7 h	3,6 g/kWh	6,8 g/kWh	0,3 g/kWh	249,2 g/kWh	89 t/a	170 t/a	6 t/a	6.171 t/a
2026	7,5 h	3,5 g/kWh	6,7 g/kWh	0,3 g/kWh	249,2 g/kWh	88 t/a	169 t/a	6 t/a	6.271 t/a
2027	7,2 h	3,4 g/kWh	6,6 g/kWh	0,2 g/kWh	249,2 g/kWh	88 t/a	171 t/a	6 t/a	6.439 t/a
2028	7,0 h	3,3 g/kWh	6,5 g/kWh	0,2 g/kWh	249,2 g/kWh	86 t/a	170 t/a	6 t/a	6.502 t/a
2029	6,8 h	3,2 g/kWh	6,4 g/kWh	0,2 g/kWh	249,2 g/kWh	84 t/a	168 t/a	6 t/a	6.557 t/a
2030	6,5 h	3,1 g/kWh	6,3 g/kWh	0,2 g/kWh	249,2 g/kWh	83 t/a	168 t/a	6 t/a	6.658 t/a
2031	6,3 h	3,0 g/kWh	6,2 g/kWh	0,2 g/kWh	249,2 g/kWh	82 t/a	166 t/a	5 t/a	6.737 t/a
2032	6,1 h	2,9 g/kWh	6,0 g/kWh	0,2 g/kWh	249,2 g/kWh	79 t/a	163 t/a	5 t/a	6.741 t/a
2033	5,8 h	2,8 g/kWh	5,9 g/kWh	0,2 g/kWh	249,2 g/kWh	78 t/a	163 t/a	5 t/a	6.842 t/a
2034	5,6 h	2,7 g/kWh	5,8 g/kWh	0,2 g/kWh	249,2 g/kWh	75 t/a	158 t/a	5 t/a	6.796 t/a
2035	5,4 h	2,7 g/kWh	5,7 g/kWh	0,2 g/kWh	249,2 g/kWh	73 t/a	156 t/a	4 t/a	6.851 t/a
2036	5,2 h	2,6 g/kWh	5,6 g/kWh	0,2 g/kWh	249,2 g/kWh	70 t/a	153 t/a	4 t/a	6.821 t/a
2037	4,9 h	2,5 g/kWh	5,5 g/kWh	0,1 g/kWh	249,2 g/kWh	67 t/a	148 t/a	4 t/a	6.775 t/a
2038	4,7 h	2,4 g/kWh	5,3 g/kWh	0,1 g/kWh	249,2 g/kWh	64 t/a	145 t/a	4 t/a	6.751 t/a
2039	4,5 h	2,3 g/kWh	5,2 g/kWh	0,1 g/kWh	249,2 g/kWh	61 t/a	140 t/a	3 t/a	6.652 t/a
2040	4,2 h	2,2 g/kWh	5,1 g/kWh	0,1 g/kWh	249,2 g/kWh	58 t/a	136 t/a	3 t/a	6.618 t/a
Vision 2040	4,0 h	2,1 g/kWh	5,0 g/kWh	0,1 g/kWh	249,2 g/kWh	68 t/a	162 t/a	3 t/a	8.095 t/a

Table II-15 Emissions from CTMV fuel transport

Complaints and public protests are reported form several airports, where less than 40 daily CTMV trips take place. This is mainly to the additional traffic caused by CTMV and the avoidable flue gas emissions.

Nigeria suffers from severe fuel robbery. Deviation of CTMV is no great deal but will lead to insufficient fuel supply for GIA.

Finally, scenario 1 cannot be considered as a permanent feasible option for an international airport. CTMV as only means of transport for Aviation Turbine Kerosene (Jet A-1) is an interim and temporary option for the fist, say three years of airport operation.

Figure II.6-7 Example of top CTMV loading facility

However, CTMV is the only realistic means of transport for avgas. To deliver the above mentioned quantities of avgas, a maximum of 10 daily CTMV trips is necessary, which is acceptable from operational, ecological and safety perspective.

II.6.5.2 Scenario 2

Scenario 2 considers rail transport as only means of aviation fuel supply to the airport. It is noteworthy that currently there is no existing normal gauge rail connection between Lagos region and GIA. The existing narrow gauge track is mainly used for passenger transport and would require capital investment for a link to GIA, to fuel unloading facilities in Lagos region and to increase transport security and capacity. The existing narrow gauge track has therefore been excluded as a feasible way of fuel transport to GIA. A new normal gauge track from unloading and / or refining facilities in Lagos region will be hardly operational before airport development phase 2. Therefore, scenario 2 is considered only for the later airport development phases 3 and 4. Regional airport development plan includes a normal gauge rail connection to GIA for freight and passenger trains.

One unloading facility sufficient to unload one entire tank train of 20 wagons is expected for development phase 2, a parallel unloading facility sufficient to unload a second tank train of 20 wagons is considered necessary for development phases 3 and 4.

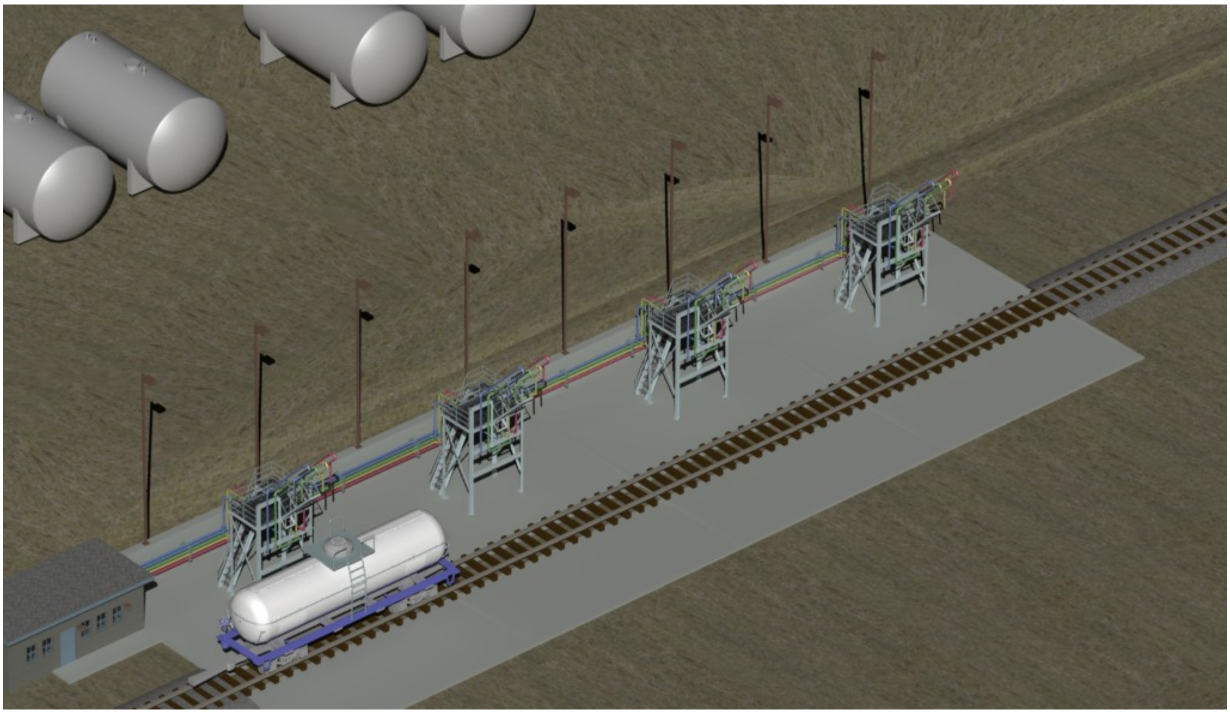

Figure II.6-8 Example design for train top loading facility (top), train bottom loading facility (bottom)

The only international airports equipped with rail fuel supply are Munich, Germany, that has been upgraded recently to unload two tank trains simultaneously, and Zurich, Switzerland, that has got four parallel operating unloading tracks.

The national railway system is not electrified. The resulting flue gas emissions from rail aviation fuel transport to GIA are considered significant. Currently no figures can be provided of the expected environmental impact of rail transport.

Deviation of entire tank trains and robbery of fuel may lead to a missing fuel amount of about 2 million liters. This amount of fuel represents the average amount of fuel required for half a day of airport operation. Due to the insufficient national rail infrastructure and inexistent normal gauge rail tracks deviation of entire tank trains is unlikely. Fuel robbery from individual tank wagons however, is realistic.

Despite train freight transport is secure and safe, considering the kilometer travelled wordwide, fatal train accidents are reported. Wikipedia[28] provides an impressive list of train accidents between 2000 and 2009. This list reports about almost 300 train accidents in this period, almost all countries with rail infrastructure are present. Many of these train accidents are collisions between freight and passenger transport, and many accidents involve hazmat transports. Often the reasons reported are badly maintained tracks and poor trained operators. Train transport and specially hazmat train transport are potential targets of terroristic attacks, too. Accidents with hazmat transport and tank wagons involved occur at loading and unloading facilities. All of above reasons for train accidents apply for GIA: passenger and hazmat freight transport is expected to take place on the same track, based on current observations, poor maintenance of technical facilities is quite likely, limited availability of well trained operators, terroristic activities occur plus the general threats at hazmat loading and unloading facilities.

Assessing the local conditions, railway aviation fuel supply to GIA is an alternative. However, it should be excluded as sole means of delivery. The necessary capital investment for reliable, safe and secure rail fuel supply to GIA are elevated.

II.6.5.3 Scenario 3

Scenario 3 considers the combined rail and CTMV aviation fuel supply to GIA. Each alternative provides the half of the required fuel demand. As for scenario 2 this scenario is only applicable for the airport’s development phases 3 and 4, since normal gauge railway track will unlikely be available earlier.

Six CTMV unloading facilities and a tank train unloading facility sufficient for 10 tank wagons (half the amount of scenario 2) would be required to provide sufficient aviation fuel. However, and since railway connection will be available only for the development phase 3, for the initial development phases CTMV will be the only means of aviation fuel supply. For the initial development phases, nine CTMV unloading facilities will be required. Further solely CTMV supply is, as outlined for scenario 1, only acceptable for the approximately first three years of airport operation. By this time the railway connections to GIA will not yet be available. Thus, scenario 3 can be excluded as a feasible and lasting option for aviation fuel supply to GIA.

[28] Wikipedia http://en.wikipedia.org/wiki/List_of_rail_accidents_(2000%E2%80%932009)

II.6.5.4 Scenario 4

Scenario 4 considers pipeline transmission as only means of aviation turbine kerosene (Jet A-1) supply to the airport. Avgas is still delivered by CTMV. Currently a product pipeline transmission system is working that links terminal facilities in Lagos with Warri. Pipeline routing passes some 20 kilometer south of proposed GIA location. The product pipeline pipe sizes are 6, 12 and 16 inch, DN150, DN300 and DN400, respectively. This size does not allow additional transmission capacities and connection of a spur line to GIA is excluded due to lacking spare capacity.

The pipeline right of way (RoW) of the existing product pipeline is available and can be used for a parallel new product transmission pipeline system. Using the available RoW between the existing Lagos terminal facility and a link to GIA, the construction of a new aviation fuel pipeline of approximately 70 kilometer, parallel to the existing pipeline system, is expected to be operable within less than one year. Thus, an aviation fuel pipeline system can be available for the initial airport development phase.

The capacity of a pipeline transmission system is governed by the pipe size which is not variable for a built pipeline system, flow speed that in turn is a function of pressure head loss and power absorption of pumping facilities, and daily pumping time that is variable to a maximum of 22 hours per day of normal operation. 24 hours pumping time is not recommended due to maintenance down time. For special conditions, such as replenishing empty storage tanks, 24 hours pumping time may be applied.

For planning purpose flow speed of 1.7 meters per second and 24 hours of pumping time for replenishing empty storage tanks (case 1) and a maximum pumping time of 22 hours per day for normal operation (case 3) has been considered. The necessary pipe size for final airport development phase is 16 inch, DN400 respectively. Increasing the flow speed to 2.5 meter per second leads to a maximum pipe size of 12 inch, DN300 respectively, for case 1. Thus, an aviation fuel transmission pipeline will be either 12 or 16 inch, DN300 or DN400 respectively. The final decision of the pipe size will be taken during design phase and considers topography on the RoW, energy prices, and other.

The environmental impact of an aviation fuel transmission pipeline is a result of the works for pipeline construction, which may be neglected if located within the RoW of an existing pipeline system and for the energy absorption of pumping facilities. A first indicator of the ecological impact of a pumping facility is it’s annual energy consumption. For pumping the annual demand ranges under 14,000 Megawatt/hour per year, which is less than the third of the estimated energy demand for CTMV operation.

Unless in Nigeria fuel robbery from pipeline systems is common, illicit connections are hardly able to divert the entire flow in a pipeline system. Accidents with pipeline transmission systems are reported and [29] provides a list of pipeline accidents. For the decade from 2000 to 2009 sixty incidents are reported in the USA and nine in Nigeria. The accident known as Abule Egba pipeline explosion killed about 500 persons. Whereas, generally the main reason of pipeline accidents are construction

[29] Wikipedia http://en.wikipedia.org/wiki/List_of_pipeline_accidents

works. In Nigeria, the majority of the accidents is due to illicit connections and fuel robbery. The proposed RoW passes densely populated areas of Lagos. The probability of illegal connections and the related risks is high. On the other hand side, at GIA, a pipeline system does not ask for unloading facilities. Pipeline supply consists of fixed pipe connections, and incidents due to operational mistakes at GIA unloading facilities are excluded.

Assessing the above information, an aviation fuel pipeline transmission system can be available from the beginning of GIA operation. Safety issues of pipeline transmission system have to be addressed during design. However it can be stated that a pipeline systems would provide at least the same degree of safety as train supply, but a higher one than CTMV transport.

II.6.5.5 Scenario 5, 6, 7, 8

Scenarios 5, 6, 7, 8 consider multi modal aviation fuel supply to GIA: Pipeline, rail, and CTMV. The contribution of the individual means to the total fuel amount varies.

While in scenario 5 all means contribute one third of the total fuel demand, in scenario 8 the pipeline system contributes 95%, rail four percent, and CTMV one percent.

If the pipeline system contributes 50% or less to the total aviation turbine kerosene (Jet A-1) demand, the pipe size can be reduced to eight inch, DN200 respectively. The number of CTMV unloading facilities can be half of the necessary number in scenario 1, but a tank wagon unloading facility sufficient to unload half tank train is required. The financial benefit of pipe size reduction and fewer unloading facilities is insignificant and scenario 5 is excluded as recommended option.

For the remaining scenarios the aviation fuel transmission pipeline needs to be 12 inch, DN300 respectively, which is sufficient to maintain 100% of the aviation turbine kerosene (Jet A-1) supply. The CTMV and rail unloading facilities are only back-up facilities and can be reduced in size and number.

II.6.5.6 Recommendation

The above technical assessment of aviation fuel supply to GIA shows the following:

- CTMV, as singe means of supply is feasible only for the first years of operation, it is the only feasible option for avgas supply to GIA,
- Rail supply cannot be made available for the initial airport development stages, to cover the demand for the initial development phases, alternative means have to be implemented, that then can be used as permanent means of aviation fuel supply,
- An aviation pipeline transmission system can be made available for the initial airport development stages, pipe size 12 to 16 inch, DN300 to DN400 respectively, is sufficient for the final aviation turbine kerosene (Jet A-1) supply.

The implementation of an aviation turbine kerosene (Jet A-1) pipeline system from the beginning, airport development stage 1, is recommended in combination with a CTMV supply for avgas and as back-up supply for aviation turbine kerosene (Jet A-

1). The late the late implementation of rail fuel supply is not necessary, when alternative means are already implemented and is not recommended.

II.6.6 Aviation Fuel Capital Cost Assessment

II.6.6.1 Cost Elements Included

Reliable aviation fuel supply requires important capital expenditures. The following capital cost assessment includes information about airport fuel storage facilities, but excludes capital expenditures for fuel infrastructure, such as landing, terminal and / or refining facilities, transmission pipeline systems, rail infrastructure and rail loading facilities, road infrastructure. Infrastructure has to be provided by the responsible governmental agencies, private stakeholders or other airport development budgets.

Further fuel systems excluded from the present cost assessment are any systems necessary for fueling services to the aircrafts, i.e. hydrant fueling systems, or apron refueling vehicles (browsers).

General works and airport infrastructure such as earthwork, grading or water and wastewater infrastructure to and for the airport fuel facility is not considered, but has to be included in the relevant airport infrastructure cost information.

Further, the following cost estimates, do not include any design and engineering services, nor construction supervision.

II.6.6.2 Pre-Design Cost Information

Certain pre-design cost information has been disclosed in October and December 2010. This cost information is revised by this study.

II.6.6.3 Capital Cost Information

Following the recommended development of the airport fuel facilities, number of storage tanks for Jet A-1, G100UL, 100LL avgas and pipeline connection the expected order of magnitude capital expenditures are as follows.

Phase 1 - Item	Quantity		Costs
Jet A-1 storage tanks, including fuel retention	2	job	2.000.000 €
Jet A-1 pipe system, manifold	1	job	1.250.000 €
Jet A-1 Pipeline connection, metering	1	job	500.000 €
Jet A-1 CTMV loading facilities	6	units	600.000 €
Jet A-1 browser loading facilities	9	units	900.000 €
Phase 1 - Jet A-1 storage			**5.250.000 €**
AVGAS storage tanks, including fuel retention	2	job	1.000.000 €
AVGAS pipe system, manifold	1	job	250.000 €
AVGAS CTMV loading facilities	3	units	300.000 €
AVGAS browser loading facilities	2	units	200.000 €
Phase 1 - AVGAS storage			**1.750.000 €**
AFFF fire protection	1	job	1.300.000 €
Shelter and Buildings	1	job	500.000 €
Phase 1 - Various			**1.800.000 €**
Phase 1 - Fuel Facility			**8.800.000 €**

Table II-16 Capital Expenditures airport fuel facility – phase 1

Phase 2 - Item	Quantity		Costs
Jet A-1 storage tanks, including fuel retention	1	job	1.000.000 €
Jet A-1 pipe system, manifold	1	job	250.000 €
Jet A-1 Pipeline connection, metering	0	job	0 €
Jet A-1 CTMV loading facilities	0	units	0 €
Jet A-1 browser loading facilities	3	units	300.000 €
Phase 2 - Jet A-1 storage			**1.550.000 €**
AVGAS storage tanks, including fuel retention	2	job	1.000.000 €
AVGAS pipe system, manifold	1	job	200.000 €
AVGAS CTMV loading facilities	0	units	0 €
AVGAS browser loading facilities	2	units	200.000 €
Phase 2 - AVGAS storage			**1.400.000 €**
AFFF fire protection	0	job	0 €
Shelter and Buildings	0	job	0 €
Phase 2 - Various			**0 €**
Phase 2 - Fuel Facility			**2.950.000 €**

Table II-17 Capital Expenditures airport fuel facility – phase 2

Phase 3 - Item	Quantity		Costs
Jet A-1 storage tanks, including fuel retention	1	job	1.000.000 €
Jet A-1 pipe system, manifold	1	job	250.000 €
Jet A-1 Pipeline connection, metering	0	job	0 €
Jet A-1 CTMV loading facilities	0	units	0 €
Jet A-1 browser loading facilities	0	units	0 €
Phase 3 - Jet A-1 storage			**1.250.000 €**
AVGAS storage tanks, including fuel retention	1	job	500.000 €
AVGAS pipe system, manifold	1	job	200.000 €
AVGAS CTMV loading facilities	0	units	0 €
AVGAS browser loading facilities	0	units	0 €
Phase 3 - AVGAS storage			**700.000 €**
AFFF fire protection	1	job	1.300.000 €
Shelter and Buildings	1	job	500.000 €
Phase 3 - Various			**1.800.000 €**
Phase 3 - Fuel Facility			**3.750.000 €**

Table II-18 Capital Expenditures airport fuel facility – phase 3

Phase 4 - Item	Quantity		Costs
Jet A-1 storage tanks, including fuel retention	2	job	2.000.000 €
Jet A-1 pipe system, manifold	2	job	500.000 €
Jet A-1 Pipeline connection, metering	0	job	0 €
Jet A-1 CTMV loading facilities	0	units	0 €
Jet A-1 browser loading facilities	0	units	0 €
Phase 4 - Jet A-1 storage			**2.500.000 €**
AVGAS storage tanks, including fuel retention	2	job	1.000.000 €
AVGAS pipe system, manifold	2	job	400.000 €
AVGAS CTMV loading facilities	0	units	0 €
AVGAS browser loading facilities	0	units	0 €
Phase 4 - AVGAS storage			**1.400.000 €**
AFFF fire protection	0	job	0 €
Shelter and Buildings	0	job	0 €
Phase 4 - Various			**0 €**
Phase 4 - Fuel Facility			**3.900.000 €**

Table II-19 Capital Expenditures airport fuel facility – phase 4

II.6.6.4 Capital Cost Comparison

The significant capital cost increase compared to the pre-design figures, is mainly due to the avgas storage facility that has not been considered previously.

Note:

Depending on the occurrence of General Aviation at GIA, the costs for avgas storage are not yet included in the capex tables, already provided. Generally, GA is operated by a FBO who will be responsible for the avgas provision and for the investment for the avgas storage facility for GA. For information of the costs to be expected, the tables above include the avgas-storage.

III Appendices

III.1 Appendix 1 - Electrical loads table

III.2 Appendix 2 - Single line diagram – Power Supply

III.3 Appendix 3 - Single line diagram – Telecommunications

III.4 Appendix 4 - Single line diagram – IT

III.5 Appendix 5 - Aviation Fuel Demand Estimate – 3 Cases

	Aviation Fuel Supply - Restore Storage					Scenario 1				Scenario 2			Scenario 3			
						0%	100%		0%	0%	0%	100%	0%	50%		50%
	fuel storage	Max. day demand	fuel supply oparation	storage restoring time	flow rate	pipeline	CTMV #/d	CTMV #/h	car tank #/d	pipeline	CTMV #/h	car tank #/d	pipeline	CTMV #/d	CTMV #/h	car tank #/d
2015	3.890.875 l	732.895 l	20 h/d	5 d	21 l/s	0 l/s	46	2,3	0	0 l/s	0	16	0 l/s	23	1,1	8
2016	6.397.090 l	1.204.775 l	20 h/d	5 d	35 l/s	0 l/s	75	3,7	0	0 l/s	0	26	0 l/s	38	1,9	13
2017	9.918.327 l	1.867.735 l	20 h/d	5 d	53 l/s	0 l/s	117	5,7	0	0 l/s	0	40	0 l/s	58	2,9	20
2018	13.407.525 l	2.524.745 l	20 h/d	5 d	72 l/s	0 l/s	158	7,7	0	0 l/s	0	54	0 l/s	79	3,9	27
2019	14.366.951 l	2.705.500 l	21 h/d	5 d	77 l/s	0 l/s	169	8,2	0	0 l/s	0	58	0 l/s	85	4,1	29
2020	13.371.171 l	2.937.015 l	21 h/d	5 d	78 l/s	0 l/s	170	8,2	0	0 l/s	0	58	0 l/s	85	4,1	29
2021	13.964.451 l	3.068.135 l	21 h/d	5 d	81 l/s	0 l/s	178	8,5	0	0 l/s	0	61	0 l/s	89	4,2	31
2022	14.759.645 l	3.241.715 l	21 h/d	5 d	82 l/s	0 l/s	188	8,9	0	0 l/s	0	65	0 l/s	94	4,5	32
2023	15.809.017 l	3.471.655 l	21 h/d	5 d	88 l/s	0 l/s	201	9,5	0	0 l/s	0	69	0 l/s	101	4,7	35
2024	16.402.297 l	3.602.775 l	21 h/d	5 d	91 l/s	0 l/s	209	9,8	0	0 l/s	0	72	0 l/s	104	4,9	36
2025	17.224.662 l	3.783.530 l	22 h/d	5 d	96 l/s	0 l/s	219	10,2	0	0 l/s	0	75	0 l/s	110	5,1	38
2026	18.047.026 l	3.964.285 l	22 h/d	5 d	100 l/s	0 l/s	230	10,6	0	0 l/s	0	79	0 l/s	115	5,3	39
2027	19.123.860 l	4.200.175 l	22 h/d	5 d	106 l/s	0 l/s	243	11,1	0	0 l/s	0	84	0 l/s	122	5,6	42
2028	19.946.225 l	4.380.930 l	22 h/d	5 d	106 l/s	0 l/s	254	11,5	0	0 l/s	0	87	0 l/s	127	5,8	44
2029	17.329.800 l	4.568.860 l	22 h/d	5 d	101 l/s	0 l/s	243	11,0	0	0 l/s	0	84	0 l/s	122	5,5	42
2030	18.221.104 l	4.803.175 l	22 h/d	5 d	107 l/s	0 l/s	256	11,5	0	0 l/s	0	88	0 l/s	128	5,7	44
2031	19.114.138 l	5.037.940 l	22 h/d	5 d	112 l/s	0 l/s	269	12,0	0	0 l/s	0	92	0 l/s	134	6,0	46
2032	19.844.969 l	5.231.820 l	23 h/d	5 d	116 l/s	0 l/s	279	12,3	0	0 l/s	0	96	0 l/s	139	6,2	48
2033	20.944.004 l	5.520.145 l	23 h/d	5 d	123 l/s	0 l/s	294	12,9	0	0 l/s	0	101	0 l/s	147	6,5	51
2034	21.651.950 l	5.708.075 l	23 h/d	5 d	127 l/s	0 l/s	304	13,3	0	0 l/s	0	105	0 l/s	152	6,6	52
2035	22.767.812 l	6.000.775 l	23 h/d	5 d	127 l/s	0 l/s	320	13,9	0	0 l/s	0	110	0 l/s	160	6,9	55
2036	23.683.488 l	6.242.715 l	23 h/d	5 d	133 l/s	0 l/s	333	14,3	0	0 l/s	0	114	0 l/s	166	7,2	57
2037	19.697.640 l	6.490.605 l	23 h/d	5 d	126 l/s	0 l/s	316	13,5	0	0 l/s	0	109	0 l/s	158	6,8	54
2038	20.594.982 l	6.786.105 l	24 h/d	5 d	132 l/s	0 l/s	330	14,0	0	0 l/s	0	114	0 l/s	165	7,0	57
2039	21.340.985 l	7.032.420 l	24 h/d	5 d	136 l/s	0 l/s	342	14,5	0	0 l/s	0	118	0 l/s	171	7,2	59
2040	22.391.049 l	7.377.555 l	24 h/d	5 d	143 l/s	0 l/s	359	15,1	0	0 l/s	0	124	0 l/s	180	7,5	62
Vision 2040	28.970.852 l	9.545.615 l	24 h/d	5 d	178 l/s	0 l/s	465	19,4	0	0 l/s	0	160	0 l/s	232	9,7	80

	Scenario 4			Scenario 5			Scenario 6			Scenario 7			Scenario 8		
	100%	0%	0%	33%	33%	34%	50%	25%	25%	75%	12%	13%	95%	1%	4%
	pipeline	CTMV #/d	car tank #/d	pipeline	CTMV #/d	car tank #/d	pipeline	CTMV #/d	car tank #/d	pipeline	CTMV #/d	car tank #/d	pipeline	CTMV #/d	car tank #/d
2015	21 l/s DN 100	0	0	7 l/s DN 100	15	5	11 l/s DN 100	11	4	16 l/s DN 100	5	2	20 l/s DN 100	0	1
2016	35 l/s DN 100	0	0	12 l/s DN 100	25	9	18 l/s DN 100	19	6	26 l/s DN 100	9	3	33 l/s DN 100	1	1
2017	53 l/s DN 200	0	0	17 l/s DN 100	39	14	27 l/s DN 100	29	10	40 l/s DN 100	14	5	50 l/s DN 200	1	2
2018	72 l/s DN 200	0	0	24 l/s DN 100	52	18	36 l/s DN 100	39	14	54 l/s DN 200	19	7	68 l/s DN 200	2	2
2019	77 l/s DN 200	0	0	25 l/s DN 100	56	20	39 l/s DN 100	42	15	58 l/s DN 200	20	8	73 l/s DN 200	2	2
2020	78 l/s DN 200	0	0	26 l/s DN 100	56	20	39 l/s DN 100	43	15	59 l/s DN 200	20	8	74 l/s DN 200	2	2
2021	81 l/s DN 200	0	0	27 l/s DN 100	59	21	41 l/s DN 100	44	15	61 l/s DN 200	21	8	77 l/s DN 200	2	2
2022	82 l/s DN 200	0	0	27 l/s DN 100	62	22	41 l/s DN 100	47	16	62 l/s DN 200	23	8	78 l/s DN 200	2	3
2023	88 l/s DN 200	0	0	29 l/s DN 100	66	23	44 l/s DN 100	50	17	66 l/s DN 200	24	9	84 l/s DN 200	2	3
2024	91 l/s DN 200	0	0	30 l/s DN 100	69	24	46 l/s DN 200	52	18	68 l/s DN 200	25	9	86 l/s DN 200	2	3
2025	96 l/s DN 200	0	0	32 l/s DN 100	72	26	48 l/s DN 200	55	19	72 l/s DN 200	26	10	91 l/s DN 200	2	3
2026	100 l/s DN 200	0	0	33 l/s DN 100	76	27	50 l/s DN 200	57	20	75 l/s DN 200	28	10	95 l/s DN 200	2	3
2027	106 l/s DN 200	0	0	35 l/s DN 100	80	28	53 l/s DN 200	61	21	80 l/s DN 200	29	11	101 l/s DN 200	2	3
2028	106 l/s DN 200	0	0	35 l/s DN 100	84	30	53 l/s DN 200	63	22	80 l/s DN 200	30	11	101 l/s DN 200	3	3
2029	101 l/s DN 200	0	0	33 l/s DN 100	80	28	51 l/s DN 200	61	21	76 l/s DN 200	29	11	96 l/s DN 200	2	3
2030	107 l/s DN 200	0	0	35 l/s DN 100	84	30	54 l/s DN 200	64	22	80 l/s DN 200	31	11	102 l/s DN 200	3	4
2031	112 l/s DN 200	0	0	37 l/s DN 100	89	31	56 l/s DN 200	67	23	84 l/s DN 200	32	12	106 l/s DN 200	3	4
2032	116 l/s DN 200	0	0	38 l/s DN 100	92	33	58 l/s DN 200	70	24	87 l/s DN 200	33	12	110 l/s DN 200	3	4
2033	123 l/s DN 300	0	0	41 l/s DN 100	97	34	62 l/s DN 200	74	25	92 l/s DN 200	35	13	117 l/s DN 200	3	4
2034	127 l/s DN 300	0	0	42 l/s DN 100	100	36	64 l/s DN 200	76	26	95 l/s DN 200	37	14	121 l/s DN 200	3	4
2035	127 l/s DN 300	0	0	42 l/s DN 100	106	37	64 l/s DN 200	80	27	95 l/s DN 200	38	14	121 l/s DN 200	3	4
2036	133 l/s DN 300	0	0	44 l/s DN 100	110	39	67 l/s DN 200	83	29	100 l/s DN 200	40	15	126 l/s DN 300	3	5
2037	126 l/s DN 300	0	0	42 l/s DN 100	104	37	63 l/s DN 200	79	27	95 l/s DN 200	38	14	120 l/s DN 200	3	4
2038	132 l/s DN 300	0	0	44 l/s DN 100	109	39	66 l/s DN 200	83	28	99 l/s DN 200	40	15	125 l/s DN 300	3	5
2039	136 l/s DN 300	0	0	45 l/s DN 200	113	40	68 l/s DN 200	86	29	102 l/s DN 200	41	15	129 l/s DN 300	3	5
2040	143 l/s DN 300	0	0	47 l/s DN 200	119	42	72 l/s DN 200	90	31	107 l/s DN 200	43	16	136 l/s DN 300	4	5
Vision 2040	178 l/s DN 300	0	0	59 l/s DN 200	153	54	89 l/s DN 200	116	40	134 l/s DN 300	56	21	169 l/s DN 300	5	6

Table III-1 Aviation fuel supply – Case 1 – Restoration of empty fuel tanks

	Max. Day Aviation Fuel Supply					Scenario 1				Scenario 2			Scenario 3				Scenario 4			Scenario 5			Scenario 6			Scenario 7			Scenario 8		
						0%	100%		0%	0%	0%	###	0%	50%		50%	100%	0%	0%	33%	33%	34%	50%	25%	25%	75%	12%	13%	95%	1%	4%
	fuel storage	Max. day demand	fuel supply operation	storage restoring time	flow rate	pipeline	CTMV #/d	CTMV #/h	car tank #/d	pipeline	CTMV #/d	car tank #/d	pipeline	CTMV #/d	CTMV #/h	car tank #/d	pipeline	CTMV #/d	car tank #/d	pipeline	CTMV #/d	car tank #/d	pipeline	CTMV #/d	car tank #/d	pipeline	CTMV #/d	car tank #/d	pipeline	CTMV #/d	car tank #/d
2015	0 l	732.895 l	20 h/d	5 d	10 l/s	0 l/s	22	1,1	0	0 l/s	0	8	0 l/s	11	1	4	10 l/s DN 100	0	0	3 l/s DN	7	3	5 l/s DN 100	6	2	8 l/s DN 100	3	1	10 l/s DN 100	0	0
2016	0 l	1.204.775 l	20 h/d	5 d	17 l/s	0 l/s	37	1,8	0	0 l/s	0	13	0 l/s	18	1	6	17 l/s DN 100	0	0	6 l/s DN 100	12	4	9 l/s DN 100	9	3	13 l/s DN 100	4	2	16 l/s DN 100	0	1
2017	0 l	1.867.735 l	20 h/d	5 d	26 l/s	0 l/s	57	2,8	0	0 l/s	0	19	0 l/s	28	1	10	26 l/s DN 100	0	0	9 l/s DN 100	19	7	13 l/s DN 100	14	5	20 l/s DN 100	7	3	25 l/s DN 100	1	1
2018	0 l	2.524.745 l	20 h/d	5 d	35 l/s	0 l/s	77	3,7	0	0 l/s	0	26	0 l/s	38	2	13	35 l/s DN 100	0	0	12 l/s DN 100	25	9	18 l/s DN 100	19	7	26 l/s DN 100	9	3	33 l/s DN 100	1	1
2019	0 l	2.705.500 l	21 h/d	5 d	38 l/s	0 l/s	82	4,0	0	0 l/s	0	28	0 l/s	41	2	14	38 l/s DN 100	0	0	13 l/s DN 100	27	10	19 l/s DN 100	20	7	29 l/s DN 100	10	4	36 l/s DN 100	1	1
2020	0 l	2.937.015 l	21 h/d	5 d	41 l/s	0 l/s	89	4,3	0	0 l/s	0	31	0 l/s	45	2	15	41 l/s DN 100	0	0	14 l/s DN 100	29	10	21 l/s DN 100	22	8	31 l/s DN 100	11	4	39 l/s DN 100	1	1
2021	0 l	3.068.135 l	21 h/d	5 d	43 l/s	0 l/s	93	4,4	0	0 l/s	0	32	0 l/s	46	2	16	43 l/s DN 100	0	0	14 l/s DN 100	31	11	22 l/s DN 100	23	8	32 l/s DN 100	11	4	41 l/s DN 100	1	1
2022	0 l	3.241.715 l	21 h/d	5 d	43 l/s	0 l/s	98	4,7	0	0 l/s	0	34	0 l/s	49	2	17	43 l/s DN 100	0	0	14 l/s DN 100	32	11	22 l/s DN 100	25	8	32 l/s DN 100	12	4	41 l/s DN 100	1	1
2023	0 l	3.471.655 l	21 h/d	5 d	46 l/s	0 l/s	105	5,0	0	0 l/s	0	36	0 l/s	53	3	18	46 l/s DN 200	0	0	15 l/s DN 100	35	12	23 l/s DN 100	26	9	35 l/s DN 100	13	5	44 l/s DN 100	1	1
2024	0 l	3.602.775 l	21 h/d	5 d	48 l/s	0 l/s	109	5,1	0	0 l/s	0	38	0 l/s	55	3	19	48 l/s DN 200	0	0	16 l/s DN 100	36	13	24 l/s DN 100	27	9	36 l/s DN 100	13	5	46 l/s DN 200	1	2
2025	0 l	3.783.530 l	22 h/d	5 d	50 l/s	0 l/s	115	5,3	0	0 l/s	0	39	0 l/s	57	3	20	50 l/s DN 200	0	0	17 l/s DN 100	38	13	25 l/s DN 100	29	10	38 l/s DN 100	14	5	48 l/s DN 200	1	2
2026	0 l	3.964.285 l	22 h/d	5 d	52 l/s	0 l/s	120	5,5	0	0 l/s	0	41	0 l/s	60	3	21	52 l/s DN 200	0	0	17 l/s DN 100	40	14	26 l/s DN 100	30	10	39 l/s DN 100	14	5	49 l/s DN 200	1	2
2027	0 l	4.200.175 l	22 h/d	5 d	56 l/s	0 l/s	127	5,8	0	0 l/s	0	44	0 l/s	64	3	22	56 l/s DN 200	0	0	18 l/s DN 100	42	15	28 l/s DN 100	32	11	42 l/s DN 100	15	6	53 l/s DN 200	1	2
2028	0 l	4.380.930 l	22 h/d	5 d	55 l/s	0 l/s	133	6,0	0	0 l/s	0	46	0 l/s	66	3	23	55 l/s DN 200	0	0	18 l/s DN 100	44	16	28 l/s DN 100	33	11	41 l/s DN 100	16	6	52 l/s DN 200	1	2
2029	0 l	4.568.860 l	22 h/d	5 d	58 l/s	0 l/s	138	6,2	0	0 l/s	0	48	0 l/s	69	3	24	58 l/s DN 200	0	0	19 l/s DN 100	46	16	29 l/s DN 100	35	12	44 l/s DN 100	17	6	55 l/s DN 200	1	2
2030	0 l	4.803.175 l	22 h/d	5 d	61 l/s	0 l/s	146	6,5	0	0 l/s	0	50	0 l/s	73	3	25	61 l/s DN 200	0	0	20 l/s DN 100	48	17	31 l/s DN 100	36	13	46 l/s DN 200	17	7	58 l/s DN 200	1	2
2031	0 l	5.037.940 l	22 h/d	5 d	64 l/s	0 l/s	153	6,8	0	0 l/s	0	52	0 l/s	76	3	26	64 l/s DN 200	0	0	21 l/s DN 100	50	18	32 l/s DN 100	38	13	48 l/s DN 200	18	7	61 l/s DN 200	2	2
2032	0 l	5.231.820 l	23 h/d	5 d	66 l/s	0 l/s	159	7,0	0	0 l/s	0	54	0 l/s	79	4	27	66 l/s DN 200	0	0	22 l/s DN 100	52	19	33 l/s DN 100	40	14	50 l/s DN 200	19	7	63 l/s DN 200	2	2
2033	0 l	5.520.145 l	23 h/d	5 d	70 l/s	0 l/s	167	7,3	0	0 l/s	0	58	0 l/s	84	4	29	70 l/s DN 200	0	0	23 l/s DN 100	55	20	35 l/s DN 100	42	14	53 l/s DN 200	20	7	67 l/s DN 200	2	2
2034	0 l	5.708.075 l	23 h/d	5 d	72 l/s	0 l/s	173	7,5	0	0 l/s	0	59	0 l/s	86	4	30	72 l/s DN 200	0	0	24 l/s DN 100	57	20	36 l/s DN 100	43	15	54 l/s DN 200	21	8	68 l/s DN 200	2	2
2035	0 l	6.000.775 l	23 h/d	5 d	72 l/s	0 l/s	182	7,9	0	0 l/s	0	63	0 l/s	91	4	31	72 l/s DN 200	0	0	24 l/s DN 100	60	21	36 l/s DN 100	45	16	54 l/s DN 200	22	8	68 l/s DN 200	2	3
2036	0 l	6.242.715 l	23 h/d	5 d	75 l/s	0 l/s	189	8,1	0	0 l/s	0	65	0 l/s	95	4	33	75 l/s DN 200	0	0	25 l/s DN 100	62	22	38 l/s DN 100	47	16	56 l/s DN 200	23	8	71 l/s DN 200	2	3
2037	0 l	6.490.605 l	23 h/d	5 d	78 l/s	0 l/s	197	8,4	0	0 l/s	0	68	0 l/s	98	4	34	78 l/s DN 200	0	0	26 l/s DN 100	65	23	39 l/s DN 100	49	17	59 l/s DN 200	24	9	74 l/s DN 200	2	3
2038	0 l	6.786.105 l	24 h/d	5 d	82 l/s	0 l/s	206	8,7	0	0 l/s	0	71	0 l/s	103	4	35	82 l/s DN 200	0	0	27 l/s DN 100	68	24	41 l/s DN 100	51	18	62 l/s DN 200	25	9	78 l/s DN 200	2	3
2039	0 l	7.032.420 l	24 h/d	5 d	85 l/s	0 l/s	213	9,0	0	0 l/s	0	73	0 l/s	107	5	37	85 l/s DN 200	0	0	28 l/s DN 100	70	25	43 l/s DN 100	53	18	64 l/s DN 200	26	10	81 l/s DN 200	2	3
2040	0 l	7.377.555 l	24 h/d	5 d	89 l/s	0 l/s	224	9,4	0	0 l/s	0	77	0 l/s	112	5	38	89 l/s DN 200	0	0	29 l/s DN 100	74	26	45 l/s DN 200	56	19	67 l/s DN 200	27	10	85 l/s DN 200	2	3
Vision 2040	0 l	9.545.615 l	24 h/d	5 d	110 l/s	0 l/s	289	12,1	0	0 l/s	0	99	0 l/s	145	6	50	110 l/s DN 200	0	0	36 l/s DN 100	95	34	55 l/s DN 200	72	25	83 l/s DN 200	35	13	105 l/s DN 200	3	4

Table III-2 Aviation fuel supply – Case 2 – Daily peak fuel demand

	Max. Day Aviation Fuel Supply					Scenario 1				Scenario 2			Scenario 3				Scenario 4			Scenario 5			Scenario 6			Scenario 7			Scenario 8		
						0%	100%		0%	0%	0%	###	0%	50%		50%	100%	0%	0%	33%	33%	34%	50%	25%	25%	75%	12%	13%	95%	1%	4%
	fuel storage	Avg. day demand	fuel supply operation	storage restoring time	flow rate	pipeline	CTMV #/d	CTMV #/h	car tank #/d	pipeline	CTMV #/d	car tank #/d	pipeline	CTMV #/d	CTMV #/h	car tank #/d	pipeline	CTMV #/d	car tank #/d	pipeline	CTMV #/d	car tank #/d	pipeline	CTMV #/d	car tank #/d	pipeline	CTMV #/d	car tank #/d	pipeline	CTMV #/d	car tank #/d
2015	0 l	563.765 l	20 h/d	5 d	8 l/s	0 l/s	17	0,9	0	0 l/s	0	6	0 l/s	9	0,4	3	8 l/s DN 100	0	0	3 l/s DN	6	2	4 l/s DN	4	1	6 l/s DN 100	2	1	8 l/s DN 100	0	0
2016	0 l	926.750 l	20 h/d	5 d	13 l/s	0 l/s	28	1,4	0	0 l/s	0	10	0 l/s	14	0,7	5	13 l/s DN 100	0	0	4 l/s DN	9	3	7 l/s DN 100	7	2	10 l/s DN 100	3	1	12 l/s DN 100	0	0
2017	0 l	1.436.719 l	20 h/d	5 d	20 l/s	0 l/s	44	2,1	0	0 l/s	0	15	0 l/s	22	1,1	7	20 l/s DN 100	0	0	7 l/s DN 100	14	5	10 l/s DN 100	11	4	15 l/s DN 100	5	2	19 l/s DN 100	0	1
2018	0 l	1.942.112 l	20 h/d	5 d	27 l/s	0 l/s	59	2,9	0	0 l/s	0	20	0 l/s	29	1,4	10	27 l/s DN 100	0	0	9 l/s DN 100	19	7	14 l/s DN 100	15	5	20 l/s DN 100	7	3	26 l/s DN 100	1	1
2019	0 l	2.081.154 l	21 h/d	5 d	29 l/s	0 l/s	63	3,1	0	0 l/s	0	22	0 l/s	32	1,5	11	29 l/s DN 100	0	0	10 l/s DN 100	21	7	15 l/s DN 100	16	5	22 l/s DN 100	8	3	28 l/s DN 100	1	1
2020	0 l	2.259.242 l	21 h/d	5 d	31 l/s	0 l/s	68	3,3	0	0 l/s	0	24	0 l/s	34	1,6	12	31 l/s DN 100	0	0	10 l/s DN 100	23	8	16 l/s DN 100	17	6	23 l/s DN 100	8	3	29 l/s DN 100	1	1
2021	0 l	2.360.104 l	21 h/d	5 d	33 l/s	0 l/s	72	3,4	0	0 l/s	0	25	0 l/s	36	1,7	12	33 l/s DN 100	0	0	11 l/s DN 100	24	8	17 l/s DN 100	18	6	25 l/s DN 100	9	3	31 l/s DN 100	1	1
2022	0 l	2.493.627 l	21 h/d	5 d	33 l/s	0 l/s	76	3,6	0	0 l/s	0	26	0 l/s	38	1,8	13	33 l/s DN 100	0	0	11 l/s DN 100	25	9	17 l/s DN 100	19	6	25 l/s DN 100	9	3	31 l/s DN 100	1	1
2023	0 l	2.670.504 l	21 h/d	5 d	35 l/s	0 l/s	81	3,8	0	0 l/s	0	28	0 l/s	40	1,9	14	35 l/s DN 100	0	0	12 l/s DN 100	27	9	18 l/s DN 100	20	7	26 l/s DN 100	10	4	33 l/s DN 100	1	1
2024	0 l	2.771.365 l	21 h/d	5 d	37 l/s	0 l/s	84	3,9	0	0 l/s	0	29	0 l/s	42	2,0	14	37 l/s DN 100	0	0	12 l/s DN 100	28	10	19 l/s DN 100	21	7	28 l/s DN 100	10	4	35 l/s DN 100	1	1
2025	0 l	2.910.408 l	22 h/d	5 d	38 l/s	0 l/s	88	4,1	0	0 l/s	0	30	0 l/s	44	2,0	15	38 l/s DN 100	0	0	13 l/s DN 100	29	10	19 l/s DN 100	22	8	29 l/s DN 100	11	4	36 l/s DN 100	1	1
2026	0 l	3.049.450 l	22 h/d	5 d	40 l/s	0 l/s	92	4,3	0	0 l/s	0	32	0 l/s	46	2,1	16	40 l/s DN 100	0	0	13 l/s DN 100	30	11	20 l/s DN 100	23	8	30 l/s DN 100	11	4	38 l/s DN 100	1	1
2027	0 l	3.230.904 l	22 h/d	5 d	43 l/s	0 l/s	98	4,5	0	0 l/s	0	34	0 l/s	49	2,2	17	43 l/s DN 100	0	0	14 l/s DN 100	32	11	22 l/s DN 100	24	8	32 l/s DN 100	12	4	41 l/s DN 100	1	1
2028	0 l	3.369.946 l	22 h/d	5 d	43 l/s	0 l/s	102	4,6	0	0 l/s	0	35	0 l/s	51	2,3	18	43 l/s DN 100	0	0	14 l/s DN 100	34	12	22 l/s DN 100	26	9	32 l/s DN 100	12	5	41 l/s DN 100	1	1
2029	0 l	3.514.508 l	22 h/d	5 d	44 l/s	0 l/s	107	4,8	0	0 l/s	0	37	0 l/s	53	2,4	18	44 l/s DN 100	0	0	15 l/s DN 100	35	12	22 l/s DN 100	27	9	33 l/s DN 100	13	5	42 l/s DN 100	1	1
2030	0 l	3.694.750 l	22 h/d	5 d	47 l/s	0 l/s	112	5,0	0	0 l/s	0	38	0 l/s	56	2,5	19	47 l/s DN 200	0	0	16 l/s DN 100	37	13	24 l/s DN 100	28	10	35 l/s DN 100	13	5	45 l/s DN 200	1	2
2031	0 l	3.875.338 l	22 h/d	5 d	49 l/s	0 l/s	117	5,2	0	0 l/s	0	40	0 l/s	59	2,6	20	49 l/s DN 200	0	0	16 l/s DN 100	39	14	25 l/s DN 100	29	10	37 l/s DN 100	14	5	47 l/s DN 200	1	2
2032	0 l	4.024.477 l	23 h/d	5 d	51 l/s	0 l/s	122	5,4	0	0 l/s	0	42	0 l/s	61	2,7	21	51 l/s DN 200	0	0	17 l/s DN 100	40	14	26 l/s DN 100	30	10	38 l/s DN 100	15	5	48 l/s DN 200	1	2
2033	0 l	4.246.265 l	23 h/d	5 d	54 l/s	0 l/s	129	5,7	0	0 l/s	0	44	0 l/s	64	2,8	22	54 l/s DN 200	0	0	18 l/s DN 100	42	15	27 l/s DN 100	32	11	41 l/s DN 100	15	6	51 l/s DN 200	1	2
2034	0 l	4.390.827 l	23 h/d	5 d	55 l/s	0 l/s	133	5,8	0	0 l/s	0	46	0 l/s	67	2,9	23	55 l/s DN 200	0	0	18 l/s DN 100	44	16	28 l/s DN 100	33	11	41 l/s DN 100	16	6	52 l/s DN 200	1	2
2035	0 l	4.615.981 l	23 h/d	5 d	56 l/s	0 l/s	140	6,1	0	0 l/s	0	48	0 l/s	70	3,0	24	56 l/s DN 200	0	0	18 l/s DN 100	46	16	28 l/s DN 100	35	12	42 l/s DN 100	17	6	53 l/s DN 200	1	2
2036	0 l	4.802.088 l	23 h/d	5 d	58 l/s	0 l/s	146	6,3	0	0 l/s	0	50	0 l/s	73	3,1	25	58 l/s DN 200	0	0	19 l/s DN 100	48	17	29 l/s DN 100	36	13	44 l/s DN 100	17	7	55 l/s DN 200	1	2
2037	0 l	4.992.773 l	23 h/d	5 d	60 l/s	0 l/s	151	6,5	0	0 l/s	0	52	0 l/s	76	3,2	26	60 l/s DN 200	0	0	20 l/s DN 100	50	18	30 l/s DN 100	38	13	45 l/s DN 200	18	7	57 l/s DN 200	2	2
2038	0 l	5.220.081 l	24 h/d	5 d	63 l/s	0 l/s	158	6,7	0	0 l/s	0	54	0 l/s	79	3,4	27	63 l/s DN 200	0	0	21 l/s DN 100	52	18	32 l/s DN 100	40	14	47 l/s DN 200	19	7	60 l/s DN 200	2	2
2039	0 l	5.409.554 l	24 h/d	5 d	65 l/s	0 l/s	164	6,9	0	0 l/s	0	56	0 l/s	82	3,5	28	65 l/s DN 200	0	0	21 l/s DN 100	54	19	33 l/s DN 100	41	14	49 l/s DN 200	20	7	62 l/s DN 200	2	2
2040	0 l	5.675.042 l	24 h/d	5 d	69 l/s	0 l/s	172	7,2	0	0 l/s	0	59	0 l/s	86	3,6	30	69 l/s DN 200	0	0	23 l/s DN 100	57	20	35 l/s DN 100	43	15	52 l/s DN 200	21	8	66 l/s DN 200	2	2
Vision 2040	0 l	7.342.781 l	24 h/d	5 d	85 l/s	0 l/s	223	9,3	0	0 l/s	0	76	0 l/s	111	4,6	38	85 l/s DN 200	0	0	28 l/s DN 100	73	26	43 l/s DN 100	56	19	64 l/s DN 200	27	10	81 l/s DN 200	2	3

Table III-3 Aviation fuel supply – Case 3 – Daily average fuel demand

III.6 Appendix 6 - Number of Aviation Fuel Loading Facilities

	Aviation Fuel Supply - Loading Facilities				Refueler	Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		Scenario 6		Scenario 7		Scenario 8	
						100%	0%	0%	100%	50%	50%	0%	0%	33%	34%	25%	25%	12%	13%	1%	4%
	spare CTMV loading facilities	spare CTMV loading facilities	spare car unloading facilities	fuel supply oparation	CTMV cnnctn	CTMV cnnctn	rail	CTMV cnnctn	rail	CTMV cnnctn	rail	CTMV cnnctn	rail	CTMV cnnctn	rail	CTMV cnnctn	rail	CTMV cnnctn	rail	CTMV cnnctn	rail
2015	0%	25%	25%	20 h/d	9	3	0	0	1/4	1	1/4	0	0	1	1/4	1	1/4	1	1/4	1	1/4
2016	0%	25%	25%	20 h/d	14	4	0	0	2/4	3	1/4	0	0	1	1/4	1	1/4	1	1/4	1	1/4
2017	0%	25%	25%	20 h/d	21	6	0	0	2/4	4	1/4	0	0	3	1/4	3	1/4	1	1/4	1	1/4
2018	0%	25%	25%	20 h/d	28	8	0	0	3/4	4	2/4	0	0	3	1/4	3	1/4	1	1/4	1	1/4
2019	0%	25%	25%	21 h/d	28	9	0	0	3/4	5	2/4	0	0	4	1/4	3	1/4	1	1/4	1	1/4
2020	0%	25%	25%	21 h/d	30	9	0	0	3/4	5	2/4	0	0	4	1/4	3	1/4	1	1/4	1	1/4
2021	0%	25%	25%	21 h/d	31	9	0	0	3/4	5	2/4	0	0	4	1/4	3	1/4	1	1/4	1	1/4
2022	0%	25%	25%	21 h/d	31	9	0	0	3/4	5	2/4	0	0	4	1/4	3	1/4	1	1/4	1	1/4
2023	0%	25%	25%	21 h/d	33	10	0	0	1	5	2/4	0	0	4	2/4	3	1/4	1	1/4	1	1/4
2024	0%	25%	25%	21 h/d	35	10	0	0	1	5	2/4	0	0	4	2/4	3	1/4	1	1/4	1	1/4
2025	0%	25%	25%	22 h/d	35	10	0	0	1	5	2/4	0	0	4	2/4	3	1/4	1	1/4	1	1/4
2026	0%	25%	25%	22 h/d	35	10	0	0	1	5	2/4	0	0	4	2/4	3	1/4	1	1/4	1	1/4
2027	0%	25%	25%	22 h/d	36	11	0	0	1	6	2/4	0	0	4	2/4	4	1/4	3	1/4	1	1/4
2028	0%	25%	25%	22 h/d	36	11	0	0	1	6	2/4	0	0	4	2/4	4	1/4	3	1/4	1	1/4
2029	0%	25%	25%	22 h/d	38	11	0	0	1	6	2/4	0	0	4	2/4	4	1/4	1	1/4	1	1/4
2030	0%	25%	25%	22 h/d	38	11	0	0	1	6	2/4	0	0	4	2/4	4	1/4	3	1/4	1	1/4
2031	0%	25%	25%	22 h/d	40	11	0	0	1	6	2/4	0	0	4	2/4	4	1/4	3	1/4	1	1/4
2032	0%	25%	25%	23 h/d	40	13	0	0	1	6	2/4	0	0	5	2/4	4	1/4	3	1/4	1	1/4
2033	0%	25%	25%	23 h/d	40	13	0	0	1 1/4	6	3/4	0	0	5	2/4	4	2/4	3	1/4	1	1/4
2034	0%	25%	25%	23 h/d	40	13	0	0	1 1/4	6	3/4	0	0	5	2/4	4	2/4	3	1/4	1	1/4
2035	0%	25%	25%	23 h/d	42	14	0	0	1 1/4	8	3/4	0	0	5	2/4	4	2/4	3	1/4	1	1/4
2036	0%	25%	25%	23 h/d	42	14	0	0	1 1/4	8	3/4	0	0	5	2/4	4	2/4	3	1/4	1	1/4
2037	0%	25%	25%	23 h/d	42	14	0	0	1 1/4	8	3/4	0	0	5	2/4	4	2/4	3	1/4	1	1/4
2038	0%	25%	25%	24 h/d	42	14	0	0	1 1/4	8	3/4	0	0	5	2/4	4	2/4	3	1/4	1	1/4
2039	0%	25%	25%	24 h/d	42	14	0	0	1 1/4	8	3/4	0	0	5	2/4	4	2/4	3	1/4	1	1/4
2040	0%	25%	25%	24 h/d	42	15	0	0	1 1/4	8	3/4	0	0	5	2/4	4	2/4	3	1/4	1	1/4
Vision 2040+ (30 MAP)	0%	25%	25%	24 h/d	55	19	0	0	1 3/4	10	1	0	0	6	3/4	5	2/4	3	1/4	1	1/4

Table III-4 Aviation fuel supply – Number of required loading facilities