Contribution to the Design of Digital Supply Chain Governance Concepts for Sustainable Development of Biodiesel

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Abstract

Recently, biodiesel and biofuel have increasingly been discussed in several papers and conferences. However, only a few have examined biodiesel from the logistics perspective, while most of the scientific investigations have addressed the production issues, e.g. efficiency, diversification and processing technology (1st, 2nd or 3rd generation). In spite of this, biodiesel poses a problem for logistic processes, such as facility planning, transport, and routing-scheduling associated with quality control along with continuity of feedstock supply. In some developing countries, the management of the biodiesel industry has also become a predicament. Even though developed countries have commonly established a national agency in charge of the biodiesel business, the institution is still in the early stages of standardisation and quality control. Currently, there is no agency concerned with supply chain governance that is capable of integrating the biodiesel business from upstream to downstream. In this thesis, the author presents a procedural technique to assess the biodiesel industry. This procedure combines business modelling/analysis (using General Electric/Mc. Kinsey Matrix), simulation, conceptual design and a prototyping system. The study provides scientific insight for planning a digital biodiesel supply chain and proposes a framework for governing such a system from upstream to downstream. The researcher employs a holistic approach, where biodiesel is not seen as a separate entity because it comes to the consumers through a long chain dependent on various aspects. Currently, a number of companies have implemented Enterprise-Resource-Planning to manage their businesses, but unfortunately, they have not been able to reach the entire value chain. Digitalisation is desirable when integrating the Information Systems of all supply chain members. A control tower must be built to accommodate such an idea and monitor the entire process. Then, the best standardised quality and sustainability can be achieved. The author also offers a transition concept in the implementation level, because, in reality, the members in the supply chain have no similar Informastion-System standard. The results from literature studies, simulations, prototyping, theoretical arguments, and conceptual design present a digitalisation pattern in the biodiesel supply chain for sustainable development.

Keywords: Biodiesel, Supply Chain, Governance, Digitalization, Control Tower.

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The Code-Listings

Acronyms

AGQM	Arbeitsgemeinschaft Qualitätsmanagement Biodiesel e. V.
ALA	Alternate Location-Allocation
ANFAVEA	Brazil Association of the Automotive Vehicles Manufacturers
ANP	Agência Nacional do Petróleo, Gás Natural e Biocombustíveis
API	Application Programming Interface
ASTM	American Society of the International Association for Testing and Materials
ATM	Automatic Teller Machines
AV	Acid Value
B	Biodiesel
BFG	The Brazil Federal Government
BP	British Petroleum
BPS	British Petroleum Statistical
BQ-9000	Biodiesel Quality – 9000 (US Biodiesel Accreditation Program)
BRIC	Brazil, Russia, India and China
BSO	Biofuels Sustainability Ordinance
BTS	Base Transceiver Station
CGI	Common Gateway Interface
CIA	Central Intelligence Agency
CNPC	China National Petroleum Corporation
CNPE	The National Council for Energy Policy
CPFR	Collaborative Planning, Forecasting, and Replenishment
CPO	Crude Palm Oil
CRM	Customer Relationship Management
CSCMP	Council of Supply Chain Management Professionals
DC	Distribution Center
DD	Decimal Degree
DED	Detail Engineering Design
DIN	Deutsches Institut für Normung
DMM	Degrees and Decimal Minutes
DMS	Degree, Minutes and Second
DSS	Decision Support Systems
EF	Existing Facility
EIA	US - Energy Information Administration (EIA)
EISA	Energy Independence and Security Act
EMO	Emerging Markets Online
EN	European Norm
EPA	Energy Policy Act

ERP	Enterprise Resource Planning
e-Tag	Electronic Tag
EvoSCM-B	Supply Chain Management Evolution for Biodiesel
FA	Fatty-Acid
FAME	Fatty Acid Methyl Esters
G8	The Group of Eight
GCS	Geographic Coordinate System
GDP	Gross Domestic Product
GE	General Electric
GIS	Geographic Information System
GoI	The Government of Indonesia
GPS	Global Positioning System
GUI	Graphical User Interface
I.D.E	Integrated Development Environment
IoT	Internet of Thing
IPv6	Internet Protocol version 6
IRAM	Instituto de Racionalización Argentino de Materiales
IS	Indian Standard
ISCC	International Sustainability and Carbon Certificate
IT	Information Technology
JASO	Japan Engine Oil Standards Implementation Panel
LBS	Location-Based Services
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MENR	Ministry of Energy and Natural Resources
MEO	Medium Earth Orbit
MILP	Mixed-integer linear programming
MRP	Manufacturing Resource Planning
MS	Malaysian Standard
NBAC	National Biodiesel Accreditation Commission
NF	New Facility
NFPA	National Fire Protection Association
NYSE	New York Stock Exchange
ON	Östereich Norm
Op	Operation
OS	Operating System
PAR	Parameter
PC	Personal Computer
PDA	Personal Digital Asisstant
PERTAMINA	State owned oil operator in Indonesia
PHP	Hypertext Preprocessor
PME	Palm-oil Methyl-Ester

PV	Peroxide Value
Q	Quality
REC	Recommendation
RED	Renewable Energy Directive
RFID	Radio Frequency Identification
RFS	Renewable Fuel Standard
RME	Rapeseed oil Methyl Ester
Rs	Result
RTRS	Round Table for Responsible Soy Association
SANS	South African National Standard
SC	Supply Chain
SCM	Supply Chain Management
SCOR	Supply Chain Operational Reference
SDLC	Software Development Life Cycle
SME	Soya oil Methyl-Ester
SNI	Standar Nasional Indonesia
SOP	Standard Operation Procedures
SPBU	Stasiun Pengisian Bahan Bakar Umum
Spec	Specification
SQL	Structured Query Language
SS	Swedish Standards
TBBM	Terminal Bahan Bakar Minyak (or Distribution Center)
TC	Total Cost
TCE	Transaction Cost Economics
TCP	Transmission Control Protocol
TFT	Thin-film transistor Display
TSI	Transaction Spesific Asset Investment
UFO	Used Frying Oils
UFOP	Union zur Förderung von Oel- und Proteinpflanzen
US	United States
USDA	Unitaed States Department of Agriculture
USFWS	United States Fish and Wildlife Services
USGS	United States Geological Survey
V	Viscosity
VEETC	Volumetric Ethanol Excise Tax Credit
WFO	Waste Frying Oil
WoT	Web of Thing
WWF	World Wide Fund

1. Introduction

1.1. Background

British Petroleum Statistical (BPS) reports that the world's primary energy consumption grew by 5.6% in 2010 and 2.5% in 2011. The growth continued until 2012-2013 by 1.8% and 2.3%, respectively (British Petroleum, 2014). Oil has become the world's energy parameter since it comprises 33.1% of global energy demand. Oil domination, followed by coal, natural gas, nuclear, hydroelectricity and renewable energy are illustrated in Figure 1-1.

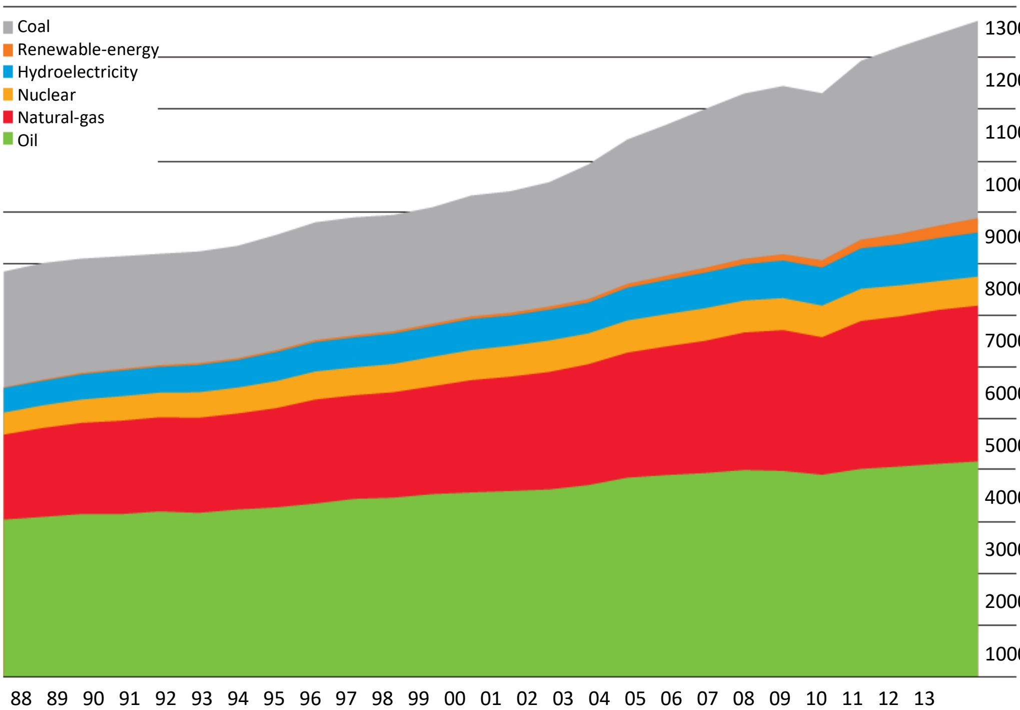


Figure 1-1 World Energy Consumption (British Petroleum, 2014)

However, the world's proven oil reserves are now getting worse year by year. As reported by the CIA, according to the January 2012 estimation, the world's oil reserve is equal to 1.532 trillion bbl (Central Intelligence Agency, 2013). Saudi Arabia has the largest oil reserves and 17.27% of total world oil. Russia is the top oil producer with 10.379 million barrels produced per day. Derived from CIA data, the remaining (year) world oil reserves by the time this thesis was written (2013) are shown in Table 1-1. The number of existing land reserves divided by the production of oil per day yields the remaining oil production years. Venezuela will be the longest remaining oil producing country, if they maintain their production rate. Venezuela reserves are estimated to last 238 years.

Saudi Arabia with the largest reserves only occupies the 7th rank with 74 years of oil production remaining due to massive field-exploitation. In fact, Saudi Arabia's economic policy tends to produce more than ten million bbl per day. It is not surprising that Saudi Arabia is called a petroleum-based country. Oil comprises 90% of the country's exports and nearly 75% of government revenues. (Organization of the Petroleum Exporting Countries, 2012).

Table 1-1 Country Comparison of Oil Possession derived from (Central Intelligence Agency, 2013)

No.	Country	Production (million bbl)	Proven Reserve (million bbl)	Remaining (Years)
1	Venezuela	2.470	209,400	238
2	Iraq	2.900	143,100	139
3	Canada	3.592	173,600	136
4	Kuwait	2.682	101,500	106
5	Iran	4.231	151,200	100
6	United Arab Emirates	3.087	97,800	89
7	Saudi Arabia	10.000	264,600	74
8	Kazakhstan	1.635	30,000	52
9	Qatar	1.631	25,570	44
10	Nigeria	2.525	38,500	43
11	Spain	0.012	150	35
12	India	0.897	8,935	28
13	Brazil	2.633	26,000	28
14	Netherlands	0.042	287	19
15	Algeria	1.885	12,260	18
16	Russia	10.370	60,000	16
17	Italy	0.099	532.20	15
18	Malaysia	0.603	2,900	14
19	Austria	0.018	85	13
20	Indonesia	0.912	4,000	12
21	Mexico	2.934	12,170	12
22	Denmark	0.221	900	11
23	China	4.150	14,800	10
24	Australia	0.483	1,426	8
25	United Kingdom	1.099	2,827	7
26	United States	9.000	20,680	6
27	France	0.049	90	5
28	Germany	0.165	276	5

The CIA data indicate that only four Gulf states have more than 100 billion barrels of proven oil reserves, i.e. Saudi Arabia, Iran, Kuwait and Iraq. Among these states only Iran, Kuwait and Iraq will have oil for over a century. An urgent and alarming oil dependent country is the United States (US). Even though they have 22.5 billion barrels of oil reserves, with the current level of production of 9 million barrels per day plus the insanely high consumption, the US oil will undoubtedly last no longer than 6 years. Industrial countries like Europe and Australia will also face the same problem as they are located in the 5th lowest positions on Table 1-1. More than ten years of oil remaining in European countries like the Netherlands, Italy and Spain means they have a bit more time due to very low production rates, but on the other hand they should improve their rate of oil imports. Thus, among The Group of Eight (G8) or elite governments' forum of the eight world's largest national economies, only Canada can remain calm when dealing with oil. What about the emerging economic countries (BRIC) such as Brazil, Russia, India and China? They are also not safe with 10 to 28 years of oil remaining. Other countries (South Africa, Mexico, Argentina, South Korea, Indonesia, Turkey and Saudi Arabia) called G20-group of 20 major economies (minus BRIC and G8), will not survive on their oil reserves for more than 12 years, except Saudi Arabia. All of this reflects a severe world oil crisis in the near future. Slowly but surely, many countries will join the importing oil club, such as the US which currently has to import more than 9 million barrels per day, far beyond the Indonesian oil production per day. All calculations of course are highly debatable, but can roughly predict the state of the planet in the future. Thus, recently people have shifted their concerns to renewable energy possibilities. Go-green initiatives and alternative energy studies have become a new concept of modern life. 'Back to nature' echoes everywhere.

The Government of Indonesia (GoI) has also made the concept of energy security part of its national security (Figure 1-2). Energy security is seen as the ability to respond to dynamic changes in global energy and the ability to meet national energy needs independently (Ariati, 2008). Besides that, GoI has mandated national energy utilisation. In the Presidential Decree No 5/2006, the targets of energy include a mix of oil, gas, coal and renewable energy by 2025 (Figure 1-3).

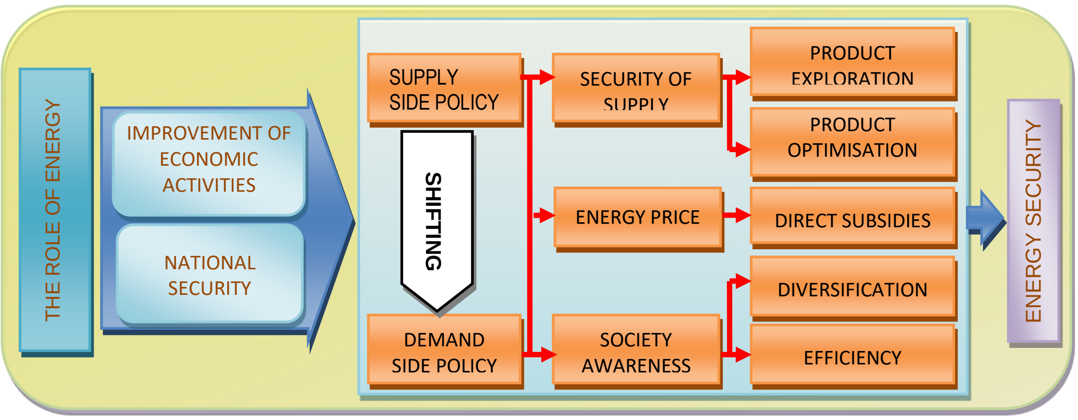


Figure 1-2 Indonesia's Energy Policy (Ariati, 2008)

The following percentages have been targeted: biofuel at 5%, geothermal at 5%, liquefaction coal at 2% and the summation of biomass, nuclear, hydro-power, solar, wind-power at 5%. Thus, the total percentage of renewable energy target by 2025 is 17% of national energy consumption. It is not surprising that geothermal and biofuel comprise a large share of this target.

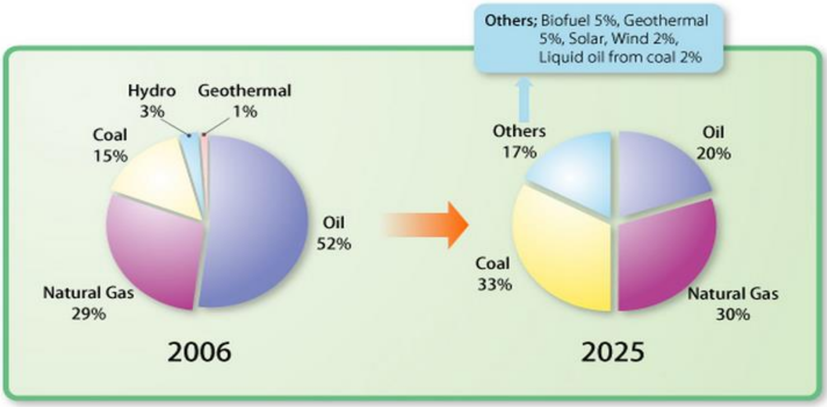


Figure 1-3 Primary Energy Supply in Indonesia (from Indonesian Presidential Decree 5, 2000)

Indonesia has the largest geothermal energy reserves in the world and biofuel has a huge prospect on feedstock. Wirawan (2007) identified that Indonesia has 27 prospective feedstocks that can be converted into Fatty Acid Methyl Esters (FAME; Diesel Alternative Called Biodiesel) and Panaka (2005) found that Indonesia has the possibility to produce ethanol (gasoline alternative) from 12 crops. The GoI projected the annual biofuel production to reach 720,000 kilolitres by 2010, steadily increasing to 1.5 million kilolitres by 2015, and finally increasing to 4.7 million kilolitres afterwards. In order to achieve the targets, the GoI has invested Rp 200 trillion (equal to € 16 billion) over five years since 2010.

1.2. Problem Identification

Diesel has influenced the world economy. Diesel is widely used in most industrial sectors because it provides more power per unit of fuel and costs less than gasoline. Diesel engines are used in: the transport sector including cars, buses or trucks; the agricultural sector, such as tractors and farming equipment to welding machines; marine vessels; diesel locomotives and power generation. There are also some aircraft that use a diesel jet-engine. One aspect that is possibly overlooked is the use of diesel generators as the backup power behind each server on the planet. The server has to run 24 hours a day, hence the regular power is usually backed up by a diesel power generator. Thus, telecommunications and the internet industry are more or less dependent on diesel engines.

The most remarkable prospect of diesel is the fact that the diesel engine can be supplied by vegetable oil. With the right quality and firm composition, it can be burned in the diesel engine without the loss of too much power or efficiency. This vegetable oil as a diesel alternative is chemically called FAME - **F**atty **A**cid **M**ethyl **E**sters or simply 'biodiesel'. Even biodiesel can overcome one of diesel's drawbacks in the case of emission. Diesel engine emission such as NOx and CO can be significantly reduced with biodiesel.

However, biodiesel is not an instant product. From farm-cultivation until production, blending, distribution and retail, it comprises a very long process (see Figure 1-4).

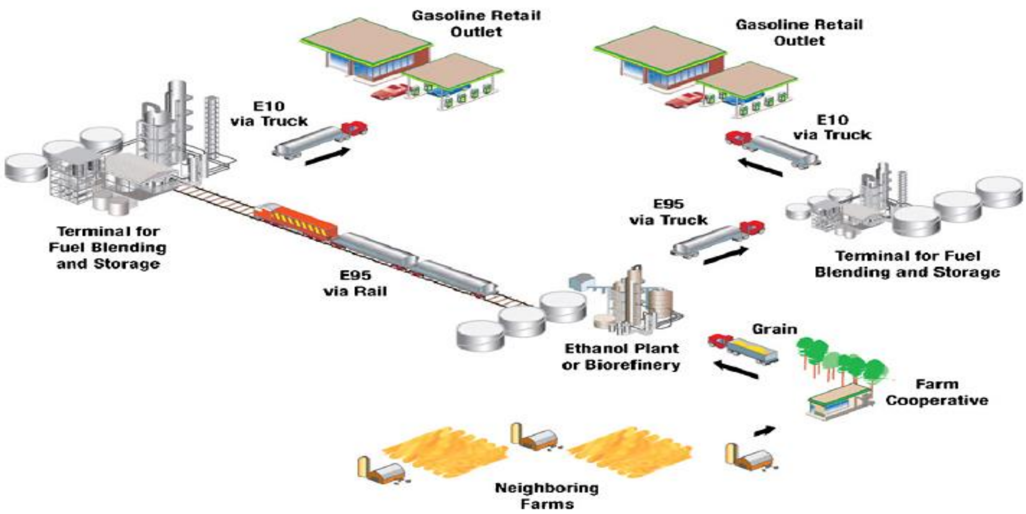


Figure 1-4 Biofuel Value Chain and Distribution (Awudu, 2012)

Another biodiesel problem that remains a concern is its degradability over time, mainly influenced by temperature, presence of light, metal, oxygen and the storage conditions. Milestone achievements and the result of biodiesel stability research over time can be summarised as follows.

Biodiesel is an alternative diesel fuel that consisting of alkyl monoester of fatty acids derived from vegetable oils. It is renewable, reduces the emission and readily biodegradable in the environment (Zhang, 1988). Bondioli (1995) and Thompson (1998) reported the degradation of rapeseed oil methyl ester (RME) under different storage conditions, using a different variable of acidity peroxide values and viscosities. It was found that acid value (AV), peroxide value (PV) and viscosity (v) increased with time. Monyem (2000) and Mittelbach (2001) discovered that the biodiesel oxidation was determined by several factors, such as elevated temperature, light, the presence of metals, and other conditions that shall accelerate oxidation. Leung (2006) stated that high temperature, together with the air exposure, rapidly grow the biodiesel degradation rate. Westbrook (2005) observed that insoluble's formation, acid number and viscosity increased significantly on the B100 (pure biodiesel) by ASTM D4625 which has been examined for 12 weeks. The least stable sample has produced unacceptable levels of insoluble and acidity during 4-8 weeks of the test. Taşyürek (2010) identified that acid value and viscosity has a linear connection. In the diesel fuel and all types of biodiesel mixture, viscosity rises in the course of time when it is not proper storage. According to Jain (2011), biodiesel oxidation stability varying with respect to time, linolenic acid methyl ester decrease and the fraction of oleic-acid methyl become relatively high. Various biodiesel feedstock/raw materials have different levels of oxidative stability (Serrano, 2013).

From these papers, biodiesel oxidation stability will affect biodiesel storage and of course will also influence its distribution.

The Indonesian biodiesel industry was selected as the case study since Indonesia is the world largest archipelagic country posing a complex problem from a logistics perspective. Indonesia has 17,508 islands and 6000 inhabited islands. The total area of Indonesia is over than 1.9 million km² with an estimated 238 million people (World Bank, 2012). The value chain of the process on the state can be among different cities, regions or across the sea on different islands. Thus, the issues of supply chain management, infrastructure, land utilisation and distribution become more important.

Since Indonesia is one of the world biggest palm oil and biodiesel producers, it is important to learn how the other biodiesel exporter countries manage their successful supply and sustainability. The biodiesel industry is now growing not only to maintain or improve their market but considering several issues, i.e., the 'food vs fuel' debate, CO_2 emissions, deforestation, soil erosion, loss of biodiversity, impact on water resources and energy balance/efficiency.

In the other hand, German as one of the major consumers, has long been aware of these issues in the biodiesel industry. Germany imposes very tight rules and regulations on their biodiesel industry. These two countries, besides Argentina, Brazil, and the US, will characterise the discussion of the best practices of efficient supply chain management on the biodiesel industry in this thesis.

In the case of Indonesia, biodiesel distribution problems experienced by state owned oil operator (PERTAMINA, 2012) are as follows:

- As empirically proven, biodiesel cannot be stored for too long and can be easily damaged by water environment.
- It was indicated that biodiesel decreased its calories when used on a truck/bus in a ramp.
- Some fuel terminals have small throughput, which is not very economical if infrastructure is built such as shore tank biodiesel. In such a case, biodiesel and fossil-diesel blending has been carried out from the tank biodiesel-truck directly. Usually, it leads to a disturbance in the distribution of biodiesel or even a delay in biodiesel supply.
- Regions which have no feedstock or remote districts have hardly any supply.
- There is not a continuous supply when the market price is higher than the market price index defined by the Government.

Moreover, the Indonesian Chamber of Commerce also determined industrial requirements for biodiesel according to the following criteria (Wirawan, 2008):

- Biodiesel has to be of compatible quality or better than diesel;
- Biodiesel price is equal to or more competitive than diesel;
- Continuity of supply, supply enhancement, planned and measurable conversion programme;
- Ease of getting supplies;
- Disclosure and transparent pricing mechanism for dominant factors of biodiesel (price of crude oil, fuel, and CPO);
- Biodiesel usage does not make radical changes to the technical work that has been done.

The problems as mentioned earlier could be summarised into the following points:

1. Remaining problems with biodiesel quality control;
2. Lack of coordination in the biodiesel supply chain and infrastructure;
3. The weakness of rules/regulations that manage biodiesel.

1.3. Research Question

According to the problems identified, the following research question was posed:

'how can biodiesel supply chains be managed in order to fulfill industrial and public requirements toward sustainable development using the digitalisation and governance mechanism?'

In order to coordinate, anticipate and solve emerging problems in biodiesel development, the integrated concept involving multiple value chains, new facility planning and distribution strategy should be created. On the basis of the aforementioned premises, detailed research questions were expressed:

a. How to evaluate and compare the biodiesel supply chain from various countries?
b. How to deal with the problems that arise in a country which is assessed?
c. Which tools can be used to overcome the identified problems in a biodiesel industry?
d. What innovative approaches for biodiesel logistics will ensure a sustainable supply?

1.4. Objectives

The objectives of this research can be divided into three general purposes:

a. To create a biodiesel supply chain management technique which has the ability to control acceptable biodiesel quality;
b. To overcome biodiesel problems using particular tools;
c. To design an innovation approach for biodiesel logistics that ensures sustainable supply.

1.5. Research Methodology, Area and Scope

Investigations over the course of this research comprise four ields of study:

- Biodiesel Supply Chain and Governance
- Facility planning
- Simulation
- System design and prototyping

Detailed methodology used for the research is explained in Figure 1-5.

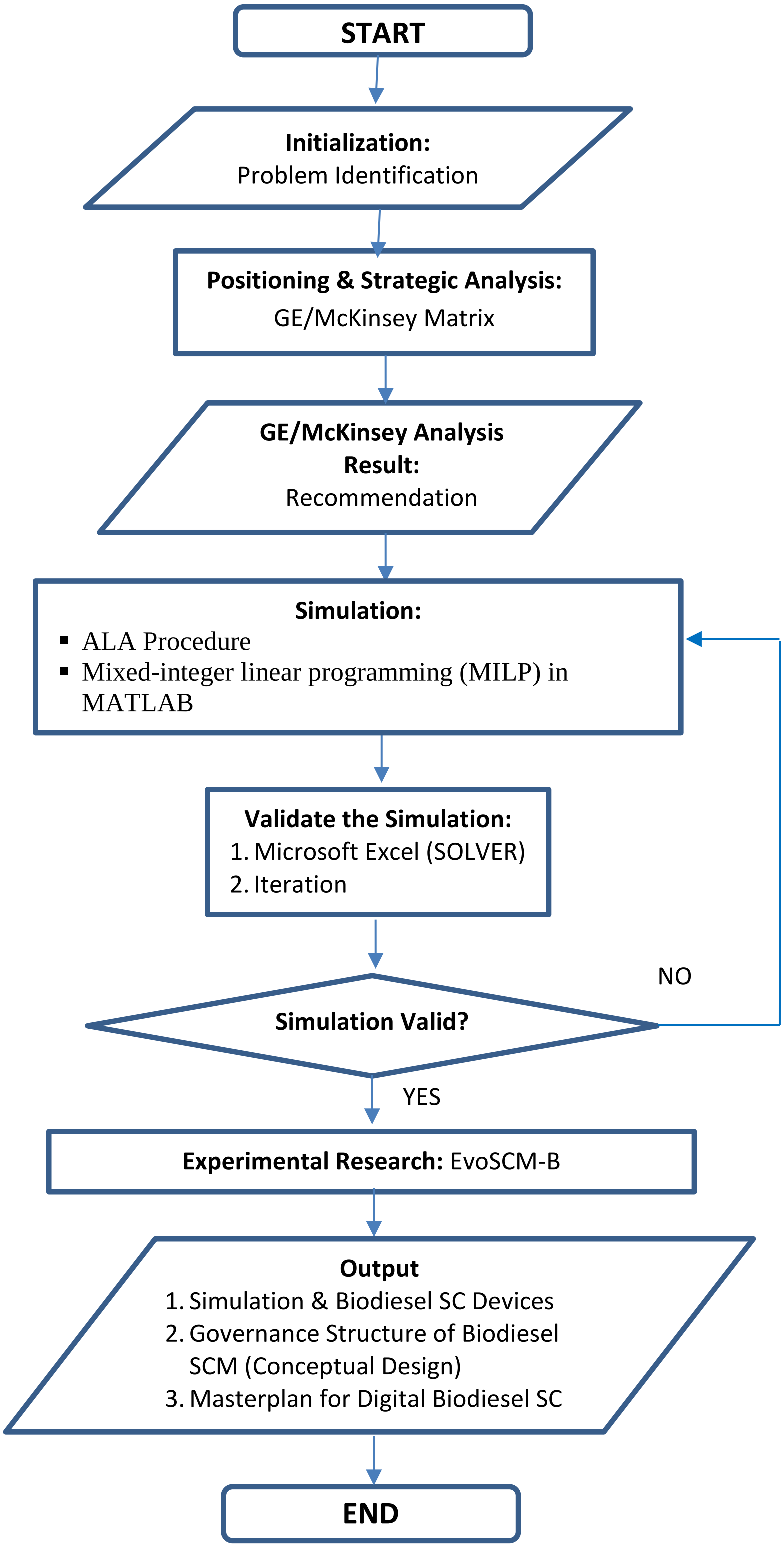


Figure 1-5 Research Methodology

Through this thesis, the author presents a procedural technique to assess biodiesel industry. That procedure combines problem identification, business modeling, positioning and analysis (using GE/Mc. Kinsey Matrix), simulation, conceptual design and prototyping IT (Information Technology) system.

1.6. Chapter Overview

The chapters are organised as follows:

CHAPTER-1: **Introduction**

This chapter provides preliminary information about the background of the study, problem identification, objectives, methodology, area and scope of research.

CHAPTER-2: **What is Biodiesel?**

This chapter discuss the formal definition of biodiesel, historical perspectives, biodiesel handling-storage and quality assurance.

CHAPTER-3: **Supporting Theories**

This chapter presents supporting theories that undergird the research, e.g. theory of logistics, supply chain, logistics information systems and tracking systems.

CHAPTER-4: **Positioning and Analysis of the World's Biodiesel Industry**

This chapter conducts a positioning and strategic analysis of the world's major biodiesel producer and consumer. The analysis employs the GE/McKinsey Matrix.

CHAPTER-5: **Tools and Master Plan for Efficient Biodiesel Supply Chain**

This chapter proposes simulation tools for biodiesel facility planning, testing and delivery. Moreover, a concept for digitising the biodiesel supply chain governance is also presented. At the end of the chapter, a master plan for Biodiesel Supply Chain is generated.

CHAPTER-6: **Discussion**

This chapter discuss all the previous works in more detail.

CHAPTER-7: **Conclusion and Remarks**

This chapter concludes the research, provides some remarks and formulates the research outlook.

2. What is Biodiesel?

2.1. Historical Perspective

Diesel fuel from vegetable oil has been around for a long time. Vegetable oil has three advantages: it can be easily harvested everywhere, can be renewably produced and environmentally, it has less emission than petroleum.

More than 100 years ago, a brilliant German inventor named Rudolph Diesel designed the original diesel engine using vegetable oil for its fuel at the Paris Exposition of 1900 (Nitschke, 1965). Knothe, the author of "*Biodiesel Handbook"*, on the chapter entitled 'The History of Vegetable Oil-Based Diesel Fuels', added that although the diesel engine was tested at this Paris Exposition using peanut oil, unfortunately, it is still not clear whether the ideas for Rudolf Diesel's original engine came from him personally or by request from the French government, because in reality the results of this research submitted to the French government (Knothe, 2005). He also reported that the French were interested in vegetable oil fuels for diesel engines given its availability in their colonies in Africa, thus it had a potential to reduce the need for liquid fuel or coal import.

In the 1940s, the African countries rose their fearless on self-sufficiency in energy-producing marked by an awareness of diesel engines fuelled by vegetable oils (Knothe, 2005). During World War II, vegetable oils were used as a substitute for diesel fuel. In China, tung oil, and other vegetable oils have been used to produce gasoline and kerosene substitutes, as reported by Cheng (1945) and Chang (1947). Later on, India tried to convert various vegetable oils for diesel engine fuel after being inspired by World War II experiences (Chowhury, 1942). This biodiesel interest has also been seen in the US where the study of cottonseed oil as diesel fuel was performed (Huguenerd, 1951).

Henry Ford, 'the father' of the American automobile-industry also created a 'Soybean Car' in 1941. At that time, Ford was thinking forward by trying to combine the automobile and the farm industry in parallel. According to Benson Ford Research Center, a single experimental soybean car was built, but unfortunately had to be suspended due to World War II. This car was lighter than all cars produced in 1941. Of course this results in better fuel efficiency. However, this soybean-car programme was discontinued after the end of World War II, and serves as a lesson to maintain innovation (Young, 2003).

Meanwhile, in the 1950s, research on biodiesel was driven more by the availability of raw materials, instead of the spirit to reduce consumption of petro-fuel. For example, the US as the top producer of soybean oil used soybean oil as feedstock, while Europe produced a large amount of biodiesel from canola oil. Furthermore, the sources for biodiesel expanded to include animal fat from slaughterhouses (Knothe, 2005). The research on biodiesel feedstock also discovered several new raw materials that could be converted into biodiesel. Since the world oil price crisis which peaked in the 1970s (due to Arab embargo), the desire to use vegetable oil has been getting stronger. Moreover, this has also been supported by a better understanding of the environmental preservation and awareness of the greenhouse effect caused by the use of petro-fuel.

In 1988, the term '**biodiesel**' was first introduced by Wang in his paper entitled: 'Development of biodiesel fuel' (Wang, 1988).

Afterwards, many organisations/institutions have been engaged and excited to develop this vegetable oil called 'biodiesel'. The US-National Biodiesel Board has managed and classified biodiesel as a domestic, renewable fuel for diesel engines. Made from agricultural co-products and by-products such as soybean oil, other natural oils, and greases, it is an advanced biofuel. To be called biodiesel, it must meet the strict quality specifications of ASTM D 6751. Biodiesel can be used in any blend with petroleum diesel fuel. Meanwhile, Europe has made a simpler statement about biodiesel as fuel produced from vegetable oils such as rapeseed oil, sunflower seed oil, soybean oil and also used frying oils (UFO) or animal fats (European Biodiesel Board, 2013). Knothe wrote in more detail about how biodiesel as fuel comes from vegetable oil or animal fat with a chemical reaction termed trans-esterification. In that reaction, the vegetable oil or animal fat reacts in the presence of a catalyst (usually a base) with an alcohol (usually methanol) to give the corresponding alkyl esters (or form ethanol, the methyl esters) of the fatty-acid (FA) mixture that is found in the parent vegetable oil or animal fat (Knothe, 2005). Glycerine is left on the bottom and methyl esters, or biodiesel, is left on top. The glycerine can be used to make soap (or any one of 1600 other products) and the methyl esters are washed and filtered. The resulting biodiesel fuel when used directly in a diesel engine will burn up to 75% cleaner than petroleum diesel fuel (Dermibas, 2002). As demonstrated statistically, the world community's attention towards biodiesel tends to increase year by year. A global market survey released in 2008 named 'Biodiesel 2020: A Global Market Survey' reported that the production and capacity for biodiesel are ready to increase rapidly over years (Figure 2-1). Europe currently represents 80% of global biodiesel consumption and production. Besides that, in the US biodiesel is exponentially produced at a faster rate than Europe. The survey even predicted that biodiesel will be used by 20% of all on-road diesel used in Brazil, Europe, China and India by 2020 (Emerging Markets Online (EMO), 2008).

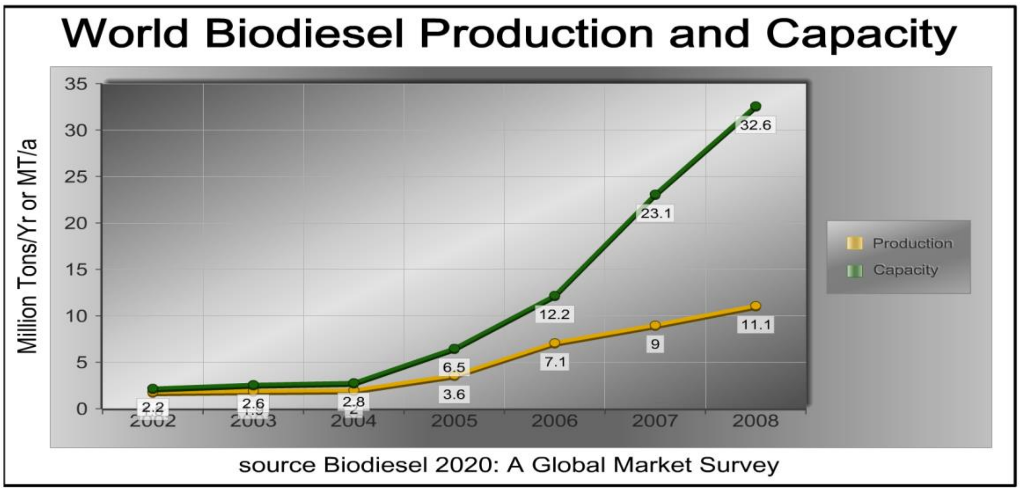


Figure 2-1 World Biodiesel Production and Capacity (Biodiesel 2020: A Global Market Survey)

In order to complete this historical and statistical perspective, biodiesel is also undertaken from the science of biotechnology point of view. In this field, biodiesel is classified as a part of biofuel that is known as solid, liquid or gaseous fuels derived from organic matter (Dragone, 2010). It is generally divided into primary and secondary biofuel. While **primary biofuels** such as fuel-wood are used in an unprocessed form primarily for heating, cooking or electricity production, **secondary biofuels** such as bioethanol and biodiesel are produced by processing biomass and are able to be used in vehicles and various industrial processes (see Figure 2-2). The secondary biofuels can be categorised into three generations: first, second and third generation biofuels on the basis of different parameters, such as the type of processing technology, type of feedstock or their level of development (Nigam, 2010).

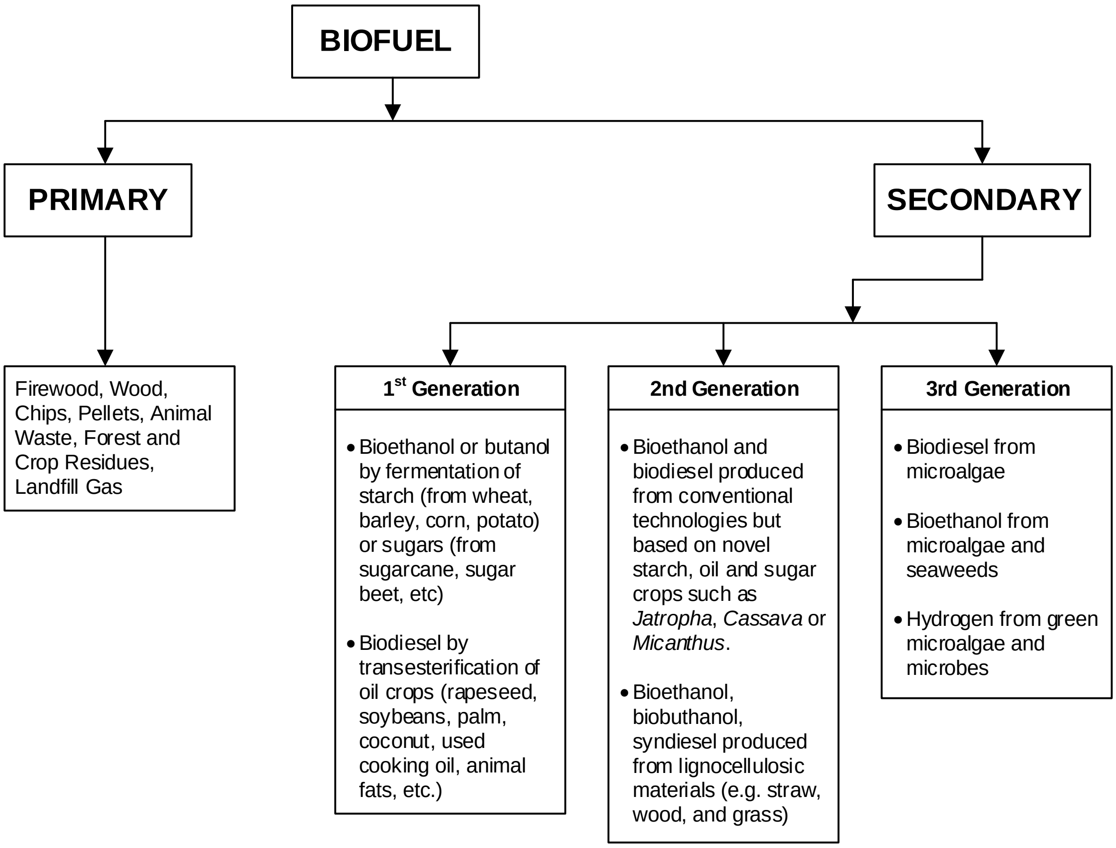


Figure 2-2 Classification of Biofuels (Dragone, 2010)

Biodiesel produced from straight vegetable oils of oleaginous plants by transesterification processes or cracking is another well-known **first-generation biofuel**. Transesterification can use alkaline, acid or enzymatic catalysers and ethanol or methanol, and produces FA (biodiesel) and glycerine as by-products (Escobar, 2009). In the biodiesel production process, a small fraction of plant biomass is used and left as a large fraction of the residue. First-generation fuels are in existence and being produced in significant commercial quantities in a number of countries. The viability of the first-generation biofuels production is, however, questionable because of the conflict with the food supply (Patil, 2008). The advent of **second generation biofuels** is intended to produce fuels from lignocellulosic biomass, the woody part of plants that do not compete with food production. Sources include agricultural residues, forest harvesting residues or wood processing waste such as leaves, straw or wood chips as well as the non-edible components of corn or sugarcane. However, converting the woody biomass into fermentable sugars requires costly technologies involving pre-treatment with special enzymes, meaning that second generation biofuels cannot yet be produced economically on a large scale (Brennan, 2010).

Hereinafter, **third generation biofuels** are developed from microalgae that are considered to be a viable alternative energy resource. It is devoid of the major drawbacks associated with first and second generation biofuels (Nigam & Singh, 2010). Microalgae are able to produce 15–300 times more oil for biodiesel production than traditional crops based on area. Furthermore, as compared with conventional crop plants which are usually harvested once or twice a year, microalgae have a very short harvesting cycle (≈1–10 days depending on the process), allowing multiple or continuous harvests with significantly increased yields (Schenk, et al., 2008).

Regardless of the emerging issues of food security, land constraints and new invention of third-generation biofuels, the first and second-generation biofuels have attained commercial level production. Biodiesel has generally been produced from food and oil crops, as well as animal fats using conventional and advanced technology in several countries (Nigam & Singh, 2010). The Global Biofuels Center ranked the top 25 countries in terms of capacity for biodiesel. The ranking was based on year-end 2010 operating capacities. The US, Germany, Spain, Indonesia and Brazil accounted for the top 5 on biodiesel operating capacity in the world. From the consumer side, the US still dominates the top 5 ranks, followed by Germany, Brazil, France and Spain. Detailed percentages of world biodiesel consumption in 2011 are depicted in Figure 2-3.

In 2011, the total world biodiesel consumption was 414.2 thousand barrels per day. The US used $\frac{1}{7}$ of total biodiesel and Germany used $\frac{1}{9}$ of the world's consumption. Big consumers mostly come from American and European continent countries, which indicate that biodiesel is well accepted in these countries. However, not all countries with large production and consumption get feedstock from their own country. The distribution map of biofuels and feedstock (see Figure 2-4) shows which countries are producing their own raw materials as well as those who import/export.

Some European, central and eastern Asian countries have become a net importer of both feedstock and biofuels, while South America, Southeast Asia, Eastern Europe and North America have become a net importer of both feedstock and biofuels. Several African countries do not produce biofuels but only export feedstock. One thing that is very interesting is Australia/Oceania; they do not have sufficient feedstock but have become a net exporter of biofuels. This means they are importing feedstock for biofuel production and then resell it in its final form.

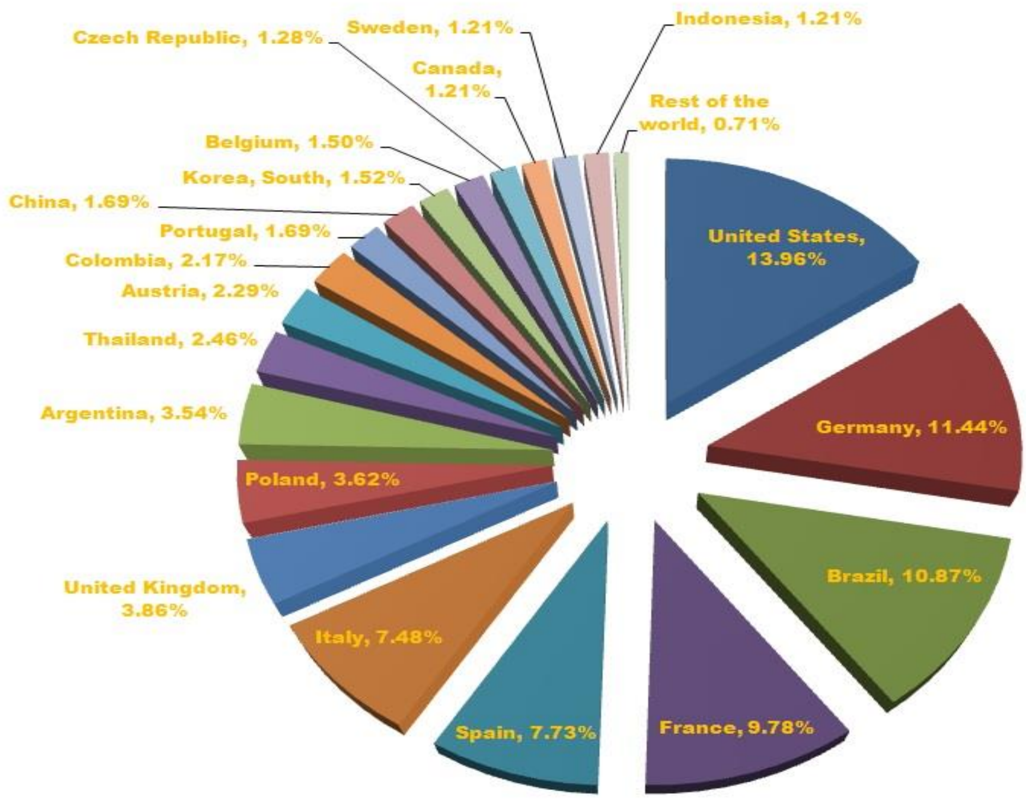


Figure 2-3 World Biodiesel Consumption (generated from (US Energy Information Administration, 2011) data)

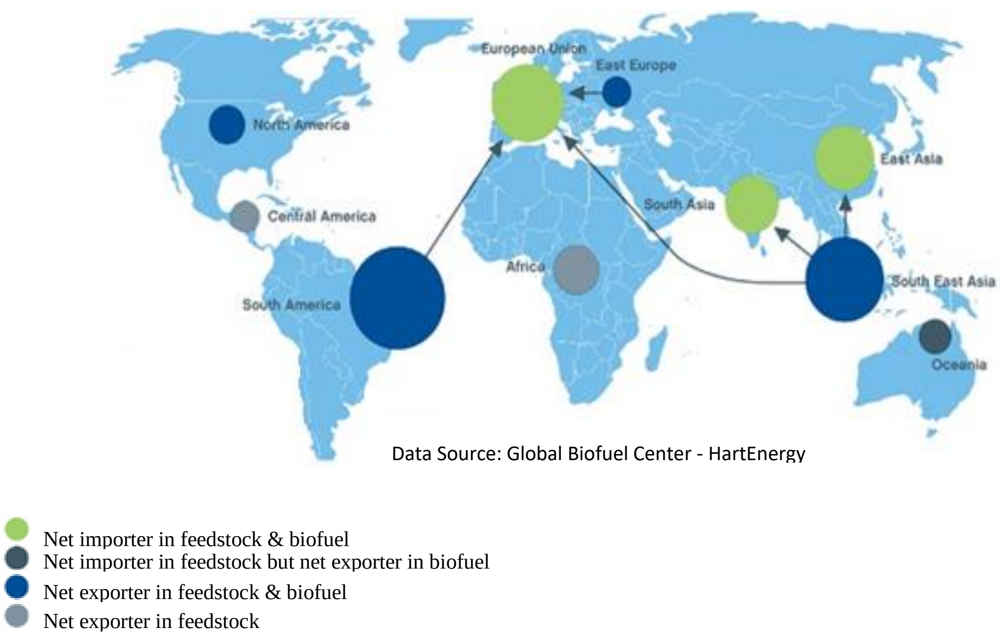
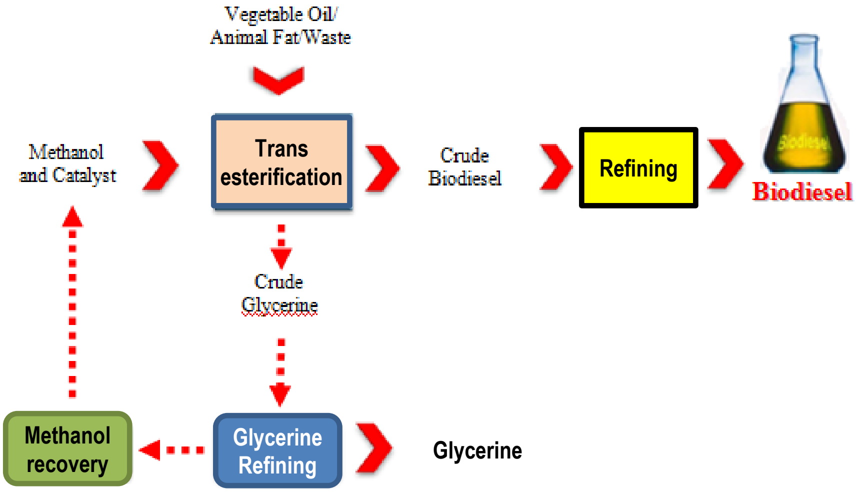


Figure 2-4 International Trade in Feedstock and Biofuel (Neste Oil, 2011)

According to these facts, the importance of arrangements and logistical distribution of biofuels from upstream to downstream are highlighted, including trade management and feedstock supply chain. Biodiesel can be produced with many possible feedstocks, i.e. vegetable oil (soybean oil, cottonseed oil, canola oil), recycled cooking greases or oils such yellow grease, or animal fat (beef tallow, pork lard). That is why biodiesel is called a renewable-energy. Biodiesel also reduces the emission of some pollutants and is environmentally friendly. Biodiesel can be applied in alternative fuel vehicles with certain adaptations to the diesel engine (Knothe, 2005).

The biodiesel fabrication converts oils and fats into chemicals called long-chain mono alkyl esters, or biodiesel. These chemicals are also referred to as FAME and the process is called 'transesterification' (US-National Renewable Energy Laboratory, 2009). Figure 2-5 provides a simplified diagram of the transesterification process



Notes:

- 100 pounds of oil or fat are reacted with 10 pounds of a short-chain alcohol (usually methanol) in the presence of a catalyst (usually sodium hydroxide [NaOH] or potassium hydroxide [KOH]) to form 100 pounds of biodiesel and 10 pounds of glycerin
- Glycerine is a sugar, and is a co-product of the biodiesel process.

Figure 2-5 Basic Transesterification Process (US-National Renewable Energy Laboratory, 2009)

On the implementation level, biodiesel is blended with petro-diesel. Basically, 6% and 20% biodiesel blends can usually be directly used on a diesel machine with minor or no modifications at all. In the world of biodiesel, the abbreviation of 'B' is used to indicate the percentage of biodiesel in a gallon of fuel. So, the composition of 6% and 20% of biodiesel in a blend with petro-diesel is referred to as 'B6' and 'B20'. Pure biodiesel derived from the trans-esterification process is called 'B100'.

2.2. Biodiesel Handling and Storage

Biodiesel handling is not merely a matter of blending and distribution. Processing biodiesel from feedstock cultivation, materialising until being ready to be used by the customer requires a long process. (Energy Alternatives India, 2012) concluded that biofuel (including biodiesel) can be developed through the following stages: 1) Feedstock Production: Plantation of biofuel feedstock, 2) Feedstock Logistics: Gathering feedstock from the area of production, processing it for use in biorefineries, storing it between harvests, and delivering it to the plant gate, 3) Conversion: The feedstocks are processed into biofuel with one or more catalysts, 4) Distribution and Retailing: End product of biofuel is distributed and blended with normal fossil fuels, 5) Consumption: This stage is executed when biofuel enters the fuel tank of a customer's vehicle. Work packages of the 5 stages of biofuel development are depicted in Figure 2-6.

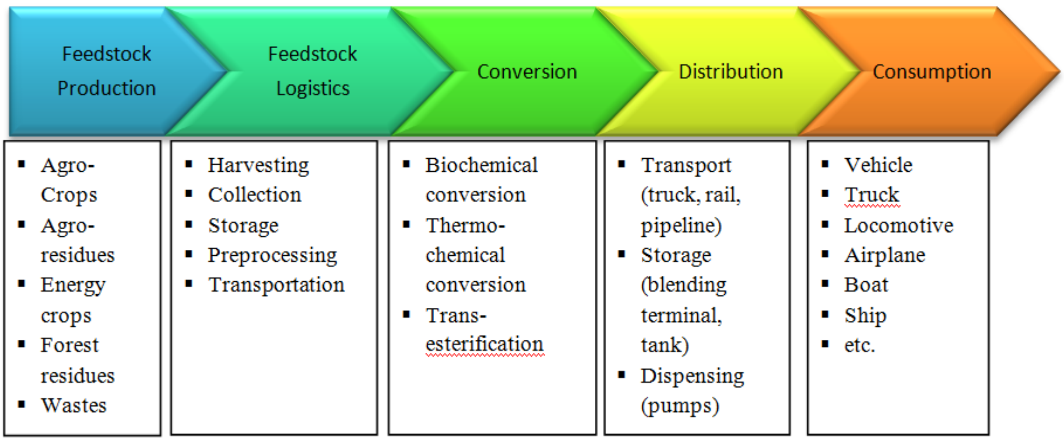


Figure 2-6 Five Stages Biofuel Development (Energy Alternatives India, 2012)

In the conversion and distribution stages, biofuel must have special handling before being consumed. It should be kept at a certain temperature, in a proper container and avoid several 'forbidden' things.

2.2.1. Temperature Properties

Biodiesel has low temperature properties. It can freeze or become gel as the temperature drops. This condition happens also for petro-diesel, but not in gasoline. Countries that have extreme winters should change their diesel content in very cold situations. It is a concern that the regular content of diesel will turn into gel in extreme winter conditions. Gel tends to clog the filter and dispensing equipment, thus the fuel cannot be pumped into the combustion chamber. B100 is commonly stored in heated above-ground tanks for blending in winter. Important temperature performance metrics for handling and blending of B100 are described as follows: 1) Flash point. A minimum flash point for diesel fuel is required for fire safety. B100's flash point is required to be at least 93ºC (200ºF) to ensure it is classified as non-hazardous under the National Fire Protection Association (NFPA) code; 2) Cloud point. This is the most commonly used measure of low-temperature operability; fuels are generally expected to operate at temperatures as low as their cloud point. The B100 cloud point is typically higher than the cloud point of conventional diesel. Cloud point must be reported to indicate biodiesel's effect on the final blend cloud point. Low-temperature properties and strategies for ensuring good low-temperature performance of biodiesel blends are discussed in more detail in later sections; 3) Pour point. The temperature at which the fuel contains so many agglomerated crystals that it is essentially a gel and will no longer flow. Distributors and blenders use pour point as an indicator of whether the fuel can be pumped, if it would not be suitable for use without heating or taking other steps.

2.2.2. Stability

This section will specifically discuss the stability of biodiesel during transport and storage. Referring to Figure 2-6, this biodiesel development stage is called the distribution phase. Actually, biodiesel will automatically degrade over time after being produced. But the most critical stage occurs during the distribution phase. Pure biodiesel is called FAME. FAME is one of the FA alkyl chains that contains varying numbers of double bonds.

Normally these double bonds are in an allylic configuration, which means that they are spaced by a single methylene group called a 'bis-allylic' carbon. Usually, common feedstocks, such as oils from soy, rapeseed, and palm, as well as lard and tallow, the FA chains contain primarily 16 or 18 carbon atoms and from zero to three double bonds.

Eighteen-carbon (C18) chains comprise one double bond for oleic acid, two for linoleic acid, and three for linolenic acid. Cosgrove et al. (1987) reported that the di- and tri-unsaturated FAs contain the most reactive sites for initiating the auto-oxidation chain reaction sequence. Thus, oxidation rates for these C18 esters are (Cosgrove,1987):

linolenic > linoleic >> oleic

Another argument (Knothe, 2005) states that the oxidation rate corresponding to the total number of bis-allylic sites (the methylene CH directly adjacent to the two double bonds) is not correlated with the total number of double bonds. Frankel (2005) and Waynick (2005) also agreed that bis-allylic sites have a strong possibility for the formation of free radicals that can directly be influenced by oxygen to form peroxide radicals. Such a condition will trigger a classic auto-oxidation mechanism. During transport and storage, this auto-oxidation mechanism could be exacerbated by external factors.

2.2.3. External Influences

Several external factors influence and accelerate biodiesel degradation, including microbial, materials or by processing and storage conditions. Microorganisms are reported to metabolise hydrocarbons contained in conventional fuels and particularly in diesel/biodiesel (Dodos, 2011). Micro-organisms' growth in the petroleum hydrocarbons was first reported in the last decade of the 19th century. However, the contamination problems and implications have started to raise concerns in the 1950s. At that time the U.S.A. Air Force confronted extended microbial contamination of the JP-4 jet fuel. The climax was a B-52 crash that was directly attributed to the clogging of fuel system screens and filters due to microbial growth (Miyoshi, 1985) (Graef, 2003). Distillation processes sterilise the fuel, tank situation, transport and fuel supply chain which may lead to microbial growth. Through these conditions, microbes find water as well as nutrients. An aquatic environment is the perfect place for microbial growth and proliferation. Microbiological action can deteriorate the quality of the fuel by creating poor oxidation stability and acidity. Empirical experience has indicated that an increasing number of cases of microbial contamination are reported by consumers who complain about tank clogging problems and sedimentation. All of these problems are associated with microbiological activities. Biocides are usually used for conventional and biodiesel fuels wherever biological growth in the fuel has been a problem. Copper, brass, bronze, lead, tin, and zinc have been tested and proven to accelerate the degradation process, creating fuel insolubles or gels and salts. The process even causes a high level of sedimentation. B100 should not be stored for long periods in systems that contain metals (US-National Renewable Energy Laboratory, 2009).

Long contact with some hoses, gaskets, seals, elastomers, glues, and plastics could make B100 deteriorate, soften, or seep. Teflon, Viton, and Nylon have very little influence on biodiesel degradation and are among the materials that can be used to update incompatible equipment. Acceptable storage tank materials include aluminium, steel, fluorinated polyethylene, fluorinated polypropylene, Teflon, and most fibre-glasses. Biodiesel tank storage must consider these materials. Lead solders and zinc linings should be avoided, as should copper pipes, brass regulators, and copper fittings. Affected equipment should be replaced with stainless steel, carbon steel, or aluminium (National Biodiesel Board, 2002). Water contamination is another issue with biodiesel storage. Since water dissolved in the biodiesel promotes microbial growth in biodiesel storage tank, water is undesired in the biodiesel. Excessive water contained in biodiesel fuels can also cause engine surface corrosion and wear. Water is much more soluble in pure biodiesel than petroleum diesel, so B100 should be stored in clean and dry tanks (US-National Renewable Energy Laboratory, 2009). Biodiesel oxidation stability can be worse during manufacture, handling and storage. This condition is known as pro-oxidising. The parameters which have been proven as pro-oxidising boosters include exposure to air, heat, light and metals influenced by the nature of the storage container (Pullen & Saeed, 2012). Knothe (2005) also wrote that the presence of air and elevated temperatures usually facilitate oxidation, due to the presence of peroxides or metals (radical initiators) (Knothe, 2007).

2.2.4. Biodiesel Blends

Biodiesel blend means that petro-diesel and biodiesel are mixed at any level of proportion. As mentioned at the beginning of chapter 2, the letter 'B' followed by numbers is the indicated proportion of biodiesel to petro-diesel. B5 biodiesel is 5% biodiesel to 95% petro-diesel and B20 is 20% biodiesel to 80% petro-diesel. B99 is biodiesel with 1% petroleum diesel added. B100 is not a biodiesel blend but 100% pure biodiesel. There are some reasons why biodiesel has to be blended. First, most vehicles and manufacturers are only allowing a biodiesel blend to be used. Some of them permit B5 and B20 utilisation on their machines and some manufacturers even only approve of low levels of biodiesel. Manufacturers will not honour a warranty when the customer violates this provision. Secondly, the machines need some adaptations before running on pure biodiesel. It is more safe if the biodiesel content is increased gradually. Another argumentation is because of government regulation. Some countries like Indonesia have made a rule and all of them have mandated biodiesel utilisation gradually or step by step starting from a minimum percentage of biodiesel. Low level biodiesel blend is specified as biodiesel concentration up to 5%. ASTM International, formerly known as the American Society for Testing and Materials (ASTM), an international voluntary consensus standard, developed ASTM D975 that approves a low level concentration of biodiesel like B5 for safe operation in any petro-diesel engine. Another alternative of biodiesel blend is B20 (20% biodiesel, 80% petroleum diesel). This kind of blending is the most common biodiesel blend in the US. B20 is popular because it represents a good balance of cost, emissions, cold-weather performance, materials compatibility, and ability to act as a solvent. Using B20 provides substantial benefits and avoids many of the cold-weather performance and material compatibility concerns associated with B100. Most biodiesel users purchase B20 or lower blends from their petroleum distributors or biodiesel marketers. Biodiesel blends of 20% (B20) or higher qualify for biodiesel fuel use credits under the Energy Policy Act of 1992.

B20 and lower-level blends generally do not require engine modifications. Engines operating on B20 have similar fuel consumption, horsepower, and torque compared to engines running on petroleum diesel. B20 has a higher cetane number (a measure of the ignition value of diesel fuel) and higher lubricity (the ability to lubricate fuel pumps and fuel injectors) than petroleum diesel.

2.3. Biodiesel Quality Assurance

Biodiesel is a synthetic bio-product which is more prone to environmental (external) influences and easily auto-oxidised as well. Therefore, quality management issues also become important in addition to production. Poor quality biodiesel can cause short- and long-term engine and equipment problems. At the beginning of biodiesel mass-production, many terrible experiences and technical problems with biodiesel utilisation emerged including filter plugging, fuel gelling, etc.

In order to avoid those problems, several countries developed their own basic chemistry of biodiesel production, fuel quality testing, diesel equipment mechanics and fuel system problems into a certain quality standard. General parts of the standards are similar, but in some cases they are specifically designed to the countries or areas with primary feedstock and the temperature zone of the area. Some examples of these standards are listed in Appendix 1: International Biodiesel Testing Standard.

3. Supporting Theories

3.1. Logistics and Supply Chain

3.1.1. Terms and Definitions

Inevitably, companies have to move their materials or products. Suppliers gather raw materials from sources that later have to be transported to the manufacturers. On the other hand, after production, manufacturers deliver the finished product to the distribution centre which spreads the product to the wholesaler who then delivers to retailers in their area. The product can be a good or service. Logistics concerns this area of implementation.

Logistics engineering is derived from systems engineering and is engaged in the scientific matter of transport, storage, distribution, purchasing and warehousing of materials and finished goods. Logistics generates value using efficiency and customer satisfaction despite being profit oriented as well. The value will easily disappear when the customer loses satisfaction. Logistics activities serve the end customer, which can include another process or work centre inside the manufacturing facility, a warehouse where items are stocked or the final customer who will use or buy the product. Another term which is very similar is called logistics management. Council of Supply Chain Management Professionals (CSCMP) defines logistics management as a part of the supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements (CSCMP, 2011).

Figure 3-1 Logistic Operations (Waters, 2002)

Logistics engineering deals with technical elements while logistics management concerns anything governing logistical activities. There are some operations that have to create companies in order to create and move their materials or products. Such operations will convert multiple inputs into certain products, as shown in Figure 3-1. The inputs could be raw materials, components, people, equipment, information, money and other resources. Operations might be manufacturing, serving, transporting, selling, training etc. The main outputs are usually goods and/or services (Waters, 2002).

Many studies distinguish these operations into two types of logistical roles called inbound logistics and outbound logistics. The inbound logistics manages the movement of materials from suppliers into the companies and outbound logistics is responsible for physical distribution out to customers (see Figure 3-2).

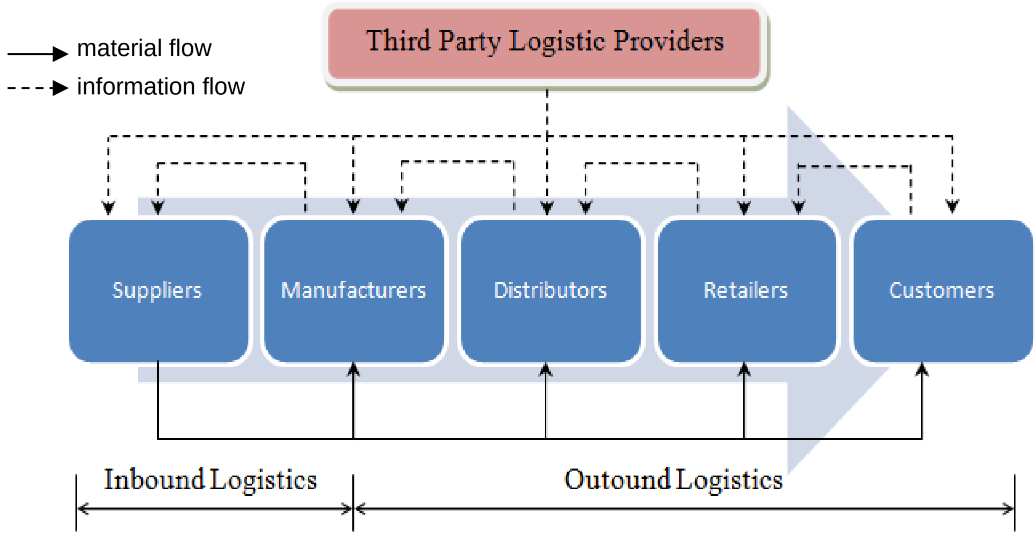


Figure 3-2 Logistics Role (Waters, 2002)

Logistics can also be viewed as a system. Customers expect such systems that ensure a service of the right goods/services in the right quantities, in the right condition are delivered to the right place, at the right time for the right cost. In the logistics field, these are called 'the six rights' (USAID-DELIVER PROJECT, 1998; Voortman, 2004). Even though the system supplies goods (e.g. groceries, clothing, household, electronics, etc.) or services (e.g. hotels, travel agent, mail services, 3PL etc.), these six rights have to be applied. Logistics management serves many activities that support the six rights of logistics. Through many empirical and research activities, logistics experts have finally developed a perfect diagram to illustrate the relationship between many activities in a logistics system. This diagram is called the logistics cycle (see Figure 3-3)

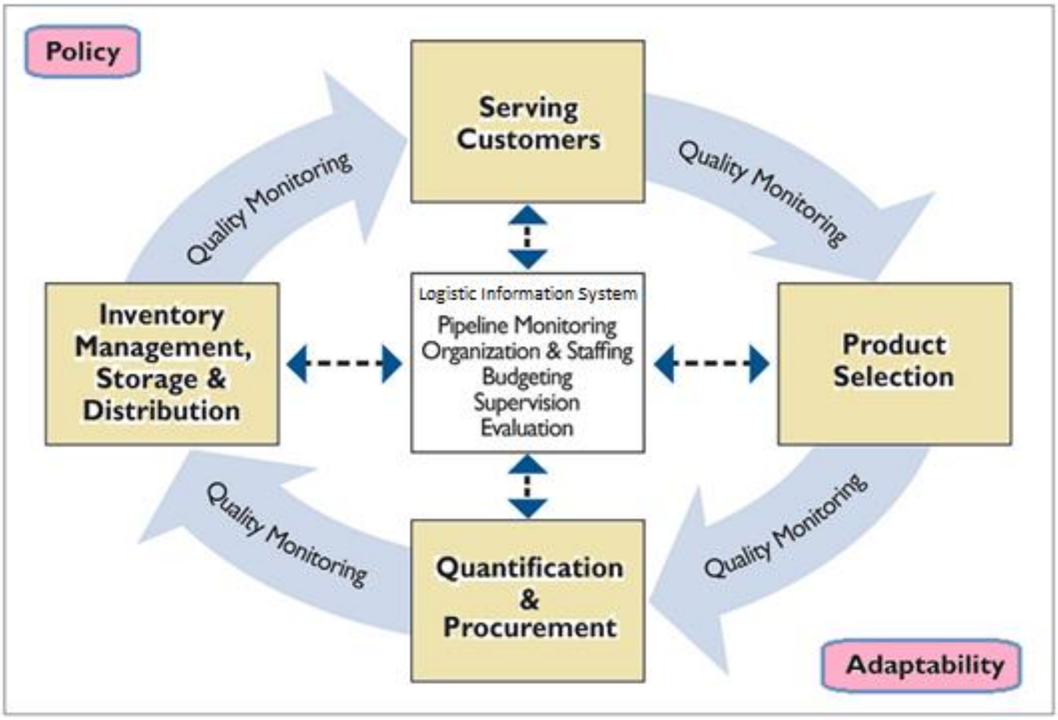


Figure 3-3 The Logistics Cycles ((USAID-DELIVER PROJECT, 1998))

The system is represented as a 'cycle' because it occurs in repetitive ways. Each domain in these activities is dependent on each other. Inventory management, storage and distribution are executed based on good quantification and procurement. On the other hand, product selection is affected by serving the customer. Nobody sells products that are not desired by customers.

The centre of the cycle represents the six activities of the management level in order to support the system. They collect data around the cycle domains, inform and arrange some implications to the other elements around the logistics cycle. They can make decisions or create a policy and sometimes have to adapt to the situation.

However, in real life there is no company that can be independent in their business. Sometimes they act as a buyer and on the other side they become a seller. Manufacturers buy raw materials from suppliers but on the other side manufacturers sells product to wholesalers. Suppliers can also be a buyer when they buy each raw material from the retail source or farmer. The chocolate industry creates the product from other materials, e.g. cocoa, sugar, milk and peanuts. Each material has a connection to many firms before they can supply the chocolate industry. This creates multiple relationships between industries. Every product moves through a series of chains before turning into final goods.

These chains are named differently specifically referring to the activities and organisations. For the company which undertakes an operation style of business, the chain is called a ‘process’; but if the company tends to market something, it is called a ‘logistics channel’. Sometimes, a value added is significantly seen, then the chain is usually called a ‘value chain’.

Supply Chain Management (SCM) is defined by the CSCMP as: ‘Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, SCM integrates supply and demand management within and across companies. SCM is an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes all of the logistics management activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, finance and information technology (CSCMP, 2014)’. Peter Drucker (1998) wrote in Forbes Magazine, that modern business management has shifted from individual businesses into supply chains. Business management has begun the era of inter-network competition. The business success will depend on the manager's skill to integrate the company's network of business relationships (Drucker, 1998).

In order to study the art of the supply chain, first of all, let us assume that a good move in a single company. Intake materials from suppliers to the company are called ‘upstream activities’ and then moving goods from the company to the customers are called ‘downstream activities’. Figure 3-4 shows the activity of a three tier supplier and customers. A manufacturer would assume sub-assembly providers as first tier suppliers, component makers as second tier suppliers, materials suppliers as third tier suppliers, and so on. On the other side, a manufacturer can consider wholesalers as first tier customers, retailers as second tier customers, and end users as third tier customers (Waters, 2002)

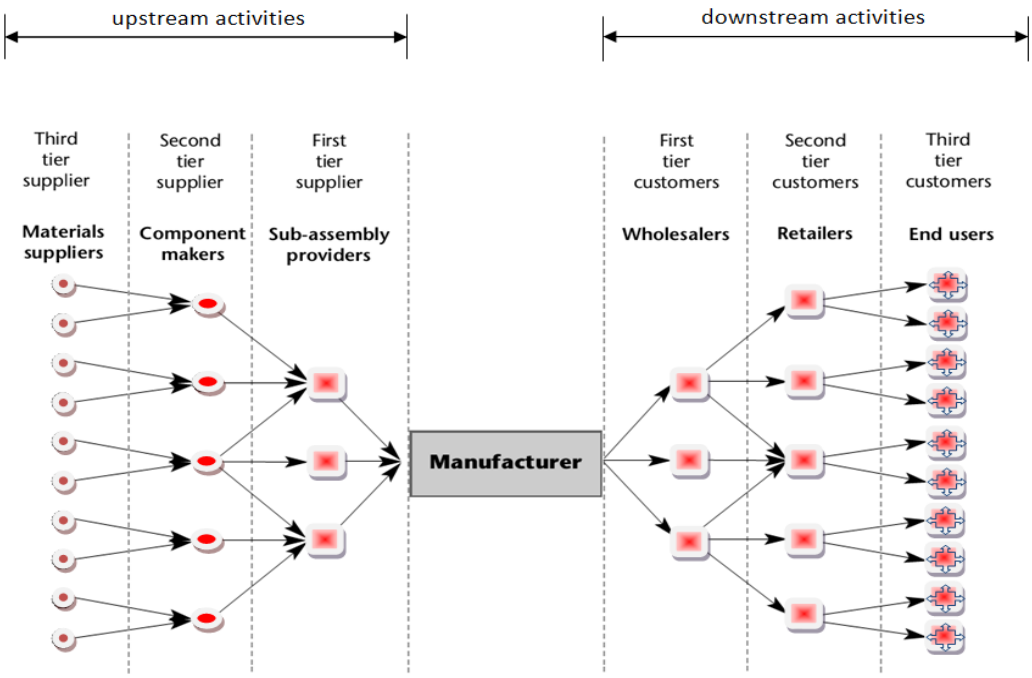


Figure 3-4 Activities in a Supply Chain (Waters, 2002)

Figure 3-4 is shown only to illustrate the theory of supply chain. Although the good is described on a simply flows in and out of the manufacturer, after the operations, a product also sale using parallel marketing channels mean that supply chains also diverge into separate downstream strands. Thus, the same product can follow different routes to different types of customer. For example, a PC Display or montior. It producer is dealing with PC (Personal Computer) manufacturer. Besides that, they also sell their product to wholesaler, retail shops, computer-shop and online shop (direct selling). But uniquely, the monitor itself also coming through its own supply chain as well. They consist of LCD (Liquid Crystal Display) or LED (Light Emitting Diode), switch, power-module, cable and casing. Each component is supplied by separate suppliers. In fact, almost supply chains follow this general pattern, each product has its own unique chains and they come in a huge variety of different shapes and sizes. (Lambert, 2000, p. 65) reported on his research: “Successful supply chain management requires cross-functional integration and marketing must play a critical role. The challenge is to determine how to successfully accomplish this integration.”

Essentially, a supply chain consists of 4 pillars, i.e. purchasing, operations, distribution, and integration. As we know, supply chain begins with **purchasing**. Purchasing managers usually manage which products are needed by their company. They list sourcing products from suppliers, vendors, and then procure products from vendors at prices and terms that meets profitability goals.

Supply chain **operations** deal with demand planning, forecasting, and inventory management. Customer demand for certain products during a specific period is forecasted by historical data and marketing strategy. Several drivers that are influenced, e.g. forthcoming sale, big promotion or trend product offering, determine the demand and are needed to develop accurate forecasts and manage inventory. Forecasts are suited to levels of inventory, thus distribution centres have an exact stock. Besides that, using forecasting, inventory can supply stores with a sufficient amount of product to meet demand. This allows companies to minimise inventory costs while still meeting customer needs.

The **distribution** of the supply chain means the product moves from warehouses or manufacturing plants to stores and finally to customers.

Supply chain **integration** refers to the practice of developing a collaborative workflow among all departments and components involved in the supply chain to maximise efficiencies and build a lean supply chain.

3.1.2. Logistics Information System

The logistics cycle as explained in Figure 3-3 comprises six activities at the management level in the centre of the cycle. Both in fact or theory, there is one thing that is most important for all six activities, i.e. ‘Logistics Information Systems’. Information is the engine that drives the logistics cycle; without information, the logistics system would not run smoothly. Information is the ‘heart’ of logistics. The cycle is started by gathering information about each activity in the system and analysing that information to make decisions and coordinate future actions. For instance, information about product consumption and inventory levels have to be known to ensure that a manager knows how much of a product to procure. As described at the beginning of chapter 3, CSCMP defines logistic management as a part of the SCM that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and **related information** between the point of origin and the point of consumption in order to meet customers’ requirements (CSCMP, 2011).

From that definition, logistics will be associated with the activities of:

1. Planning, implementing and controlling;
2. Movement and storage of goods or services;
3. **Management information.**

We can see that logistics information is very important so that must be included in the definition. Moreover, logistics evolves to not only serve a single entity but rathernetworks. A supply chain as explained before can be seen as a network of logistics. In such networks, there are three types of flows, i.e. physical product, money and information flow. Thus, information again becomes a key point of this network. Logistics scientists have been aware of this and many papers about it can be summed up in the following section.

A supply chain has the primary responsibilities of linking major business functions and business processes within and across companies, into a cohesive and high-performing business model. Thus, SCM drives the coordination of activities across areas of marketing, sales, product design, finance and information technology (Eltantawy, 2006; Simchi-Levi, 2008). Information systems are an important enabler of effective SCM, since with the advent of e-business, if there is no effective web-based information system in place, there is essentially no business. Any company, though, can benefit from the successful implementation of SCM using different information systems options, including enterprise resource planning (ERP) and decision support systems (DSS) that are aimed towards assisting the different functional areas in a supply chain (Wang, 2010).

SCM is considered the 21st century global operations strategy for achieving organisational competitiveness and requires an integrated set of information systems for sharing and processing information on various value-adding activities along the supply chain. As a result, information technology has assumed a critical and strategic role in organisations (Compass Group, 1999). Within this context, organisations are attempting to find ways to improve their flexibility and responsiveness and in turn competitiveness by changing their operations strategy, methods and technologies that include the implementation of SCM and of information technology (Gunasekaran & Nhai, 2004).

3.1.3. Storage, Handling and Distribution

The theory of storage and distribution becomes very important to the research topic. Most of this discussion will more or less intersect with storage and distribution. Goods can be stored at every facility in the supply chain. The people around the supply chain are responsible for product storage. Storage ensures the physical integrity and safety of products and their packaging, throughout the various storage facilities, until they are handed over to the customer. An important goal in storage of fuel products is the correct expiration calculation of fuel products to ensure that orders can meet quality standards. Regardless of storage facility size, from a small storage to a central warehouse, the main operational activities for storage are usually similar. The complexity of storage only slightly differs based on the volume of the products and special treatment requirements, for instance, biodiesel storage needs extraordinary precaution before the degradation phase. In the case of biodiesel, storage is needed for the phase from raw material procurement, production and distribution of goods. Handling of raw materials and work-in progress occur until the finished products. Sometimes, the storage point in the warehouse becomes a dispatch point serving the next customer in the chain; they are critical to the provision of high customer service levels. Therefore, the warehouse is an integral part of the storage system that can affect market volatility, product range growth and shortening customer lead times. The storage activities are categorised (USAID-DELIVER PROJECT, 1998) into four important steps: material receiving and incoming inspection, put away, picking and packing and shipping.

Material receiving and incoming inspection manage activities during the unloading of vehicles (Figure 3-5). Thus, it includes the visual inspection of delivered packages to ensure that products were not damaged during transport. The quantities of products received compared to the packing slip or shipping invoice must also be considered (report any discrepancy).

Figure 3-5 Illustration of Material Receiving and Inspection (Pierce, 2011)

Put away is a process including moving products from the unloading dock, or receiving area, after they are released for storage, and assigning them to their designated storage area (rack, shelf, etc.). It is important that every product moved into or out of the racks, shelves, or any storage area is correctly recorded on the stock-keeping records (see Figure 3-6). An inventory control system could be employed to manage this.

Figure 3-6 Moving Product to the Rack (Chronos Process Integration Sdn Bhd , 2011)

Picking and packing include the operations of filling shipping requests or picking lists (Figure 3-7). The products must be located, pulled from inventory, and prepared for shipment. In some cases, products need to be packed into shipment containers or palletised; and, sometimes, bundled with other products into kits before being shipped. When any packing or repacking activity takes place, the new package must be labelled correctly.

Figure 3-7 Packing Illustration (University of Florida, 2002)

Shipping is the process of delivering the product (Figure 3-8). In order to guarantee good shipping accuracy, the list of products and their quantities must be checked against shipping orders, or requests, prior to preparing the required shipping documents and loading of the cargo for transport. To avoid damage during transit, products must be arranged and secured within the vehicle using the requirements and conditions for adequate loading and transport

Figure 3-8 Shipping Illustration (Chiang & Standing, 2013)

3.1.4. Liquid Logistics

General logistics were discussed previously. Since this research is focused on biodiesel distribution, it is important to discuss 'liquid logistics'. Most products have liquid components or ingredients. Sometimes, companies use direct liquids, like the industry of petroleum, food products, chemicals, beverages, cooking oils etc. But liquids can also be used indirectly to support most businesses on the planet. Liquids are used to lubricate the machines of production, to clean the production or office facilities of industrial companies and to paint/colour their building. Liquids are consumed as well, both directly in the form of beverages and also in the liquid ingredients contained in most food products. Finally, every business is dependent on fuels and lubricants to transport their products.

Unfortunately, only a few people talk about liquid logistics and there are not as many people listening. Logistics for liquids not only comprise the movement of the fluid but also the movement of the package and identifying the usual form of 'packaging'. Wally Klatch (2005), the author of 'Supply Chain for Liquids' reported that in over four billion web pages, he searched for the phrase 'supply chain for liquids' and it did not appear once! If life means appearing in Google and death means being a broken link, what does non-appearance mean? Even the phrase 'supply chain for dummies' appears twice. Do liquids matter less than dummies?

However, liquids need special treatment in the logistics business. For the term 'supply chain', liquid entails a very different way of thinking. Liquids are usually carried in containers such as barrels, gallon-bottles or jugs and then, for all intents and purposes, that container is treated like solid logistics until the user pours the liquid out of the container and uses it. The whole logistics process is based on the conversion of the liquid to a solid (container), with all handling, inventorying, transporting, and finally use by pouring it directly to the customer at the retailer. In some cases, the customer also takes a small 1 litre bottle as the ultimate product to be bought (e.g. cooking oil, beverage) instead of a poured product like beer, lubricant, petroleum or diesel. The liquid stream needs a very distinctive approach from the movement of solids in a chain connection. An optimal supply chain for liquids is not merely an adaptation of an 'ordinary' supply chain, it is an integrated system whose elements take advantage of the liquid nature of the product which cannot be done with solid products.

There are special characteristics of logistics for liquid products that should be taken into account (adopted from Klatch, 2005):

- The liquid should flow directly to the point at which it is to be used, with no need for additional effort by the user.
- Liquids can be flowing and filling the shape of the container which provides a great deal of flexibility in the design of storage systems. It also fills in the 'dead' space for storage. Based on that nature, the level of a liquid as it settles in a tank may be used to automatically and continuously know the quantity of liquid in the tank.
- Liquids should be treated as a flow rather than as individual, identifiable units. This characteristic should be used to the greatest benefit of the logistics flow.
- A supply stream of liquid logistics can include two or more forms of logistics based on the characteristics of the different segments of the stream.
- Logistics methods can incorporate multiple capabilities that can be used in different ways, such as with railroad tank cars, liquid containers or pipelines.
- Liquid-logistics principles can be applied to certain types of non-liquid materials that have flow and other characteristics similar to liquids.
- Liquids are flowing from a higher level to a lower level. Thus, the ability to move the liquids without mechanical propulsion or manual intervention should be considered.
- Liquids provide indications through changes in their characteristics that may be sensed and translated into measures of the quality of the liquid.
- Many security and safety risks are significantly reduced or eliminated using liquid logistics techniques. Tools such as liquid level sensors and flow meters can be useful in reducing security risk by providing direct, near real-time and accurate measurements of the product's movement and balance along the supply-chain flow. The safety risk is reduced as the product is independently controlled and moved through the process of supply stream.
- Liquids may in some cases be 'processed' well downstream from the original production facility and thus offer the opportunity for improved efficiencies throughout the supply stream together with more flexibility as to the nature of the product at the point of final usage.

- Information regarding inventory balances should be readily available to the user or, better, be transmitted directly to the supplier for replenishment action. Close control and reporting usage, including quantity and other meaningful user/usage data, should emanate from as close to the point of usage as possible.

The comparison of a traditional supply chain, adapted supply chain, typical and optimal supply chain for liquid configuration are discussed in detail in Appendix 2.

3.2. Tracking System

The necessity of visibility and transparency through business flow has rapidly grown in the last decade. Increasing needs for mobility, performance monitoring and energy efficiency have encouraged business players to track their works in all circumstances. Either using desktop applications or wireless technology people can track and monitor their business in real time. This technique is called 'information system based on geo-location'. Such information systems are supported by 'geographic information system' or 'GIS'.

3.2.1. Geo Information System using GPS

In the 1990s, the digital map was very popular. Along with the development of internet technology, the web-map appeared as the new option for information systems. Mapping technology on the internet was spreading very rapidly due to its flexibility, being easy to distribute, interactive and the possibility to combine with multimedia applications. 'Geo-information' is an abbreviation of 'geographic information' and refers to spatial information. Spatial information is information about objects, facts and processes that are linked with a specific geographical position on earth. It is estimated that about 80% of all information contains a direct or indirect spatial link/reference (Adams, 2010).

Several decades ago, spatial data collecting and editing took substantial time. Besides that, manual works contained many errors. Spatial data was usually obtainable by field mapping and involved many map sheets. Manual editing and database process could take months or years. Certainly, this process can make the data no longer up-to-date. With modern technology and the internet, the field mapping process has become easier and fun. Field workers use Global Positioning System (GPS) devices to record the coordinate objects that are mapped. The result is synchronised to the digital map that is already taken by satellite on the GPS device. Distribution points of the objects that are recorded will create a line or a mark that appears on the digital satellite map. Editing and creating databases only take weeks, one day, or even hours. The most important feature of this new approach is that the acquired data recorded can easily be modified, subtracted or added later. With just a few touches, a new record can easily be added or removed.

The basic system is built upon GPS which is connected with satellites to monitor the movements of the containers. GPS is a positioning, navigation, and timing (PNT) system owned by the US government. The technical and official explanation of GPS is given by the US government on their web-page: http://www.gps.gov/.

The GPS system consists of three segments: the space segment, the control segment, and the user segment. The US Air Force develops, maintains, and operates the space and control segments (US-Official (NOAA), 2013)

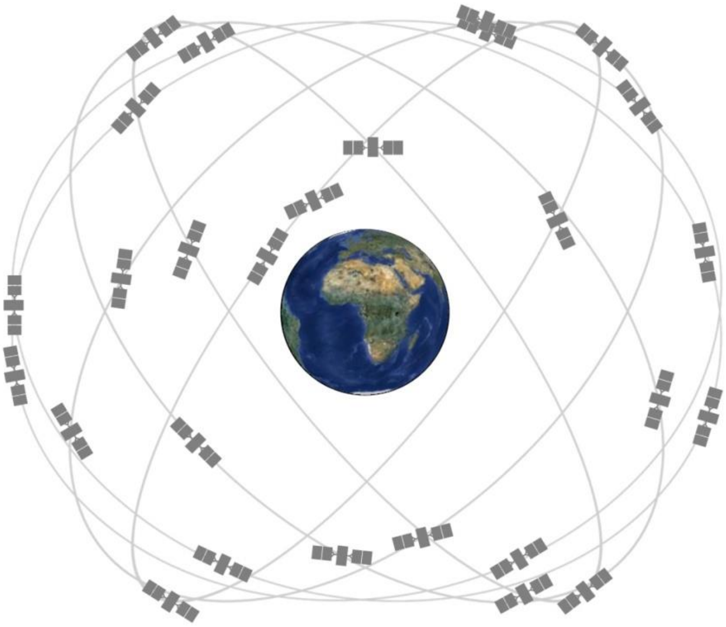


Figure 3-9 Satellite Constellation (US-Official (NOAA), 2013)

GPS ‘space-segment’ is defined as a constellation of satellites transmitting radio signals to users. The US Air Force manages the constellation to ensure the availability of at least 24 GPS satellites, 95% of the time. For the past several years, the Air Force has been flying 31 operational GPS satellites, plus 3-4 decommissioned satellites (‘residuals’) that can be reactivated if needed.

GPS satellites are put on Medium Earth Orbit (MEO) at an altitude of approximately 20,200 km. Each satellite circles the Earth twice a day. Figure 3-9 shows the six orbital planes of the constellation and expandable to 24-Slot satellite constellation with six equally-spaced orbital planes surrounding the Earth configured in the GPS satellite constellation. Each plane contains four "slots" occupied by baseline satellites. This 24-slot arrangement ensures there are at least four satellites in view from virtually any point on the planet. The US Air Force usually flies more than 24 GPS satellites to maintain coverage and the baseline satellites are serviced or decommissioned.

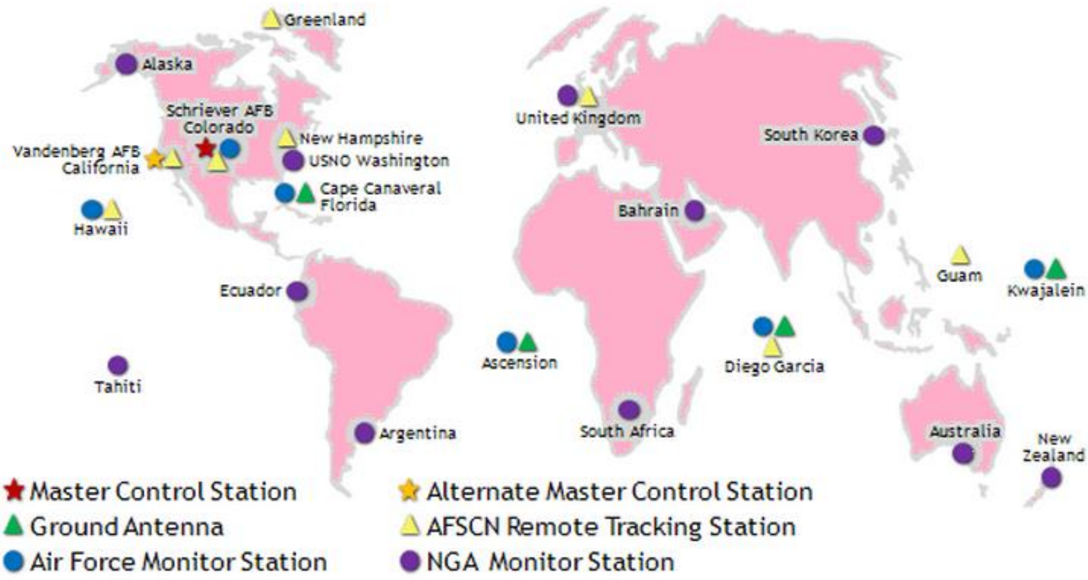


Figure 3-10 GPS Control-Segment

The extra satellites may increase GPS performance but are not considered part of the core constellation. In June 2011, the Air Force successfully completed a GPS constellation expansion known as the "Expandable 24" configuration. Three of the 24 slots were expanded, and six satellites were repositioned, so that three of the extra satellites became part of the constellation baseline. As a result, GPS now effectively operates as a 27-slot constellation with improved coverage in most parts of the world. Concurrently, there is a global network of ground facilities that track the GPS satellites, monitor their transmissions, perform analyses, and send commands and data to the constellation. These facilities are known as 'control-segment'. Control segment operates a master control station, an alternate master control station, 12 command and control antennas, and 16 monitoring sites. The locations of these facilities are depicted in Figure 3-10.

The User Segment is the phrase given to all of the receivers listening to the satellites at any time. There is no organisation to the User Segment; it consists of the receiver currently in use and its associated antenna. The user receivers are passive, they need only listen to the Space Segment and not broadcast anything, thus making the system accessible to any number of users at one time without users interfering with each other.

In the presence of these 24 satellite, the entire surface of earth can be observed anytime. Positioning signal is always emitted by GPS satellite. Somebody can track his/her position by determining latitude and longitude of the point where he/she stands using a GPS receiver. Moreover, GPS satellites also have the ability to calculate velocity, direction, distance and time of measurement.

3.2.2. GIS Technology at a Glance

The World's population is growing very fast and of course each resident requires basic needs such as energy, clothing, food, water, housing, etc. These demographic changes will inevitably affect the layout and geography of the earth. Not only because of the spread of the population but also approximately 7 billion humans are behaving. Human actions are significantly affecting nature. This condition is quickly changing our climate, biodiversity of the planet and ecosystems that support human life as well as the shape of the earth. The land that used to be rice fields, fields and irrigation has turned into housing. Forests as the lungs of the world are converted into plantations. These changes in turn affect our economy, security and sustainability. That is why knowledge that visualises our world and geospatial workflows that manage our vision are needed. GIS is systematically organising geographic knowledge into easily shareable information. This sharing of knowledge can be used to monitor any changes all over the world. GIS stands for Geographic Information System or Geographic Information Science. GIS is one of three geospatial technologies; the other two are Global Positioning Technology (GPS) as discussed above and the last one is Remote Sensing. Many scientists and institutions have tried to define GIS and there are common phrases in every definition.

Dr. Paul Bolstad:

'GIS is a computer-based system to aid in the collection, maintenance, storage, analysis, output and distribution of spatial data and information (Bolstad, 2007, p. 1)'.

Environmental Systems Research Institute:

'GIS is an organized collection of computer hardware, software, geographic data, and personnel design to efficiently capture, store, update, manipulate, analyse and display all forms of geographically reference information (Environmental Systems Research Institute, 1997, p. 1)'.

United States Geological Survey (USGS):

‘GIS is a computer system capable of capturing, storing, analyzing, and displaying geographically referenced information; that is data identified according to location (USGS, 2007)’.

Dr.-Ing. Alexander C. Adams, MSEE:

’A GIS is a system containing a spatial database representing aspects of a cultural and physical environment of a particular geographic region together with procedures for analyzing combinations of attributes and generating graphical or statistical products (Adams, 2010, p. 4)’.

Dr. Roger Tomlinson, ‘Father of GIS’:

‘A simple definition of GIS is not sufficient (Tomlinson, 2003)’.

The definition from Dr. Tomlinson seems very unique and unusual, but in fact is absolutely right. GIS is not merely a digital map but more than that, GIS provides a GEO-science-based approach, connecting geospatial measurement and data collection with data management; spatial analysis and modelling; geospatial visualisation; design and planning; decision making; and ultimately suggesting human action. The benefits of this approach are that it is systematic, holistic, analytic, quantitative, and visual.

GIS implementations follow three common patterns: desktop, server and distributed system. Although there is also a mobile GIS, such a system is included in the category of distributed system. These patterns are related to the architecture of the GIS. Why does architecture become important? Because GIS can be classified by its architecture. Each type of architecture has three elements: Presentation, Logic, Data (see Figure 3-11). ‘Presentation layer’ represents the user interface while ‘logic layer’ (business logic) refers to processing.

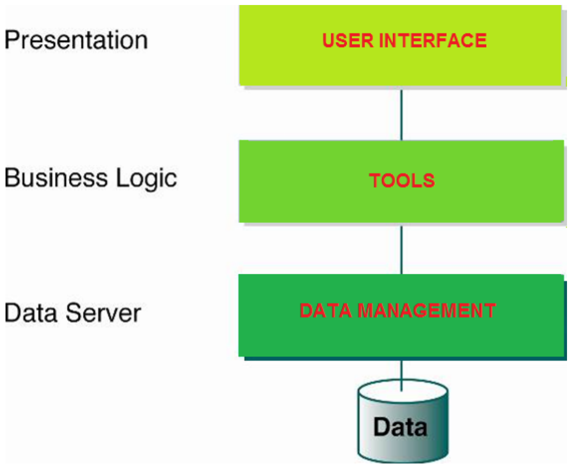


Figure 3-11 Three Elements of GIS Architecture (Longley, 2005)

GIS architecture has evolved very fast on very wide ranging application. GIS is developing from centralised GIS systems to distributed GIS services. Illustration of this evolution is depicted in Figure 3-12. The GIS started work on the mainframe in the early 1980s. Furthermore, along with the widespread use of PCs, in the early 1990s GIS was changed to desktop GIS that can be executed on the stand alone PC or usually used in a geographic-laboratory. But this evolution cannot be stopped and in the middle of the 1990s the increasing GIS evolution was triggered by connected or networked computers. The internet has become the most important system that has influenced GIS. Web-GIS became popular and spread around the world. In the early 2000s GIS transformed into handheld-devices, thus turning mobile. Web and mobile GIS as a distributed system make GIS more accessible and cheaper.

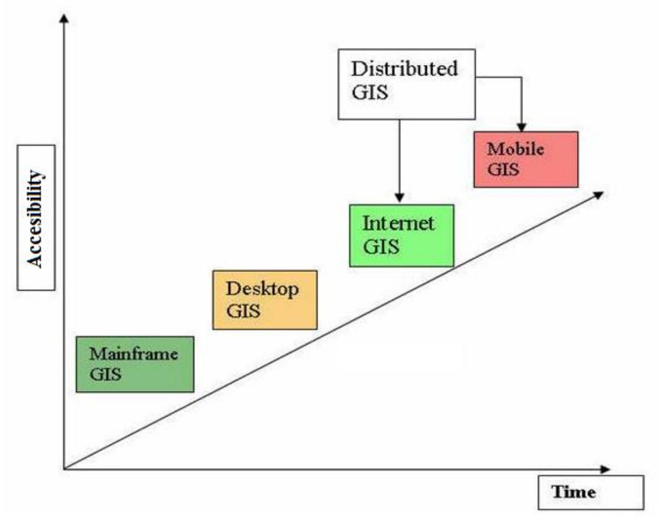


Figure 3-12 GIS Architecture Evolution (Longley, Michael F., David J., & David W., 2005)

Thus, GIS is categorised into: Desktop GIS, Web-GIS, Distributed-GIS and Mobile-GIS.

Desktop GIS defined as geographic information system is implemented on stand-alone computers. Desktop GIS can be identified as follows:

1) GIS application is running on a ‘stand-alone’ computer;
2) The software/application does not run simultaneously with two or more people on the network;
3) Desktop GIS application has the following features:
    - Plot data in a digital map format
    - Analyse map data
    - Develop professional map;
4) Data processing procedure keeps up these schemes:
    - Data creation
    - Data editing
    - Data analysing
    - Data visualisation.

One of the most popular Desktop GIS applications is called ‘ArcGIS’ (see Figure 3-13)

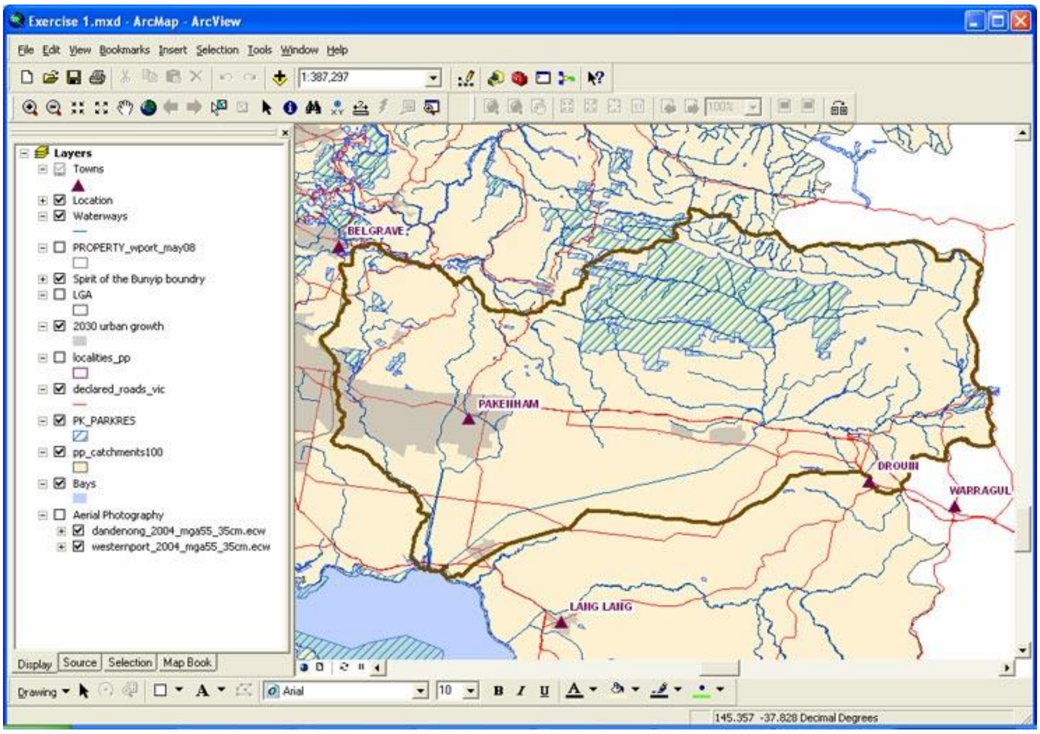


Figure 3-13 Snapshot of Desktop GIS – ArcGIS (Spatial Vision, 2013)

Keep pace with internet development, GIS was also served on the Web, or called Web-GIS. (Gillavry, 2000) defines Web-GIS as an information system which provides geographic data that distributed to the computer network in order to integrate, broadcast and communicating geographic information on the world wide web (www) through the internet.

Characteristics of Web-GIS can be identified by the following abilities:

1) The software/application runs simultaneously at the same time with two or more people on the network (served online);
2) Data processing procedure consists of 4 stages:
   - Data management
   - Data archiving
   - Data sharing
   - Data distribution;
3) The architecture of Web-GIS can be centralised (Client-Server architecture) or distributed.

One instance of centralised-architecture is shown in Figure 3-14.

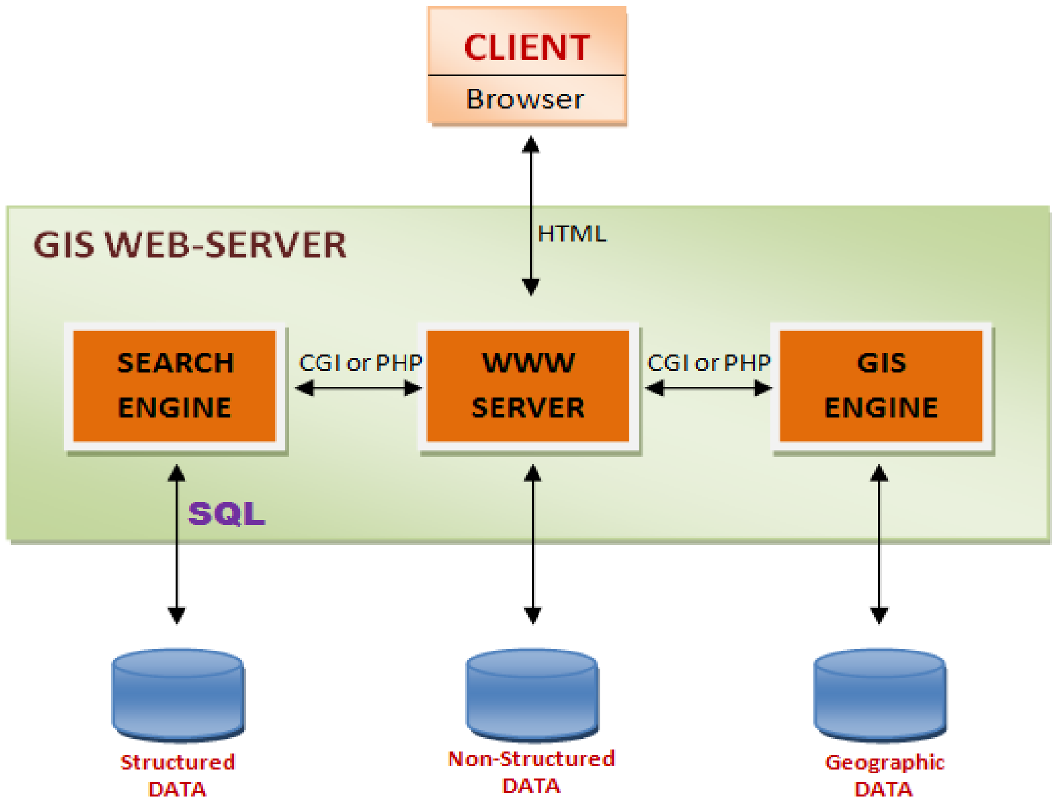


Figure 3-14 The Architecture of Web Based - Geographic Information System

Captions for Figure 3-14:

CLIENT: Browser that is used to access Web-GIS application, e.g.: Internet Explorer, Opera, Mozilla Firefox, Google Chrome etc.

GIS WEB-SERVER: Web server built to process GIS files in order to appear on the browser. It also handles client-server communications, thus allowing geographic information to be accessed by many users at the same time. The most popular web server in the world called 'Apache' is used by many people in the world even beating IIS (Internet Information Services) from Microsoft and Netscape. That is why many web-developer standards like PHPTriad, XAMPP and several Linux Distro (Red-Hat, Ubuntu, Mandrake, SuSE) have inserted Apache as their default web-server.

CGI (Common Gateway Interface): a standard communication of a Web server to pass a user's request to an application programme and to receive data back to forward to the user. When the user requests a Web page (for example, by clicking on a highlighted word or entering a Web site address), the server sends back the requested page.

PHP (Hypertext Preprocessor): a server-side scripting language created for web development, general-purpose programming language and also client-server internet application.

SEARCH ENGINE: an engine that is used to process (set or get) structured data.

WWW SERVER: a server which responds to an incoming TCP connection and provides a service to the client (caller). In this case, the service is dedicated to unstructured data.

GIS ENGINE: an engine responsible for spatial data processing based on the client's request.

SQL (Structured Query Language): Standard query language for requesting information from a database.

Structured DATA: Data that is located in a fixed field within a record or file. This includes data contained in relational databases and spreadsheets. Thus, structured data have a high degree of organisation, such that inclusion in a relational database is seamless, readily and easily searchable by simple, straightforward search engine algorithms or other search operations.

Non-Structured DATA: Data that are not stored and organised in a well-defined structured format.

Geographic DATA: a collection of data that interpret objects and things with relation to space. Normally this is done using x,y coordinates or longitudes and latitudes.

Another sample of Web-GIS architecture known as distributed Web-GIS is depicted in Figure 3-15.

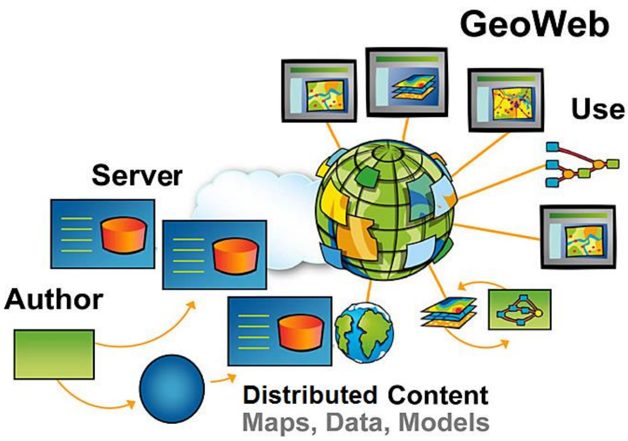


Figure 3-15 Distributed Web-GIS (Dangermond, 2008)

The main idea of this system is to distribute the component framework into interoperable components across operating systems, networks, and hardware (e.g., DCOM, CORBA, .NET, Java Platform). Usually, distributed GIS application rely on object-oriented modelling, thus applications can be seen as comprising components that can interoperate across languages (e.g. COM).

Meanwhile, requirements of a mobile-GIS device began in the 1990s. At that moment, mobile technologies were initially developed for military operations but later used for location-based services (LBS) to leverage business and public services. Professor Ming-Hsiang Tsou described mobile GIS as an integrated technological framework for accessing geospatial data and LBS through mobile (handheld) devices (Tsou, 2004). This definition is completed by ESRI (GIS Software-Developer) as follows: 'Mobile systems allow GIS tools to be accessed wirelessly and utilized in field situations, away from the desktop, for a sustained period of time (Raper, 2009)'.

Mobile GIS has the following capabilities:

1) Embedded on mobile devices which have limited storage, memory and resolution;
2) Can be executed on stand-alone devices using portable storage software for simple application or more complicated application connected to the web-GIS;
3) Typical mobile-GIS services, i.e.:
    - Map display and navigation
    - Identify, search and query data
    - Attribute modification
    - Marking area (redline)
    - Geometry modification
    - Data integration;
4) There are two types of mobile-GIS data transfer, i.e. 'data collection' and 'navigation'. Data collection can be connected to the GPS, rangefinder or digital camera. Efficient data collection is served using 'point and click';

Spatial data is managed using reference dataset.

3.2.3. Google Maps

Google Maps is one web service application provided by Google (see Figure 3-16). Such application provides map-based assistance, including the Google Maps website, Google Ride Finder, Google Transit. Several map features like street maps and a route planner are given as well. It also shows a locator for urban businesses in numerous countries around the world. However, Google Maps' satellite images are unfortunately not executed in real time, but Google renews data in their Primary Database regularly. Docjason, a Wikianswer-contributor, explained that Google Maps uses the same satellite data as Google Earth and they are updated together usually once or twice a month, although not every area is updated on each update (Docjason, 2014). Google Maps was introduced in a blog post on Google in February 2005. It revolutionised the way maps on web-pages work by letting the user drag the map to navigate it. This was new at the time. The map solutions used then were expensive and required special map servers, yet they did not deliver the same level of interactivity. Google Maps was originally developed by two Danish brothers, Lars and Jens Rasmussen. They cofounded Where 2 Technologies, a company dedicated to creating mapping solutions. The company was acquired by Google in October 2004, and the two brothers then created Google Maps (Svennerberg, 2010).

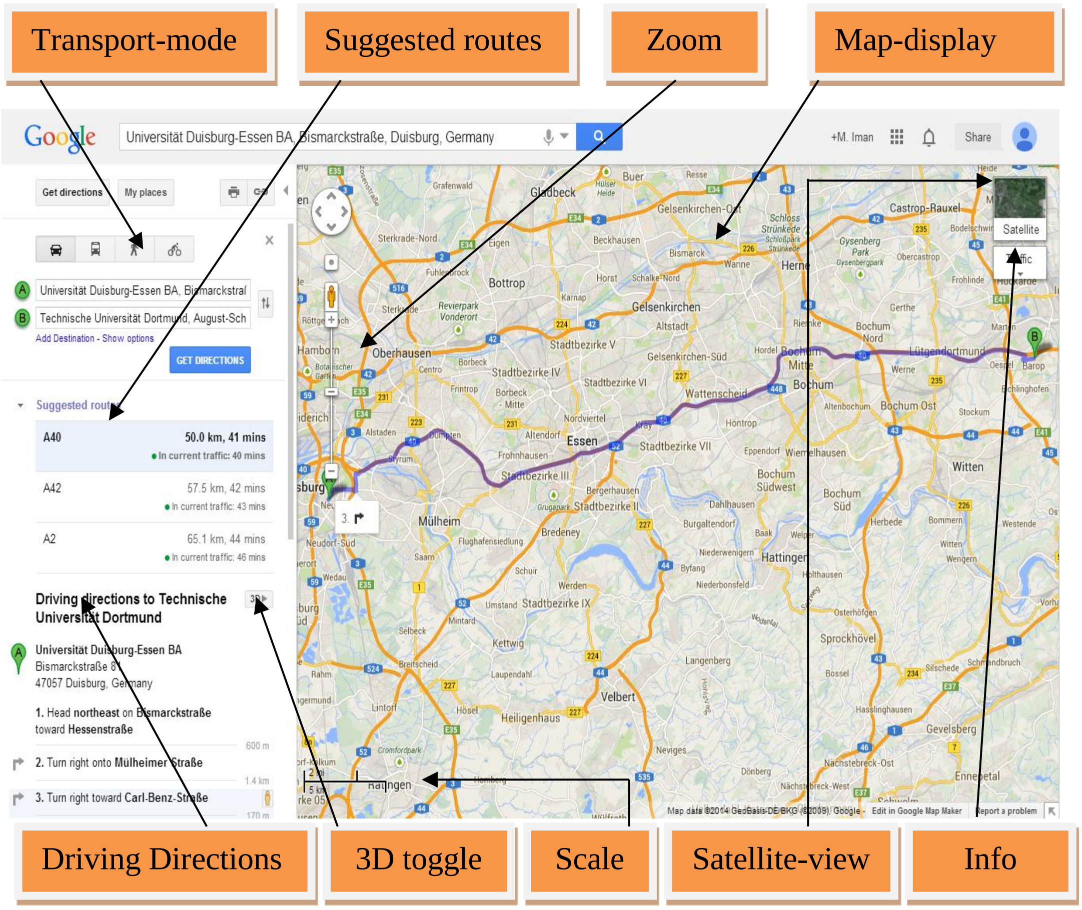


Figure 3-16 Google Maps Feature: Get Directions (source: https://maps.google.de/)

Moreover, Google Maps offers embedded-code that runs on third-party websites via the Google Maps Application Programming Interface (API). Actually, a long time before there was a public API, some developers figured out how to hack Google Maps to incorporate maps on their own web sites. This led Google to release a public API, and in June 2005 it was publically opened. The free Google Maps API allows thousands of programmers to tap into the powerful Google mapping service by connecting it with various types of data (Darlin, 2005).

At the moment, there are several mapping solutions including Yahoo! Maps and Bing Maps, but the most popular one is still Google Maps. In fact, according to Programmableweb.com, it is the most popular API on the Internet. This site listed on January, 30th 2014 that 39% of all ‘mashups’ use the Google Maps API (see Figure 3-17). Applications and web sites that are combining data or functionality from two or more sources are commonly referred to as ‘mashups’. Mashups are becoming increasingly popular and have revolutionised the way information is being used and visualised.

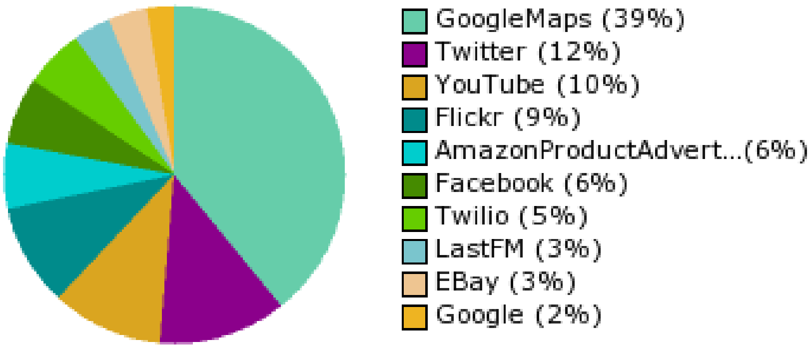


Figure 3-17 Top APIs for Mashups (Musser, 2014)

Mapping solutions have become one important ingredient in a number of 'mashups'. The Google Maps API can be used in private applications to display individual (or others') data in an efficient and usable manner.

An example of a 'mashup' using the Google Maps API is the coverage of the Deepwater Horizon oil spill in the Gulf of Mexico. Google Maps is combined with the Gulf Oil Spill scenario to visualise its massive impact (see Figure 3-18).

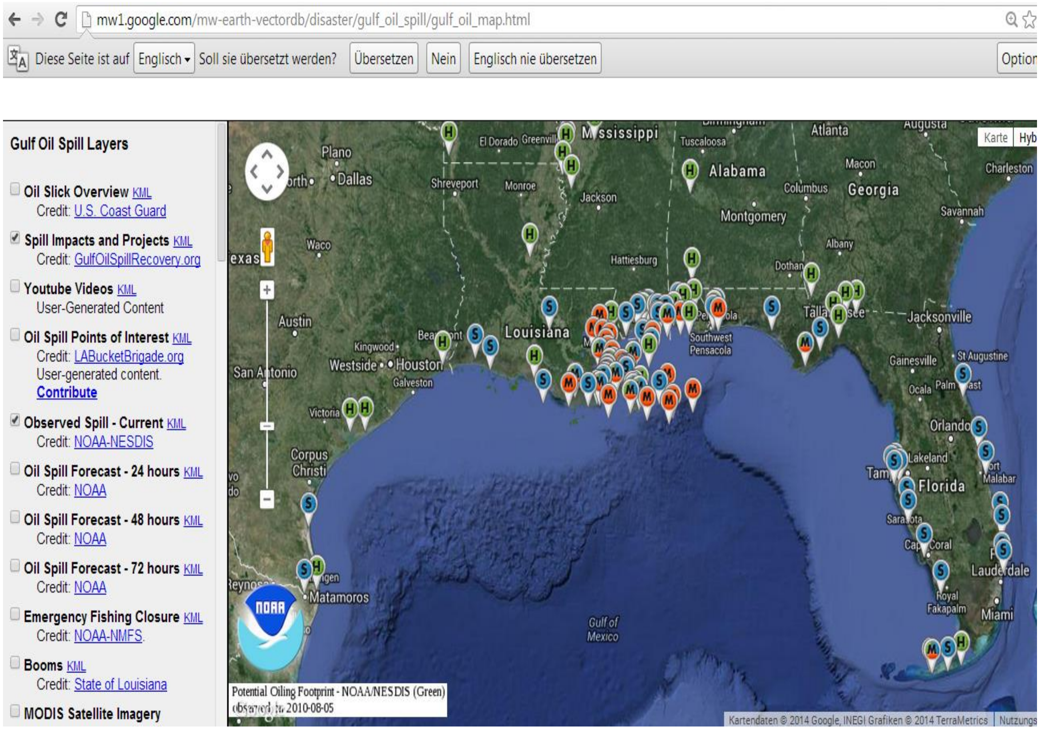


Figure 3-18 Website of oil spill forecast in the Gulf of Mexico using Google Maps API (NOAA , 2010)

4. Positioning and Analysis of the World's Biodiesel Industry

4.1. Positioning Criteria

To understand the problem of biodiesel, each producer/consumer cannot be counted individually. Biodiesel should be observed as a business entity associated with the raw materials, production processes, blending-stations, distribution and marketing points that are not only between regions but also linking countries or even inter-continents. Before going any further and deeply understanding the root causes, people need to know the position, the strengths and weaknesses of each player. Furthermore, the right strategy for developing the biodiesel business will be determined. For this reason, the author employed the General Electric (GE)/McKinsey Matrix.

The GE/McKinsey Matrix is a two-dimensional matrix that aims at analysing the strengths and weakness of a business unit in various areas. This tool describes the business entities and compares their position to its competitors. It enables the organisation to identify the most attractive markets or to pull the company from the unattractive markets. Besides that, it endeavours to identify the boundaries of the competition and determine competitor actions within the same key field. Indeed, the analysis will consider both the inherent potential (the so-called core competencies) and the potential industrial attractiveness. Based on those actions, managers can define the strategic compass to move forward (Bergen & Peteraf, 2002). GE/McKinsey Matrix assesses the business based on two criteria, i.e. the attractiveness of the industry/market concerned (the vertical axis) and the strength of the business (the horizontal axis). Rather than analysing a company or business unit, this chapter presents a GE Matrix evaluation of the whole biodiesel industry for selected major biodiesel countries: Argentina, Brazil, China, German, Indonesia, and the US.

	Low strength	Medium strength	High strength
High attractiveness	Y Cell 3	Y Cell 2	X Cell 1
Medium attractiveness	Y Cell 6	Y Cell 5	Y Cell 4
Low attractiveness	Z Cell 9	Y Cell 8	Y Cell 7

Figure 4-1. The GE Matrix Cell and Groups

The matrix is arranged with three categories and nine cells (Figure 4-1):

Band X: Successful - the business is strong and the industry is attractive;

Band Y: Mediocre - either the industry is less attractive and/or the business lacks strengths;

Band Z: Disappointing - the business is weak and the industry unattractive.

Several key steps are necessary to create the matrix:

- Make a list of a complete range of products that are produced or sold by a particular business unit (country).
- Identify factors that make a particular market attractive.
- Consider and evaluate the strategic business unit's position in the market. The market attractiveness and the business strength need to be calculated.
- Determine the category of strategic business units: High, Medium or Low.
- Categorise the index of market attractiveness and business strength for each country, total all the scores to obtain coordinate points of the matrix and plot it in the matrix plane.

The next step is the analysis of the business unit condition and the right strategy based on the nine cell matrix positions based on the following meanings:

CELL-1: Protect position - maintain position
CELL-2: Try harder - challenge the leader
CELL-3: Be choosy - keep an eye on opportunities – if risk is low
CELL-4: Harvest - reduce cost to maximise profits
CELL-5: Manage carefully
CELL-6: Grow wisely - invest in attractive areas
CELL-7: Regroup - preserve cash flow, defend strengths
CELL-8: Keep investment to a minimum - protect the position that you have
CELL-9: Get out

The rising environmental attention and the demand for energy sovereignty have driven the spread of biodiesel industries. There are several places on the planet that have become a biodiesel icon. Brazil, China, US, Germany, and Southeast Asia (Indonesia, Malaysia, and Thailand) were appointed as world-leaders of biodiesel. The history and world biodiesel has been briefly explained in sub-chapter 2.1. Furthermore, this chapter discusses the current status of global biodiesel in more detail. Despite the economic recession, the global biodiesel market has shown exponential growth (see Figure 4-2). Currently, the field is not only dominated by producers but more biodiesel than ever before is sourced from abroad and procurement areas, especially among large scale exporters and traders that span the globe. The law of international supply-chain is used in this case. Consequently, the biodiesel industry is also connected to the other sectors (agriculture and mineral oil industry in particular). These facts make significant market disturbances and some of which have delivered various unfortunate circumstances in the last years. Somehow, the interaction of domestic policies has influenced global trade streams towards different markets, in particular in connection with underlying trade policies and local market forces.

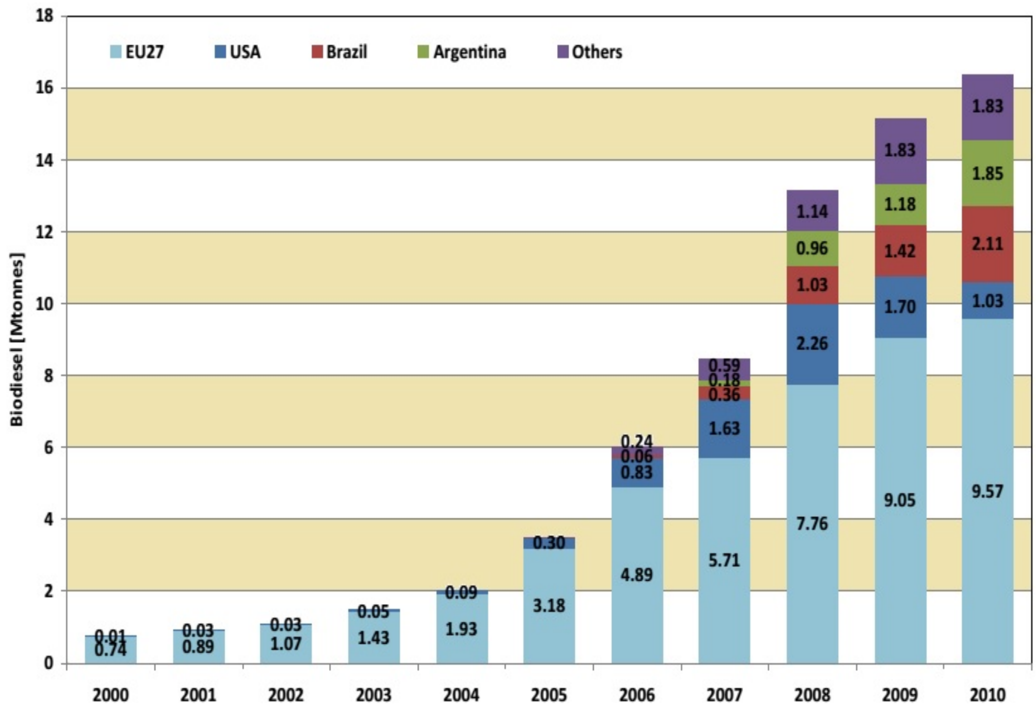


Figure 4-2. Biodiesel growing fact over decade (Lamers P, 2011)

Lamers (2011) summarised an exponential growth of global biodiesel production in the past decade (see Figure 4-2). Global biodiesel production grew from less than 1 Megaton (Mton) in 2000 to over 15 Mton in 2009. Meanwhile, M&M (2014) reported that 2009 global biodiesel trade represented a 17.9% increase over 2008 levels. The biodiesel market is growing from $8.6 billion in 2009 to $12.6 billion in 2014. Market growth is primarily dependent on the availability, quality, and yield of feedstock, as it accounts for 65% to 70% of the cost of biodiesel production.

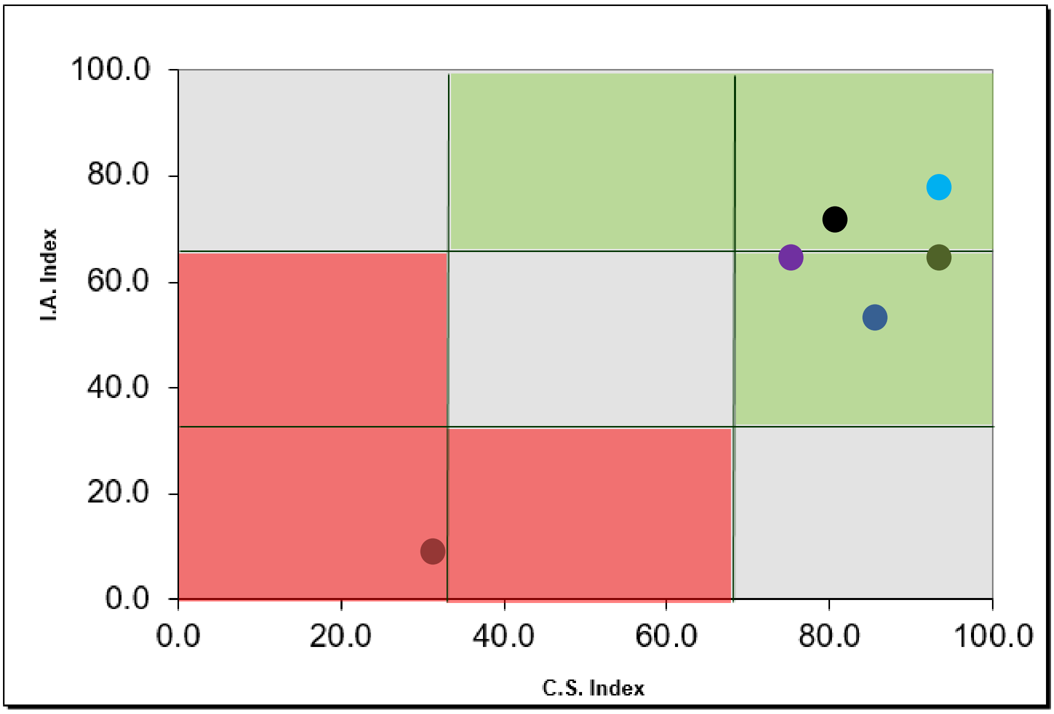
Subchapter 2.1 provides information about biodiesel feedstock based on the geographic region. In fact, an end product of biodiesel is affected by the availability of local feedstock. In Argentina, Brazil and US, biodiesel is almost exclusively derived from soybean, thus, their biodiesel is called 'soya oil methyl-ester' (SME). Palm oil feedstock mostly comprises Indonesian and Malaysian biodiesel, so their biodiesel is called 'palm-oil methyl-ester' (PME). However, in the EU biodiesel is mainly from rapeseed oil and named 'rapeseed methyl ester' (RME) although the portions of PME and SME have increased since 2005. At that time, less strict technical requirements, as well as the production of drop-in biodiesel, allow for even larger portions of non-rapeseed oil. Expansion trends of rapeseed oil production after 2003 were correlated with the biodiesel policy in Europe.

Biodiesel production has also increased in other world territories and is also associated with the aforementioned feedstock, i.e. palm oil in South-East Asia and soya oil in South America. Another emerging player in this business is China. China is rapidly growing as the candidate world leading importer of vegetable oils. Though China is not strong enough concerning regulation and policy to coordinate the sale and distribution of biodiesel, their production capacity is not low. Argentina and Indonesia dominate the export market of vegetable oil, representing approximately 75%. Brazil has become one of the world's largest exporters of soybeans, next to the US. Another player of soya oil is Argentina, which is rapidly becoming one of the world's top exporters of soya oil. The explosive growth of a global market for biodiesel is also predicted by Emerging Markets Online (EMO, 2008). In 2008, Europe represented 80% of global biodiesel consumption and production and the US increased their production at a faster rate than Europe. It is predicted that by the year of 2020, with the pursuit of second generation non-food feedstocks, biodiesel could comprise as much as 20% of all on-road diesel used in Brazil, Europe, China, and India. At that time, biodiesel demand and over-capacity in Europe, the US and Asia are the compelling investments in the global trade of alternative feedstocks.

The following section will analyse data concerning the significant stream of biodiesel in the selected countries. The discussion is based on two broad categories of examination, namely: 1) market attractiveness and 2) business strength. The first category considers 5 factors, i.e. Market Penetration, Export/Import Ratio, R & D capability, Technology, Consumption, Number of export destinations. The second category examines another 5 factors, i.e. Standardisation/Accreditation, Location-Facilities, Capacity, Regulation and Relative Profit Margin. Research examination of those factors is described for six selected countries (Argentina, Brazil, China, Germany, Indonesia and US) in Appendix 3.

4.2. GE/McKinsey Matrix Total Score and Position

This section calculates the score, location and mapping the biodiesel industry of six selected countries using the GE Matrix concept. Recapitulation of all per country data are presented in Table A4-1 through Table A4-13 and their country matrix position is given in Figure A4-1 through Figure A4-6 (see Appendix 4). The summary of the GE/McKinsey matrix analysis displayed in Figure 4-3.



Notes	
●	Argentina
●	Brazil
●	China
●	Germany
●	Indonesia
●	US

Figure 4-3. GE/McKinsey Matrix Position for All Selected Countries

Argentina
Brazil
China
Germany
Indonesia
USA

4.3. GE/Mc Kinsey Analysis and Recommendation

There are three cells occupied by the six evaluated countries (see Figure 4-3). The analysis will concern Figure 4-1 (The GE Matrix Cell and Groups) as a basic platform for determining the strategic plan.

CELL-1: Germany, Indonesia - **[High Attractiveness – High Strength]**
The biodiesel industry belonging to the countries located in this cell are identified as a very attractive market. Besides that, it has great strength and distinguished competencies, thus can be harnessed for good advantages. One primary recommendation is maintenance of leadership. In order to keep the leadership, concentrating on strengthening the organisation is needed. In the case of the biodiesel industry, the government should maintain and supervise regulation so that it is always able to achieve the predetermined mandate. Moreover, with a very high position and strong possession, the countries have a right to maximise market share, seek dominance and develop the business infrastructures, e.g. the construction of warehouses, distribution centres, blending stations, multimode transports or biodiesel refineries. The countries can invest and expand the potential development of higher biodiesel concentrations (B10, B15 or B25) and conduct research on advanced biodiesel as well.

CELL-4: Argentina, Brazil, US - **[Medium Attractiveness – High Strength]**
The countries that comprise this cell have a high rating in business strength and a medium rating in industry attractiveness. This means that the biodiesel industry in these countries still offer some promises. Consequently, the suitable recommended strategies are building leadership which needs to prefer or focus on 'the most attractive markets'. Furthermore, this position is expected to avoid competition and emphasise improving profits by increasing productivity. Besides that, it is also important to organise existing strengths to maintain sustainable competitive ability, such as feedstock diversifications and regulate land usage.

CELL-9: China - **[Low Attractiveness – Low Strength]**
As depicted in Figure 4-3., the Chinese biodiesel industry has low industry attractiveness and business strength, so the recommendation is to divest (release). Companies are advised to remove the shares at the right time to maximise the cash value. Another alternative is to sell the total assets and the business venture. The company can cut fixed costs and avoid investment during the releasing process. In this position, the company has minimum internal strength and the market has less interest

in using the services of this company. Therefore, any attempts to gain market share by increasing the strength of the business will become very expensive. In the case of the owner insisting on gaining the market share, then it should be done with caution, for instance by conducting joint or having very strong business partners. The Chinese low position in the biodiesel industry has been recognised by most Chinese biodiesel companies. From 54 biodiesel plants, less than half of the producers are still performing (USDA-China, 2014). The NYSE listed Gushan Group also withdrew from the biodiesel market in China after encountering several years of heavy financial losses (Hornby, 2014).

5. Tools and Master Plan for Digital Biodiesel Supply Chain

5.1. Pre-Condition

The previous discussion presented important positions as well as analysis and recommendations related to the biodiesel industry of selected countries. This chapter addresses strategic recommendations that are highlighted by the GE/McKinsey study. In order to obtain empirical findings, the case study was conducted with primary data from one of the main biodiesel producers: Indonesia. Indonesia is the largest archipelagic country with around 17,000 islands spread across more than 5,000 kilometres from west to east. The land area is 1,860,360 km² and the sea area 5,800,000 km². The population is more than 237 million (2010). The geography and uneven population distribution pose a major challenge when developing infrastructure and tackling inequalities (see Table 5-1).

Table 5-1 Indonesian Land Area and Population

Province	Area (km)	%	Population	%
Sumatera	480,793	25	50,631,000	21
Java	129,438	7	136,610,600	58
Bali, Nusa Tenggara	73,070	4	13,074,800	6
Kalimantan	544,150	28	13,787,700	6
Sulawesi	188,522	10	17,371,800	7
Maluku & Papua	494,957	26	5,405,000	2
Total Indonesia	1,910,931	100	236,880,900	100

Indonesia was chosen, not only for being one of the largest biodiesel producers, but also because of the complexity of their logistics system. Currently, Indonesia needs a more efficient logistics system to reduce the disparities between regions, providing easier access and less expensive commodities in the domestic market (Bahagia, 2013).

In terms of the biodiesel industry, those facts are very relevant to the GE/McKinsey analysis and the recommendations already proposed (see the previous chapter). The following summarises the complete GE/McKinsey matrix recommendation of Indonesia for further discussion. Indonesia's location in the matrix-cell identified a very attractive market. Moreover, it has great strength and distinguished competencies. Thus, proper recommendations [REC] have been formulated as follows:

[REC-1] Maintain & supervise regulation to achieve predetermined mandate.

[REC-2] Maximise market share, seek dominance by developing the business infrastructures, e.g. the construction of warehouses, distribution centres, blending stations, multimode transports or biodiesel refineries.

[REC-3] Invest and expand the potential development of higher biodiesel concentration (B10, B15 or B25).

[REC-4] Conduct research on advanced biodiesel.

The author proposes three schemes for improving Indonesia's biodiesel supply chain. The 1st idea addresses [REC-2], the 2nd idea answers [REC-1] and [REC-2] and the 3rd idea covers [REC-1], [REC-3] and [REC-4] (see Table 5-2).

Table 5-2 The Proposal for Biodiesel Industry Improvement (Case Study: Indonesia)

No	Proposal	GE/McKinsey Matrix Recommendation
1	Simulation Tools for Biodiesel Facility Planning	[REC-2]
2	Digitalising of Biodiesel Supply Chain Governance	[REC-1], [REC-2]
3	Master Plan of Indonesian Biodiesel Supply Chain	[REC-1], [REC-3], [REC-4]

The following part presents the biodiesel supply chain system in Indonesia. There are four entities involved in the biodiesel SCM in Indonesia, i.e. biorefinery-station, petro-diesel refinery-station, distribution centre (TBBM) and filling station or big consumer (Figure 5-1). Biodiesel sales are fully controlled by the state owned company called 'Pertamina: Perusahaan Tambang dan Minyak Negara' or literally translated as 'The State Owned Oil, Gas and Mining Company'.

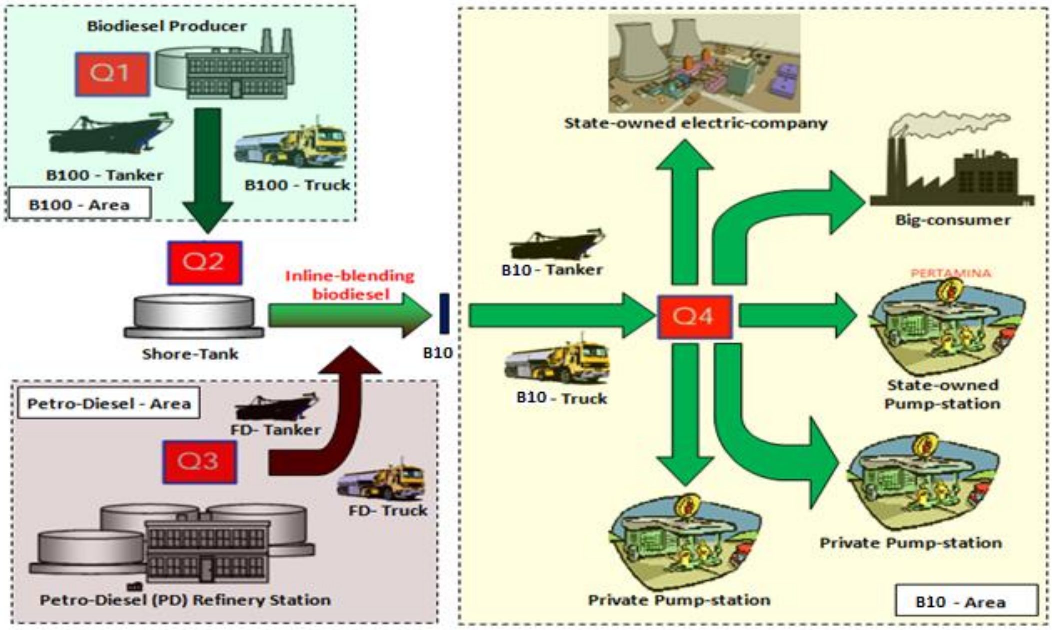


Figure 5-1 Indonesian Biodiesel Supply Chain (PERTAMINA, 2012)

The filling stations, distribution centres and petroleum oil refineries are operated by Pertamina. From the entire business network of biodiesel, only biorefinery stations (biodiesel plants) are managed by private companies (see Appendix 3, Figure A3-9). In order to meet the annual target, Pertamina offers a public auction for biodiesel supply in two or three stages per year. Most of the Pertamina suppliers have feedstocks which come from their own palm oil plantations. Hence, the private biorefiner executes the following sequences: 1) cultivates and harvests the crops, 2) transports the crops to the plant, 3) presses and processes the crops into FAME or B100, 4) sells and delivers B100 to Pertamina or exports it abroad.

The winners of the Pertamina auction furthermore deliver B100 to the Pertamina distribution centres (DCs) called ‘TBBM: Terminal Bahan Bakar Minyak’. There are 101 DCs scattered around the nation as depicted in Figure 5-2.

Figure 5-2 The Indonesian Biodiesel TBBM (Distribution Centre) (Trikora, 2013)

Pertamina biodiesel DCs and its service areas are summarised in Table 5.3.

Table 5-3 Pertamina Distribution Centres and Service Areas

Region	Coverage	The Number of DC (or TBBM)
Region-1	North-part of Sumatera	15
Region-2	South-part of Sumatera	9
Region-3	Banten, Jakarta and West Java	7
Region-4	Central Java	7
Region-5	East Java, Madura and Nusa Tenggara	19
Region-6	Kalimantan	6
Region-7	Sulawesi	17
Region-8	Maluku and Papua	21
TOTAL		101

Inside the DC, biodiesel is stored in the shore tanks or blended with the petro-diesel prior to being sent to the consumers. Since April 2015, the Indonesian Government officially announced B15 as the new blending mandate. Thus, Pertamina should increase the biodiesel content (from 10% previously) in each mixture before it is sold at the filling stations. That blending process is handled by the DC.

The customers are classified into two categories, i.e. 1) industrial consumer using biodiesel for non-transportation purposes such as electricity company or steel company and 2) filling station which directly sells biodiesel to the people.

The successive biodiesel supply chain in Indonesia is depicted in Figure 5-1. It describes the biodiesel process from the producer to the consumer, completed also by the transport mode in every stage. Pertamina performs quality control as well (see Figure 5-1). In every quality check-point (Q1 – Q4), Pertamina takes a biodiesel sample from the tank and conducts laboratory tests. Only products that have passed a quality inspection are moved to the next stage. First of all, pure-biodiesel is produced, then quality checks are performed by the manufacturer in Q1 (the first quality check). Furthermore, the producers send B100 (pure-biodiesel) to the DCs (Pertamina-Depot) around the nation. The site-manager checks the 7 parameters of B100 before it is stored in the shore-tanks of the DC in Q2 (the second quality check). Q3 (the third quality check) examines the quality parameters of petro-diesel from the refinery-station that will be mixed with the biodiesel. Afterwards, Pertamina blends B100 and petro-diesel with the specific composition in their DC. Pertamina executes Q4 (the fourth quality check) after shipping the blending-biodiesel but shortly before being accepted by the retailers (pump-stations), industrial-consumers and state-owned electrical company.

5.2. Simulation Tools for Biodiesel Facility Planning

In order to maintain the mandate achievement, the Indonesian Government needs to increase their market share. The domestic market becomes a very attractive business since Indonesia has a population of around 230 million, especially when linked to the fact that the economy and industries in Indonesia are rapidly growing. Power plants and industry machinery have always been a loyal market of biodiesel in Indonesia, besides freight trucks and private cars. Based on the statistics, by 2014, domestic consumption of biodiesel in Indonesia more than doubled (see Table 5-4). The enthusiasm of the market confirms that this product has garnered public trust and is proven in the field.

Table 5-4 Indonesian Biodiesel Statistic (USDA-Indonesia, 2014)

Biodiesel (Million Liters)									
Calendar Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Beginning Stocks	0	27	18	15	81	38	40	55	101
Production	65	270	630	330	740	1,800	2,200	2,450	3,650
Imports	0	0	0	0	0	0	0	0	0
Exports	33	257	610	204	563	1,440	1,515	1,356	1,000
Consumption	5	22	23	60	220	358	670	1,048	2,625
Ending Stocks	27	18	15	81	38	40	55	101	126
Production Capacity									
Number of Biorefineries	2	7	14	20	22	22	26	26	26
Nameplate Capacity	215	1,709	3,138	3,528	3,936	4,281	4,881	5,670	5,670
Capacity Use (%)	30,2%	15,8%	20,1%	9,4%	18,8%	42,0%	45,1%	43,2%	64,4%
Feedstock Use (1,000 MT)									
Feedstock A (CPO)	64	265	619	324	727	1,769	2,163	2,408	3,588
Feedstock B									
Feedstock C									
Feedstock D									
Market Penetration (Liters – specify unit)									
Biodiesel, on-road use	5	22	23	60	220	358	670	930	1,644
Diesel, on-road use	9,059	9,400	10,311	12,781	15,291	16,383	18,690	20,727	22,986
Blend rate (%)	0.1%	0.2%	0.2%	0.5%	1.4%	2.2%	3.6%	4.5%	7.2%
Diesel, total use	15,636	15,575	17,001	20,158	23,049	22,921	24,611	26,257	28,014

However, the biodiesel market demand is not easy to handle. Distribution becomes a problem because of the Indonesian geographical location, which consists of many islands. The challenge is how to meet this demand so customer needs are satisfied.

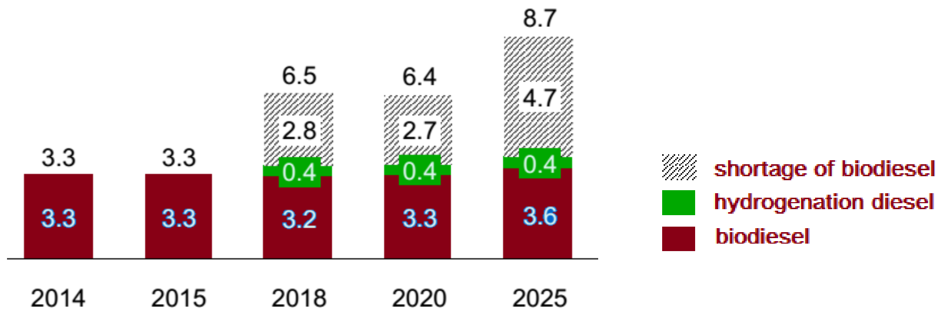


Figure 5-3 Biodiesel Demand and Opportunities (in Million KL)

Indonesian biodiesel supply will not meet the demand of biofuel until 2025 (see Figure 5-3). According to [REC-1], Indonesia must always maintain its predetermined mandate to preserve their position. Hence, Indonesia needs more than 10 Green Diesel Refineries cap. 10,000 bbl/day in the upcoming ten years (Prakoso, 2014). These refineries should be placed nearby the feedstock production areas. However, additional infrastructure such as DCs (TBBM), blending stations, filling stations, etc. must also be built.

Business infrastructure development is one of the strategic actions to enhance the efficient logistics system in Indonesia, hence the disparities between regions can be reduced. This section explores new locations proposed for biodiesel DCs (TBBM) by considering available existing TBBMs. The decision algorithm of the new place is based on the alternate location-allocation (ALA) procedure. In the end, consideration of whether it is economically necessary to make new investment by building new DCs or to keep the current available existing DCs will be explored.

5.2.1. Biodiesel Distribution Network Identification

The following theories are some of the transportation network designs to provide the knowledge distribution patterns that may be applied from the supplier to the customer (Chopra & Meindl, 2007).

a) Direct Shipment Network

This shipment network supplies products from each supplier directly to each location of the buyer (Figure 5-4). This system decides the transport mode and quantity of product shipment. Decisions made for one shipment will not affect other deliveries. Such a network may involve a trade-off between the transportation cost and products inventory. This model can reduce the cost of expenditures in the warehouse given the absence of warehouse procurement. The model has a relatively short transportation time from supplier to customer and is prioritised for delivery of large shipments; if the shipment is small using this design, the transportation costs would be higher.

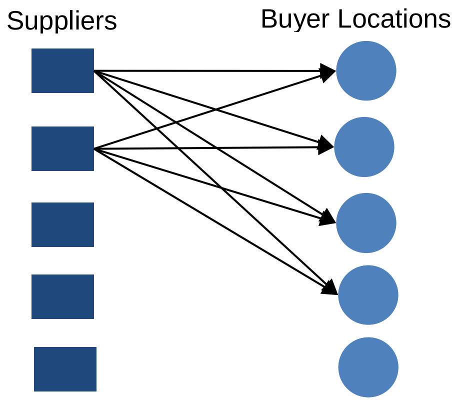


Figure 5-4 Direct Shipment Network

b) Direct Shipment Network with Milk Run

A milk run is a route in which products are shipped from a single supplier to multiple retailers or from some suppliers to a single buyer's location (see Figure 5-5). The system used in direct shipment with milk run is nearly the same as the direct shipment, which distinguishes only between routing and delivery patterns. Decisions taken in this network design include the routing of each milk run. With direct shipping it is not necessary to supply warehouses where it will reduce expenses. By using this model, it will reduce transportation costs by maximising truck load, because a supplier will collect supplies from several other suppliers to a buyer's location in one shipment, or from one supplier to several buyers' locations.

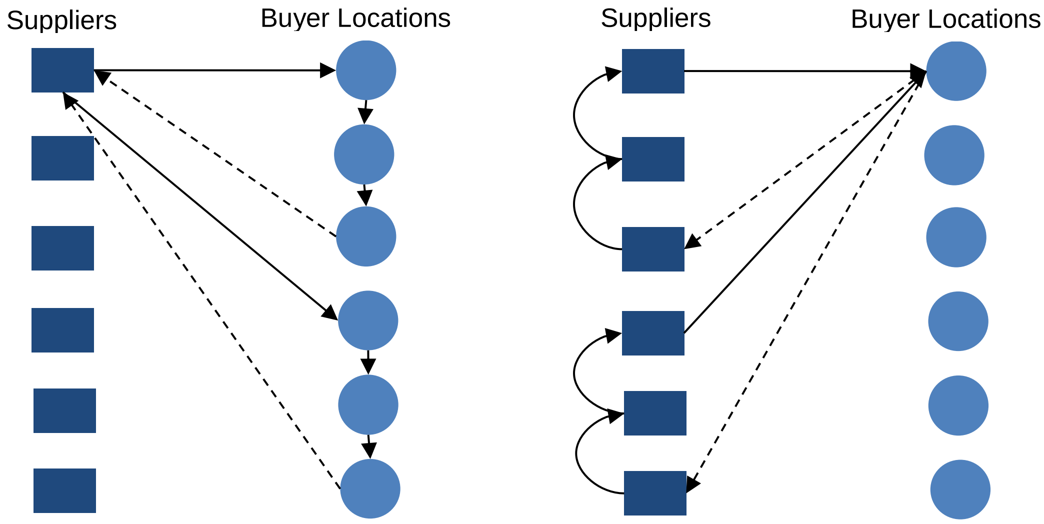


Figure 5-5 Milk Runs from Multiple Suppliers to Multiple Buyer Locations

c) Shipment via DC

The DC is a warehouse, storage or other particular building stocked with products to be redelivered to the wholesalers, retailers or directly to the consumers. DC is a solution to reduce transportation cost in which the distance between the suppliers and the buyers is too far. DCs are constructed by dividing the geographical location of a region.

1) All shipment via central DC with inventory storage

   The central DC is the intermediary between suppliers and buyers that has product inventory from the suppliers' side and serves as a transfer location for buyers (Figure 5-6). This network can accommodate more products to be stored until needed by the buyers.

2) All shipment via central DC with cross-dock

   Typical warehousing is where products from various suppliers are received in a DC then combined and sent immediately to the same buyer's location without having to be stored in the DC. The DC is a transit location because in this system it uses 'zero inventory' so that there is no product storage. DC does not need a large place, just to put the goods on pallets (not requiring a rack).

3) Shipping via DC using milk runs

   Milk runs used in outbound processes can reduce the price of transportation in which the product in a DC is distributed on a small scale to the buyers' locations. DC and buyers' locations form a circle of distribution where cross-docking appears from buyer to DC as transit and milk run from each buyer (see Figure 5-7)

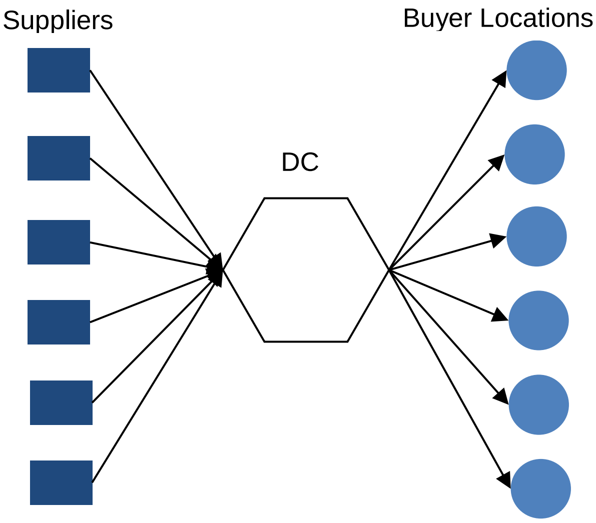


Figure 5-6 Shipment via Central DC

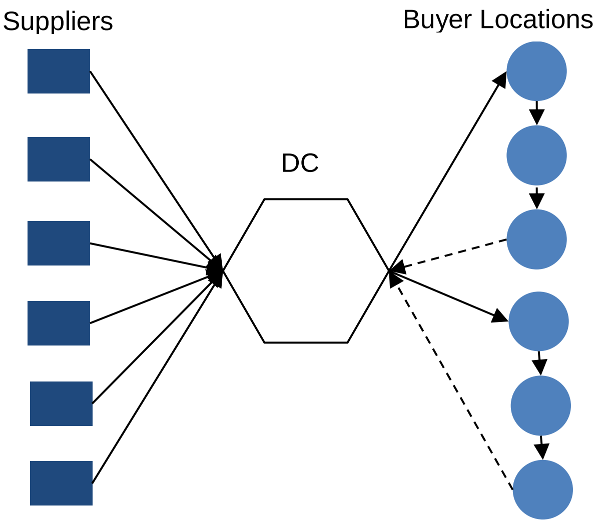


Figure 5-7 Milk Runs from DC

d) Tailored Network

This network using flexibility in combining several transportation networks described earlier. Combinations that may be used are cross-docking, DC, milk runs etc. with the goal to minimise transportation costs and inventory expenses. This network uses multiple options according to the demand situation. Of course, the complexity of the use of this network will be higher considering the different shipping procedures used for product and retail outlets. Because of that, it is necessary to have investment in information infrastructure to facilitate the coordinates, like a network where the use of a shipment network minimises transportation and inventory costs.

Pertamina has chosen the 'Tailored Network System' that incorporates multiple types of networks and distribution. A big consumer with high demand requires direct delivery. The low request area has to be served from DC and combined with several consolidations. The DC becomes a central point. The main DC receives a shipment of biodiesel from the tender winners. Furthermore, they will continue shipment of primary products to the pump station or a fuel terminal in the vicinity. Inside the DC, biodiesel trucks come and undergo a variety of cross-docking processes but in this case, they handle a liquid. Part of the biodiesel is stored in the underground shore-tanks for a while and another portion is blended with petro-diesel and then shipped to retailers/pump stations. The distribution is then called 'storage carrier delivery' (Hadiguna, 2015).

5.2.2. Design Parameters and Assumptions

a) Parameters

There are some parameters for the facility location planning, i.e.

1) Facility

   The facility that becomes a subject of research in this simulation is a DC or TBBM (Indonesian-language). This parameter considers the amount, type, and cost of existing and new facilities. The new facilities' position and calculation are typical subjects of most simulations in this field. That new facility can be single or multiple, depending on the desired criteria.

2) Location

   The location is an important part of the supply chain. It answers the question of procurement strategies, such as whether the location is close to the buyers' locations, manufacturer or other existing facilities. Hence, location decisions may be the most critical to obtain an efficient supply chain. There are also some parameters that must be considered, such as labour costs, availability of infrastructure, taxes and other strategic factors.

3) Customer

   A customer (known as a buyer, client or purchaser) is the beneficiary of a product (also recognised as a good, a service, or an idea) received from a seller through a commercial trade or some other worthwhile consideration (Kendall, 2007; Reizenstein, 2004). Customer demand patterns are deterministic or probabilistic. Deterministic demand has a repetitive pattern and will not change instantaneously. The usual pattern is obtained based on the existing case studies (existing knowledge) where the average demand becomes a reference for a deterministic pattern. For instance: company A as a consumer using biodiesel to run the engine for production with a tender for five years, means that biodiesel demand will have the same pattern for 5 years.

Probabilistic demand is an unexpected order where the demand pattern may be unknown, but may have a pattern through a number of case studies (new knowledge) that have been experienced. For example, company A, during the five-year tender, might have three new tenders where demand patterns will change due to adding three new bids. Furthermore, based on a case study of company A as a consumer, the supplier will now gain new knowledge and can discern the probability from this case, so that reserve supply will be available to meet the probabilistic customer demand.

b) Assumptions

There are some assumptions in this facility planning simulation:

1) The data and mathematical models in the simulation are deterministic.
2) There is no unexpected/uncertain event, such as natural disaster, war or terrorism attack, etc.
3) All improper forecasts are neglected, e.g. product is not available (under-stocking); or in the reverse situation over stocking.

Human errors do not occur, e.g. damage to biodiesel processing machine, leaks in pipes, etc

5.2.3. Simulation

The facility planning which is conducted in this thesis uses the heuristic methods introduced by Cooper in 1963 called ‘the Alternate Location Allocation (ALA) Procedure’. This method forms an iterative location allocation algorithm until no further changes occur. The simulation involves several existing facilities (EFs), new facilities (NFs) and aforementioned parameters. In the field of facility planning, it is literally known as a ‘multifacility location problem’.

The single facility location problem is presented beforehand, as the basis of any further consideration. Based on the Indonesian biodiesel industry, local input costs are either the same at every location or are insignificant compared to transport costs. Thus, the most suitable approach of this condition is the minimum transport-oriented single-facility location formula. The equation is focusing on minimising the sum of weighted distances between NF and m existing facilities EFi, $i = 1, \ldots, m$:

$$Minimise\ (X) = \sum_{i=1}^{m} w_i d(X_, P_{i,}) \qquad \text{Eq. 5-1}$$

where:

$w_i =$ monetary weight
$q_i =$ allocated flow requirements
$P_i =$ location of existing facility i (EF_i)
$d(X_j, P_i) =$ distance between NF at X and EF_i at Pi (kilometre)
$X =$ Location of new facility (NF)

If *m* EFs and initial *n* NFs are defined, Location-Allocation (LA) Problem can determine the allocation of the flow requirements of *m* EFs to the *n* NFs that minimise total transportation costs (see Eq. **5-2**).

$$Minimise\ f(X,W) = \sum_{j=1}^{n} \sum_{i=1}^{m} w_{ji} d(X_{j,} P_{i,}) \qquad \text{Eq. 5-2}$$

subject to:

$$\sum_{i=1}^{m} w_{ji} = w_i, i = 1, \dots, n$$

$$w_{ji} \geq 0, j = 1, \dots, m$$

where:

$X = [X_j] = [(x_j, y_j\ )], j = 1, \dots\ , n$, NF location
$W = [w_{ji}], j = 1, \dots\ , n; i = 1, \dots, m$, allocated flow requirements
$P_i = (a_i, b_i)$, location of EF_i
$d(X_j, P_i)$, distance between NF at X and EF_i at P_i (kilometre)

The author established an ALA local improvement procedure that optimises the EF allocation and then finds optimal NF locations for these allocations by the given initial NF location. Such a procedure employs MATLAB as a computational tool (see Figure 5-8)

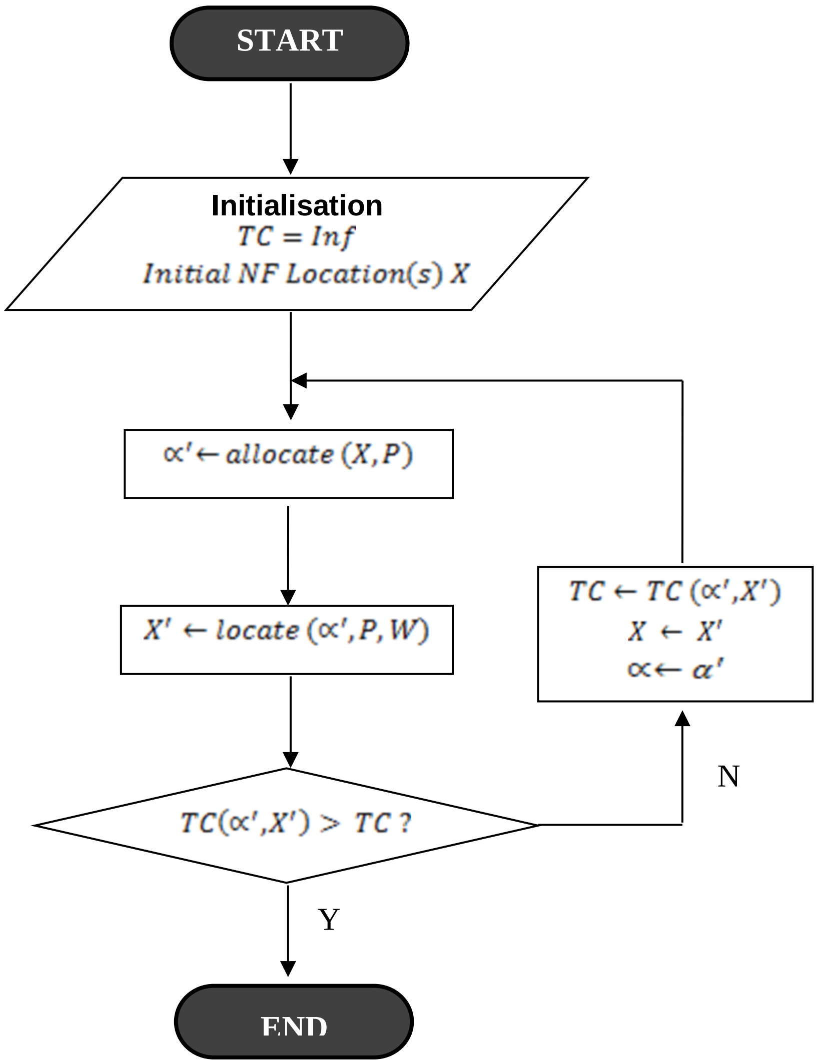


Figure 5-8 ALA Procedure in MATLAB

Location procedure solves n single facility location problems by using the EFs allocated to each NF. The n initial location of NF can optionally be taken from EFs. Exact (m) procedure for rectilinear distances (median conditions) is undertaken. Iterative optimisation procedure for general distances is realised using quasi-Newton followed by Nelder-Mead simplex SOLVER.

The allocation procedure will allocate each EF to its closest NF. If NF were capacitated, then it may solve a minimum cost network flow problem to perform the allocation process. Each EF might be allocated to more than one NF.

The total cost is determined by an optimal value from the following formula:

$$Minimise\ TC(X) = \sum_{j=1}^{n}\sum_{i=1}^{m} w_{ji} d(X_{j,} P_{i,}) = \sum_{j=1}^{n}\sum_{i=1}^{m} f_i r_i d(X_{j,} P_{i,}) \qquad \text{Eq. 5-3}$$

where:

$TC\ (X) =$ Total Cost (IDR : Indonesian Rupiah)
$X = [X_j] = [(x_j, y_j\ )], j = 1, \dots\ , n,$ NF location
$W = [w_{ji}] =\ f_i\ r_i$
$f_i =$ Total Biodiesel Consumption per DC (liter)
$r_i =$ Transport Cost $\left(\frac{\text{IDR}}{\text{Kilometre .Liter}}\right)$
$P_i = (a_i, b_i)$, location of EF_i
$d(X_j, P_i)$, distance between NF at X and EF_i at P_i (kilometre)

Prior to this simulation, a local minimum in MATLAB has to be determined for a precise result. Such an approach will tighten the tolerance of function 'fminsearch', since [0 0] stopped short of optimal. Function tolerance is defined as the size of the latest change in objective function value. In this simulation, *Tolfun* is defined in this thesis as 1e $^{-06}$. The practical TolFun in the real iteration is illustrated in Figure 5-9.

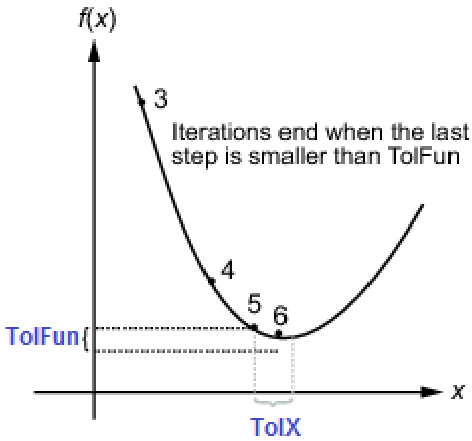


Figure 5-9 TolFun Approach

a) Scenario

The facility planning in this thesis employs Matlog as a tool for simulation. Matlog is a MATLAB Toolbox dedicated for logistic application developed by the University of North Carolina State University (NCSU) in Raleigh, North Carolina (Kay, 2015). Besides Matlog, the MATLAB simulation in this thesis is powered by geocoding-function called 'M_MAP'. It presents a GIS (Geographic Information System) on the decimal latitude-longitude (geographic coordinate system). Several M_Map-functions (e.g. makemap.m, insirect.m, pplot.m, m_proj.m, m_coord.m, m_coast, mpauseplot.m, etc) are inserted into the Matlog to plot the Indonesian coastline with 1/4 degree resolution (EOAS-UBC, 2014).

Furthermore, these two functions will be executed to obtain the minimum value of transport cost. Several parameters are considered, i.e. the amount of EFs, NFs, location and unit cost of transport between EF-NF per km and the total consumption of biodiesel

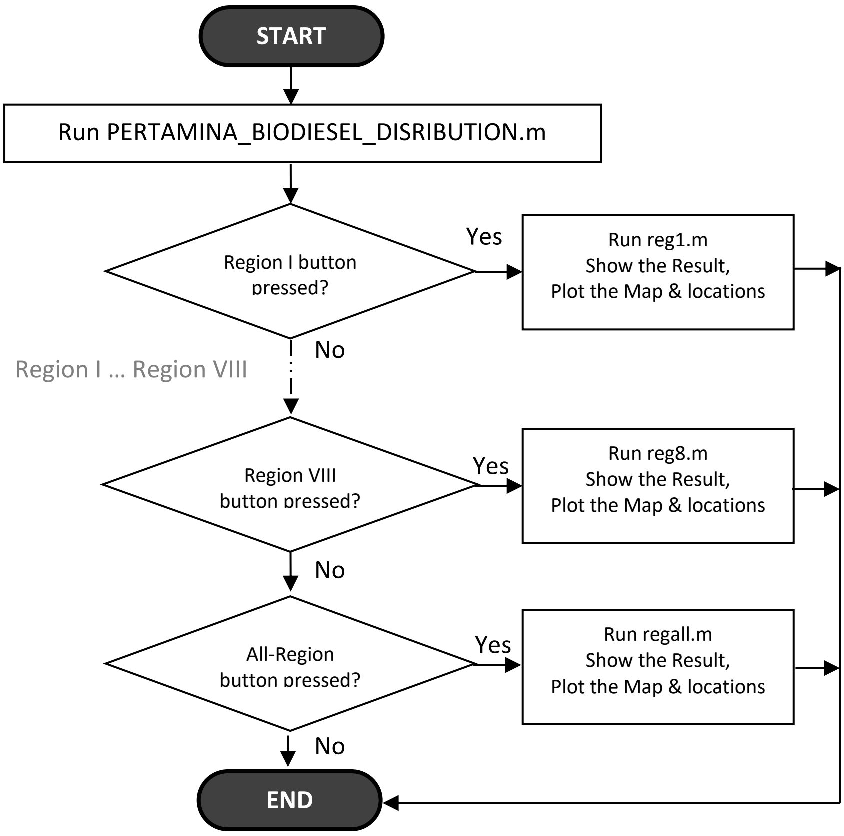


Figure 5-10 The GUI of Facility Planning Simulation

The calculation is performed in two scenarios. The first scenario optimises total cost per region (to obtain one prospective NF) and the second considers EF-NF configuration (to obtain three prospective NFs) which consider all regions (see the algorithm in Figure 5-10). In order to manage the implementation of matlog and m_map in each region, the author presents a Graphical User Interface (GUI). The GUI performs a user-friendly simulation. It is also able to control the selection order of the functions belonging to matlog and m_map under a particular algorithm (Figure 5-11).

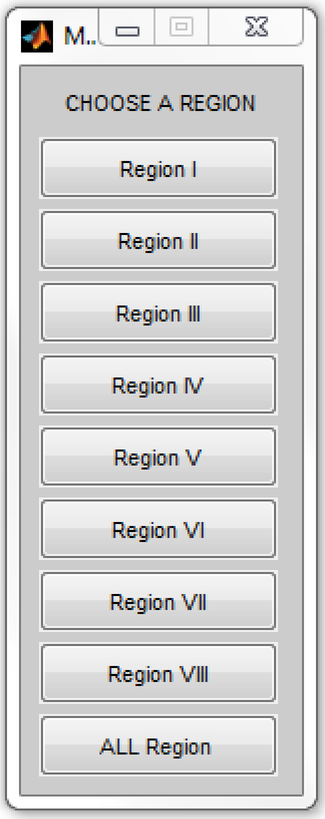


Figure 5-11 The GUI of Modular Simulation Package per Region

The simulation is carried out per region, represented by the file regX.m. X refers to the number of the region from 1-8, thus the files are: reg1.m, reg2.m, reg3.m, reg4.m, reg5.m, reg6.m, reg7.m and reg8.m. In the final option, the author also provides a simulation facility planning for all regions in the file regall.m. The MATLAB code of each file regX.m is presented in Figure 5-12.

START

RegX.m is the m file for each region from I to VIII, depending on X.
For example, reg5.m is a file to run regional V only.

XY = Mx2 matrix of city lon-lat (in decimal deg)
Pop = m – element vector of Average consumption Of the DC

P = m-row matrix of m existing facility (EF) locations
w = m-element vector of weights

regX.m
Loads data file 'regionX.mat'

Sub Function:
Loaddatafile.m

Input:
Indcity.mat (XY, Cap)

Output:
P,w

makemap.m
Create projection plot of map based on input P

Sub Function:
Isinrect.m (XY points in rectangle)
Pplot.m (projection plot)
- normlonlat.m (convert longitude and latitude to normal form)
- proj.m (Mercator projection)
- projtick.m (project tick marks on projected axes)
- Invproj.m (inverse Mercator projection)
- list2adj.m (Arc list to node node weighted adjacency matrix representation)
- mat2vect.m (**Utility** : Convert columns of matrix to vectors)
- is0.m (true for zero elements (within tolerance) and show rectangle within NF
- tri2list.m (onvert triangle indices to arc list representation)
- argmax.m (**Utillity** : Indices of maximum component)

mapdata.m (mapdata : Data for maps of the World)
boundrect.m (utility : Bounding rectangle of XY points)

Input:
P

Output:
Plot and projection of Existing Facilities

m_proj.m
To initializes map projection info

Sub Function:

m_coord.m (initializes the coordinate system for various conversions)
pauseplot.m (draw and pause after plotting)
randX.m (Random generation of n points X that are within P's boundaries)

1

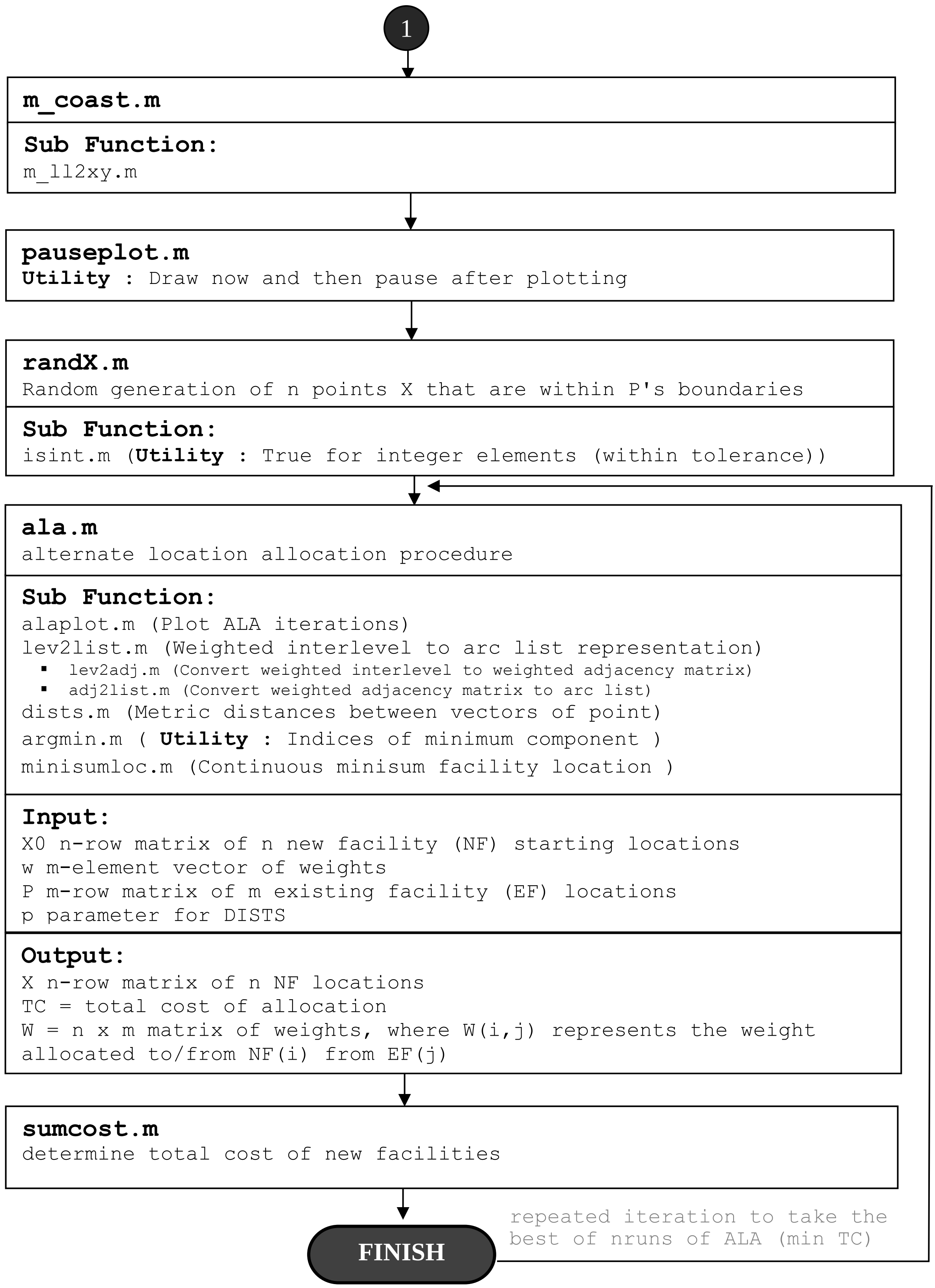


Figure 5-12 MATLAB Algorithm of the Simulation per Region

According to Eq. 5-3, there are three important parameters, i.e. the location, biodiesel consumption and transport cost. The following section presents those parameters before the simulation is undertaken.

Set of Parameter

[PAR-1] Location

The locations of the terminals/depots are mapped using the coordinates system; the numbers represent vertical and horizontal positions. In Geographic Coordinate System (GCS), these vertical and horizontal positions are often referred as Longitude and Latitude, respectively.

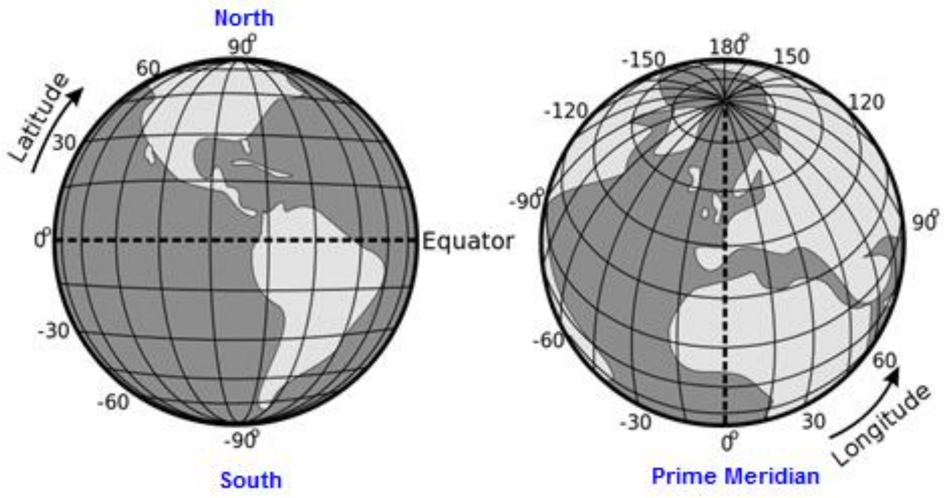


Figure 5-13 Latitude and Longitude of the Earth (Sickle, 2010)

In the geographic field of study, people express Latitude and Longitude in three formats (Sickle, 2010):

- Degree, Minutes and Second (DMS);
- Degrees and Decimal Minutes (DMM);
- Decimal degree (DD).

This simulation employs the Longitude and Latitude as input locations in DD formats. Figure 5-14 shows the distribution of positive and negative values for Longitude (X) and Latitude (Y) coordinates worldwide. X coordinates are Longitude values measured in degrees between -180 and 180 relative to 0,0 coordinates (the cross section between Equator and Prime Meridian). Y coordinates are Latitude values measured in degrees between -90 and +90 relative to 0,0 coordinates. By knowing the locations, the distance between depot/terminals can be measured.

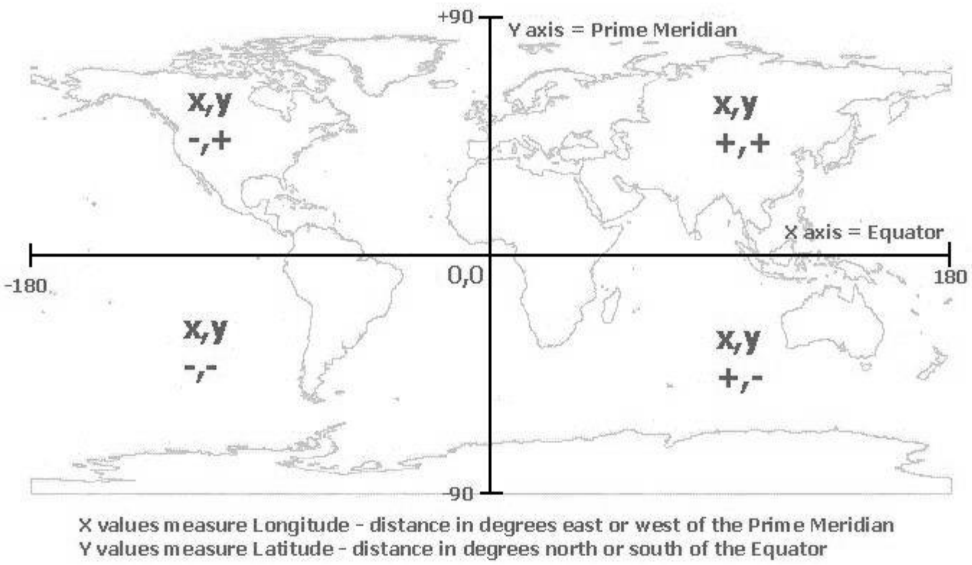


Figure 5-14 Distribution of Positive and Negative Values for Longitude (X) and Latitude (Y) Coordinates Worldwide

The makemap.m function (see Code-Listing 1) creates the projection plot and the XY parameters (longitude-latitude pairs, in decimal degree). A set of Indonesian Longitude-Latitude data was prepared in the file 'indcity.m'. It is used to fix axes limits by calling boundrect.m to get bounding rectangle of the view.

```
makemap(P) %% Create projection plot of World or Indonesia
```

Code-Listing 1 MATLAB 'makemap' Function

The distance between two locations is measured and calculated using the great distance method on the surface of a sphere (e.g., the earth) corresponding to the shortest distance between two points on the surface along the circle formed by the intersection of the surface and a plane passing through the centre of the sphere. In this case, the elevation of the points on the surface is ignored.

The Haversine formula is used to measure great circle distance (d_{rad}) in the radian unit of a sphere (see Figure 4.7):

$$d_{rad} = c = 2sin^{-1}\min\left\{1, \sqrt{sin^2\left(\frac{y_1 - y_2}{2}\right) + cos(y_1)cos(y_2)sin^2\left(\frac{x_1 - x_2}{2}\right)}\right\} \quad \text{Eq. 5-4}$$

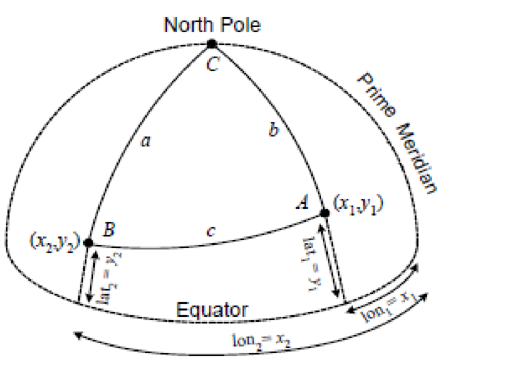


Figure 5-15 Great Circle Distance Derivation

This formula will be formulated in MATLAB as follows:

```
D = 2*asin(min(1,sqrt(sin((X1(:,2) - X2(:,2))/2).^2 + ...
    cos(X1(:,2)).*cos(X2(:,2)).* ...
    sin((X1(:,1) - X2(:,1))/2).^2)))';
```

Code-Listing 2 Haversine Formula Written in MATLAB

Finally, the great circle distance (d_{GC}) between 2 points on the surface of the earth specified by their Longitude (lon) and Latitude (lat) angles (in radians) is as follows:

$$(lon_1, lat_1) = (x_1, y_1);\ (lon_2, lat_2) = (x_2, y_2)$$
$$d_{GC} = distance(x_1, y_1)\ to\ (x_2, y_2) = d_{rad}.R \qquad \text{Eq. 5-5}$$

Where:

$d_{rad} = c$ (Eq. 5-4)

and

$$R = 6.378388 - 21.476sin\left(\frac{y_1 + y_2}{2}\right)\ km \qquad \text{Eq. 5-6}$$

MATLAB represents Eq. 5-5 in the following form:

```
D = (6378.388 - 21.476*abs(sin(meanlat))).*D;
```

Code-Listing 3 MATLAB Formula to Find Radius in km

All the calculations of distance are handled by the main function dists.m

```
D = dists(X,P,p);
```

Code-Listing 4 MATLAB Distance Function

[PAR-2] Biodiesel Consumption per Fuel Terminal/DC

Another parameter to be considered is total assumed biodiesel consumption. W is considered as monetary weight. The value of W can be obtained by multiplying the rate of physical weight and transport rate ($W = f_i\, r_i$). The author uses the average biodiesel consumption (***f****i*) data per DC or TBBM in 2014 as the physical rate input (see Appendix 5).

[PAR-3] Transport Rate

The transport rate (***r****i*) is given by Pertamina (2015), as summarised in Table 5-5.

Table 5-5 2014 Transport Rate per Region

Region	IDR/KL-Km Average	IDR/L-Km Average
I	1043.375	1.043375
II	987.875	0.987875
III	858.375	0.858375
IV	913.875	0.913875
V	1117.375	1.117375
VI	1209.875	1.209875
VII	1265.375	1.265375
VIII	2604.75	2.60475

A typical biodiesel tank-truck for transport can be seen in Figure 5-16.

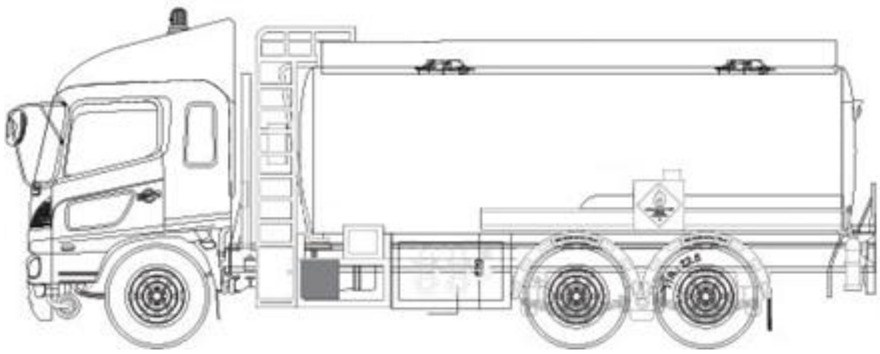


Figure 5-16 Biodiesel Tank-Truck

b) Results

Scenario-1: Simulation per Region for one Prospective NF.

Simulation per region basically has the same structure and procedure. One example of a region is displayed, and then the results of running simulations in every region are presented afterwards.

Consider: Region I

[PAR-1] Location

The following data are identified as the DC locations in Region VI (see Table 5-6):

Table 5-6 The Coordinate Locations of DCs in Region VI

No.	Location	Longitude	Latitude
1	Medan	3.7471	98.676
2	Dumai	1.6725	101.4896
3	Siak	0.5432	101.4603
4	Kabil	1.0707	104.133
5	Tg Uban	1.0681	104.2295
6	Tembilahan	1.0782	104.2167
7	Kisaran	2.9853	99.6198
8	Siantar	2.9619	99.0576
9	Lhokseumawe	5.1884	97.1498
10	Sibolga	1.7364	98.7809
11	Meulaboh	4.145	96.1397
12	Krueng Raya	5.5418	95.2939
13	Sabang	5.89	95.3174
14	Sitoli	1.1959	97.675
15	Kijang	0.8645	104.6105

[PAR-2] Biodiesel Consumption per Fuel Terminal/Depot

The consumption rate of biodiesel in Region VI is presented in Table 5-7 (taken from Appendix 5):

Table 5-7 2014 DC Consumption in Region VI

No.	Location	Consumption Rate (Liter)
1	Medan	212048000
2	Dumai	112276000
3	Siak	63975000
4	Kabil	37667667
5	Tg Uban	18833833
6	Tembilahan	37667667
7	Kisaran	21237667
8	Siantar	21237667
9	Lhokseumawe	27793000
10	Sibolga	10618833
11	Meulaboh	27793000
12	Krueng Raya	13896500
13	Sabang	13896500
14	Sitoli	10618833
15	Kijang	18833833

[PAR-3]

The transport rate for Region I is **1.043375** IDR/ Liter-Km (see Table 5-5).

MATLAB calls the function region6.m and executes several procedures to conduct an iterative calculation in order to obtain the minimum TC using equation 5-3: $Minimise\ TC(X) = \sum_{i=1}^{m} f_i\, r_i\, d(X_{j,}P_{i,})$. First, MATLAB loads the data file of ‘region6.mat’ which contains a list of city names where the EFs are located. The location of the city is written in Longitude-Latitude by DD. Moreover, the region6.mat file also encompasses consumption rate of biodiesel per DC. The simulation result shows that the proposed NF is located at Longitude: 99.4116 and Latitude: 3.0679.

The nearest distances between existing biodiesel terminals (EFs) and the new terminal (NF) are calculated in Table 5-8.

Table 5-8 The Nearest Distance of Existing Facilities to a New Facility

No	EF		NF	Nearest distances (km)
	Longitude	Latitude		
1.	98.676	3.7471	(99.4116, 3.0679)	111.31
2.	101.4896	1.6725		278.40
3.	101.4603	0.5432		361.79
4.	104.133	1.0707		570.22
5.	104.2295	1.0681		580.23
6.	104.2167	1.0782		578.48
7.	99.6198	2.9853		24.90
8.	99.0576	2.9619		41.07
9.	97.1498	5.1884		344.49
10.	98.7809	1.7364		163.94
11.	96.1397	4.145		382.62
12.	95.2939	5.5418		533.36
13.	95.3174	5.89		552.10
14.	97.675	1.1959		284.09
15.	104.6105	0.8645		628.11

The result of Region VI simulation is shown in Figure 5-17.

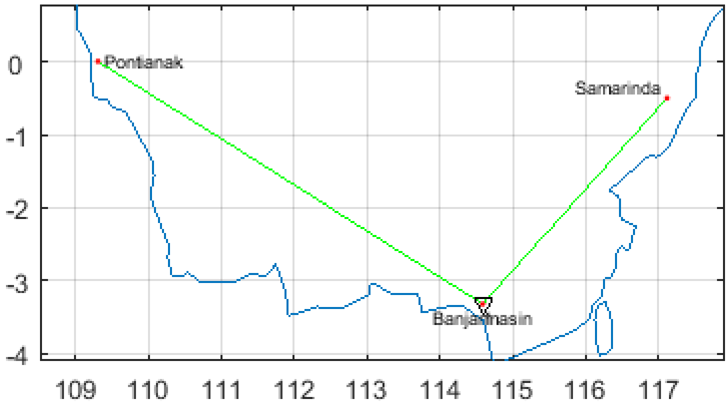


Figure 5-17 MATLAB Result Graph for Scenario-1 Simulation

The MATLAB command-window returned the following results:

```
P =
    98.6760    3.7471
   101.4896    1.6725
   101.4603    0.5432
   104.1330    1.0707
   104.2295    1.0681
   104.2167    1.0782
    99.6198    2.9853
    99.0576    2.9619
    97.1498    5.1884
    98.7809    1.7364
    96.1397    4.1450
    95.2939    5.5418
    95.3174    5.8900
    97.6750    1.1959
   104.6105    0.8645

Name =
    'Medan Group'
    'Dumai'
    'Sei Siak'
    'Kabil'
    'Tg Uban'
    'Tembilahan'
    'Kisaran'
    'Siantar'
    'Lhokseumawe'
    'Sibolga'
    'Meulaboh'
    'Krueng Raya'
    'Sabang'
    'Sitoli'
    'Kijang'
```

```
w =
   212048000
   112276000
    63975000
    37667667
    18833833
    37667667
    21237667
    21237667
    27793000
    10618833
    27793000
    13896500
    13896500
    10618833
    18833833

m =
    15

n =
     1

NF =
   99.4116    3.0679

TC =
   1.9356e+11
```

Notes:

P: the matrix of EF coordinates
Name: the location name of EF
w: the financial weigth (DC consumption rate)
m: the number of EF
n: the number of NF to be simulated
NF: the coordinate location of NF
TC: the total cost

The location of the NF can be identified by the function ‘lonlat2city.m’. This function determines the nearest city given the Longitude-Latitude of location.

```
function [idx,dist,drt,dstr] = lonlat2city(XY,city)
```

Code-Listing 5 The Function to Determine the Nearest City

Code-Listing Notes:

```
XY = n x 2 matrix of lon-lat (in decimal degrees) of n locations

Optional input argument:
city = stucture with fields:
       Name = m-element cell array of m city name strings
       ST = m-element cell array of m 2-char state abbreviations
       XY = m x 2 matrix of city lon-lat (in decimal deg)
           = indcity, (contains 101 cities of Indonesian DC or TBBM)
```

```
Output arguments: 'dstr' is displayed if no output arguments
specified
       idx = index of nearest city
      dist = distance to nearest city (in km)
       drt = direction to nearest city,
             reported from 0 to 2-phi radians clockwise from north
      dstr = display of nearest city to lat-lon
             (in city, if dist < 4 km)
           = string, if n == 1
           = n-element cell array, if n > 1
            (disp(dstr{i}) used to display ith display string)
```

Using 'lonlat2city.m' function, the NF coordinate can be translated into the city location where EFs are located.

```
>> lonlat2city(NF)

 NF is 15.47 km W of Kisaran, KIS
```

It means that a NF is calculated as 15.47 km in the direction of Kisaran (code: KIS).

Then, all of the NFs resulted from 'per region – simulation' can be reported in Table 5-9.

Table 5-9 The Results of Per-Region Simulation Using 1 Iteration and 1 NF Targeted

Region	NF		Location	TC
	Longitude	Latitude		(IDR)
I	3.0679	99.4116	NF is 15.47 km W of Kisaran	193,560,000,000
II	-3.461	104.1660	NF is 42.15 km N of Baturaja	64,312,000,000
III	-6.3933	107.4246	NF is in Cikampek	52,150,000,000
IV	-7.4423	110.4224	NF is 18.03 km W of Boyolali	20,469,000,000
V	-8.5000	115.2502	NF is 16.65 km N of Sanggaran	118,350,000,000
VI	-2.7247	114.4409	NF is 42.71 km N of Banjarmasin	105,810,000,000
VII	-2.6606	121.1718	NF is 46.96 km S of Kolonedale	94,195,000,000
VIII	-2.9299	132.3035	NF is in Fak-Fak	116,140,000,000

Scenario-2: Simulation of All Regions for Three Prospective NFs.

Moreover, using the same procedure, further simulation was performed to obtain three prospective NFs involving all regions simultaneously. The simulation result is shown in Figure 5-18.

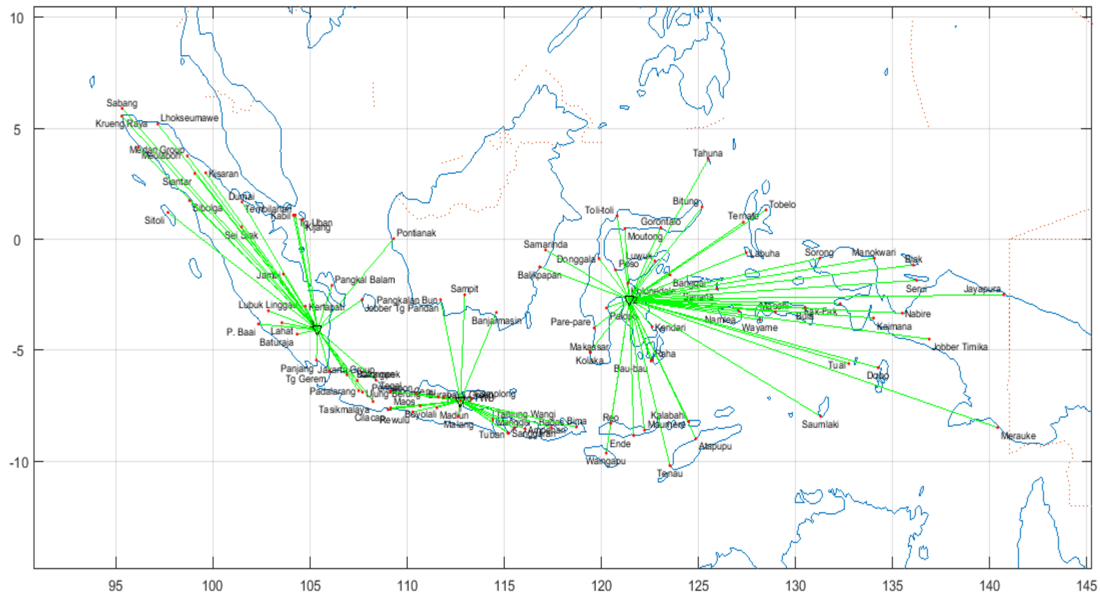


Figure 5-18 Graphical Illustration of Results for Scenario-2

In the command window, MATLAB returned the following results:

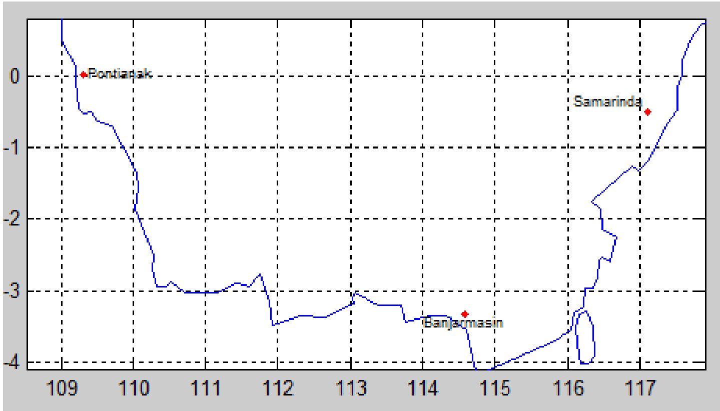
```
m =
   101

n =
     3

NF =
  112.7373   -7.3014
  121.4459   -2.7455
  105.3797   -4.1041

TC =
   1.8700e+12

>> lonlat2city(NF)

NF 1 is in Surabaya Group, SBY
NF 2 is 51.45 km S of Kolonedale, KLN
NF 3 is 73.92 km E of Baturaja, BTR
```

c) Validation

A validation check was undertaken by comparing the output result from MATLAB (ALA procedure) and Microsoft Excel (SOLVER). The core problem to be solved was to find an optimal value for total cost (Eq. 5-3). This section uses 5 case studies which are divided into two parts. The first part is conducted through three simple cases using 1, 2 and 3 prospective NF(s) in Case-1, Case-2 and Case-3. The purpose of this evaluation was to compare the results of MATLAB and Microsoft Excel. From this comparison, the reader can justify that the outcome is accurate. Moreover, the second part studies the relationship between several established NFs and the obtained total cost (TC). It is presented in Case-4.

Case-1:

There is a study about the urgency to build a new DC among 3 existing DCs in Pontianak, Banjarmasin and Samarinda (Region VI). The goal is to find a location which has minimal TC. TC factors to be considered are the transportation cost, distance and biodiesel consumption/capacity annually. The study begins by examining DC/TBBM Pontianak as the initial location (Figure 5-19).



Location of existing facilities	
Pontianak	[109.3026;0.0073]
Banjarmasin	[114.5902;-3.324]
Samarinda	[117.1198;-0.4997]

Initial location of New TBBM	
Pontianak	[109.3026;0.0073]

Figure 5-19 Location of Three Existing DCs/TBBMs and Pontianak set as a New Initial Location

Calculation in Microsoft Excel (SOLVER):

SOLVER in Excel minimises the TC using the following formula:

```
fx  =((F11*F4)+(F12*F5)+(F13*F6))*1.209875
```

Code-Listing 6 Case 1 Total Cost Formula in Microsoft Excel

TC was obtained by changing the NF value until it reached a minimum. The NF was set [109.3026 0.0073] before the simulation was run. Design value and parameters of the simulation are described in Figure 5-20 and Figure 5-21. The result after Microsoft Excel (SOLVER) was executed is then presented in Figure 5-22.

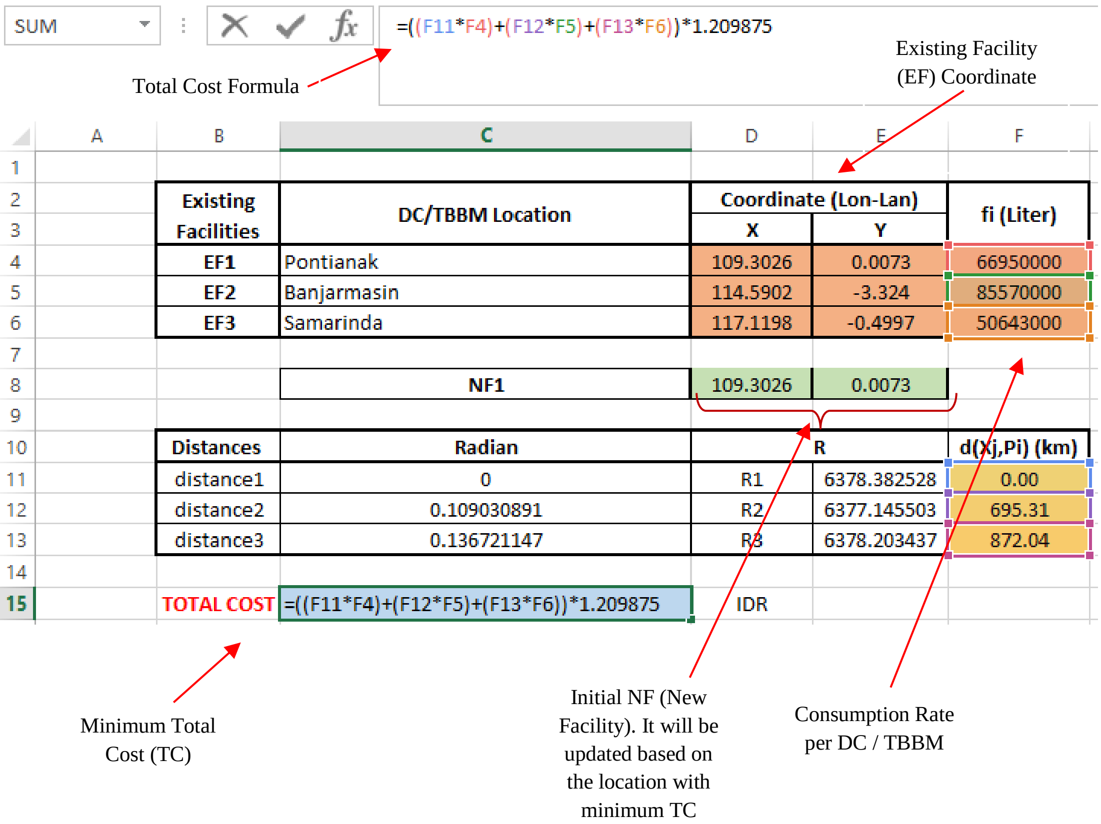


Figure 5-20 Case 1 Excel (SOLVER) Design

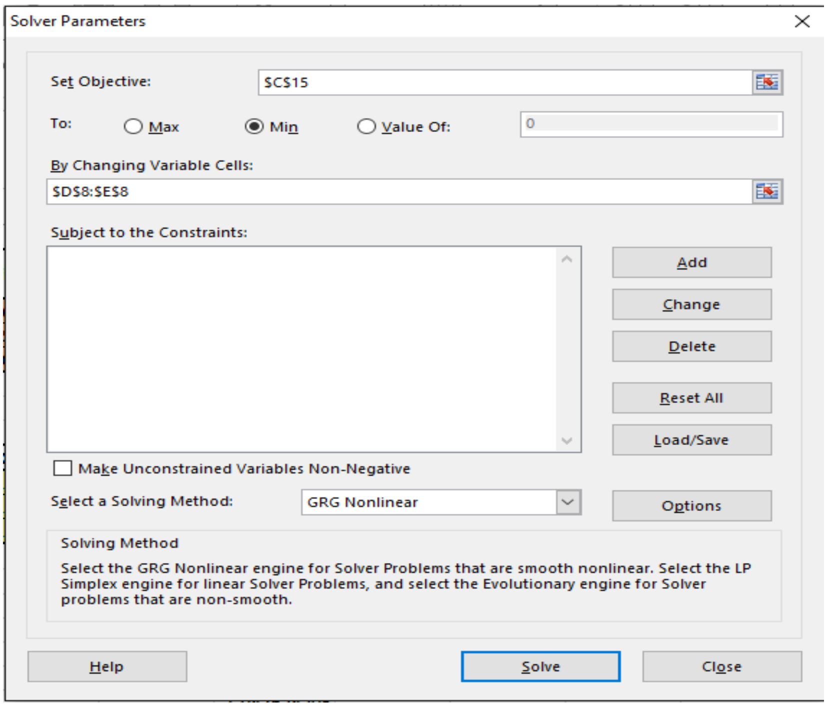
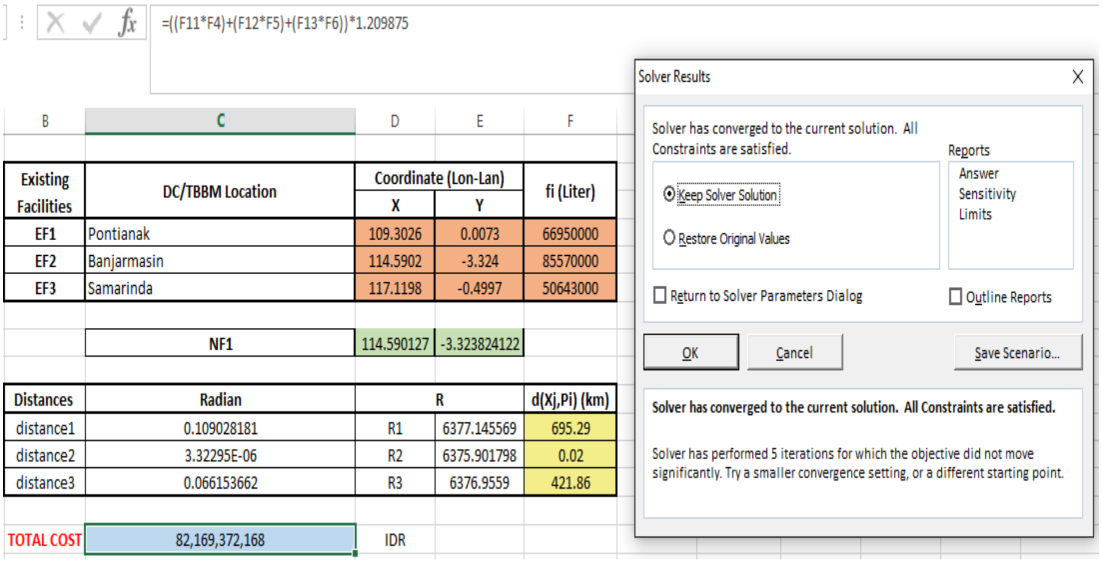


Figure 5-21 Case 1 Excel (SOLVER) Parameter



Existing Facilities	DC/TBBM Location	Coordinate (Lon-Lan) X	Coordinate (Lon-Lan) Y	fi (Liter)
EF1	Pontianak	109.3026	0.0073	66950000
EF2	Banjarmasin	114.5902	-3.324	85570000
EF3	Samarinda	117.1198	-0.4997	50643000
	NF1	114.590127	-3.323824122	

Distances	Radian		R	d(Xj,Pi) (km)
distance1	0.109028181	R1	6377.145569	695.29
distance2	3.32295E-06	R2	6375.901798	0.02
distance3	0.066153662	R3	6376.9559	421.86
TOTAL COST	82,169,372,168	IDR		

Figure 5-22 Case 1 Result Using Excel (SOLVER)

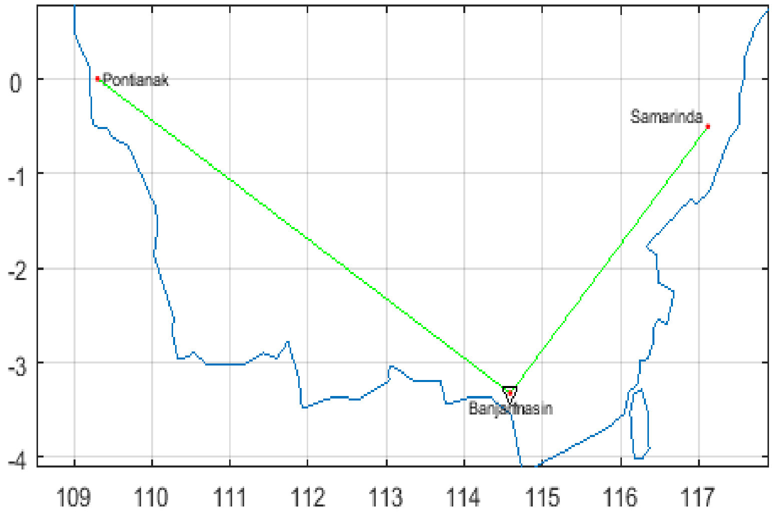
Calculation in MATLAB

ALA function will be called to solve iteratively until NF with minimum TC is located.

```
%% Use DEFAULT ALA Procedure
[NF,TC] = ala([109.3026 0.0073],w,P,'km') % Initial NF location in Pontianak
```

Code-Listing 7 Case 1 using ALA Function in MATLAB

The case-1 simulation in MATLAB gave the following result (see Figure 5-23).



MATLAB Calculation

```
NF =

  114.5902   -3.3240

TC =

   8.2176e+10

>> lonlat2city(NF)

NF is in Banjarmasin, BJR
```

Figure 5-23 Case 1 Result using MATLAB (ALA Function)

Case-2:

There is a plan to build 2 new terminals/depots by considering 4 existing terminals/depots in Pontianak, Banjarmasin, Samarinda and Balikpapan (see Figure 5-24). The study begins by examining DC/TBBM Pontianak and Banjarmasin as initial locations.

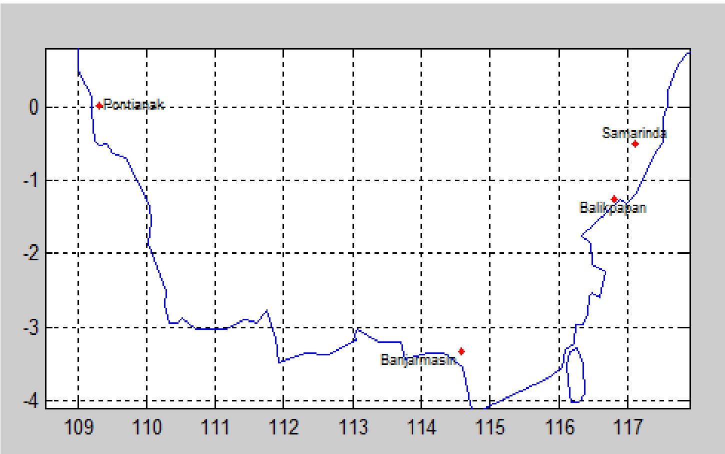


Figure 5-24 Location of four existing DCs/TBBMs in Case-2

Calculation in Microsoft Excel (SOLVER):

SOLVER in Excel will try to minimise the TC formula:

```
fx  =(H20*E14+I20*E20+H21*E15+I21*E21+H22*E16+I22*E22+H23*E17+I23*E23)*1.209875
```

Code-Listing 8 Case 2 Total Cost Formula in Microsoft Excel

TC was obtained by changing the NF value until it reached a minimum. Initial new locations for NFs were defined from EFs TBBM Banjarmasin and Pontianak (see Table 5-10).

Table 5-10 The Coordinates of Initial NF1 Banjarmasin and NF2 Pontianak

NF1	114.5902	-3.324
NF2	109.302593	0.00729544

The calculation design of the Excel (SOLVER) is illustrated in Figure 5-25 and the result given is depicted in Figure 5-26. The result after Microsoft Excel (SOLVER) was executed is then presented in Figure 5-27.

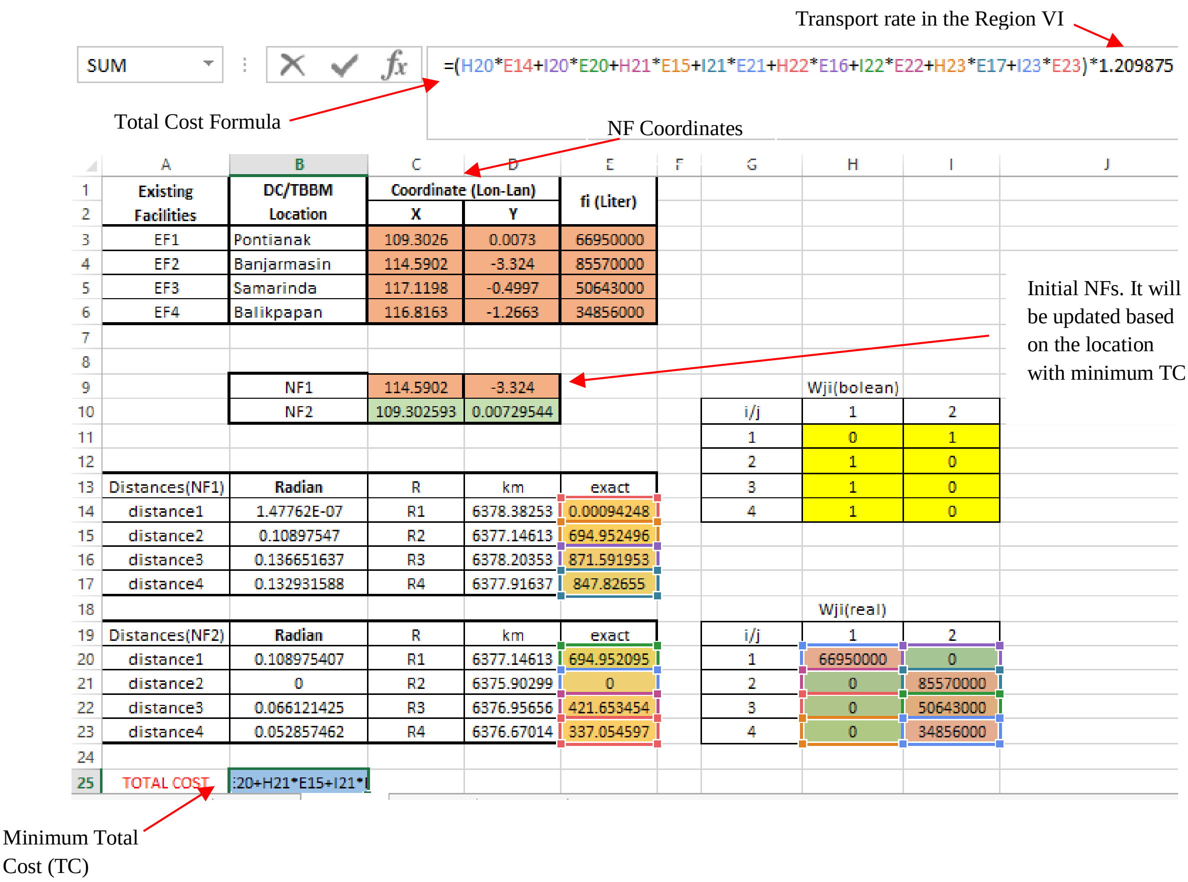


Figure 5-25 Case 2 Excel (SOLVER) Design

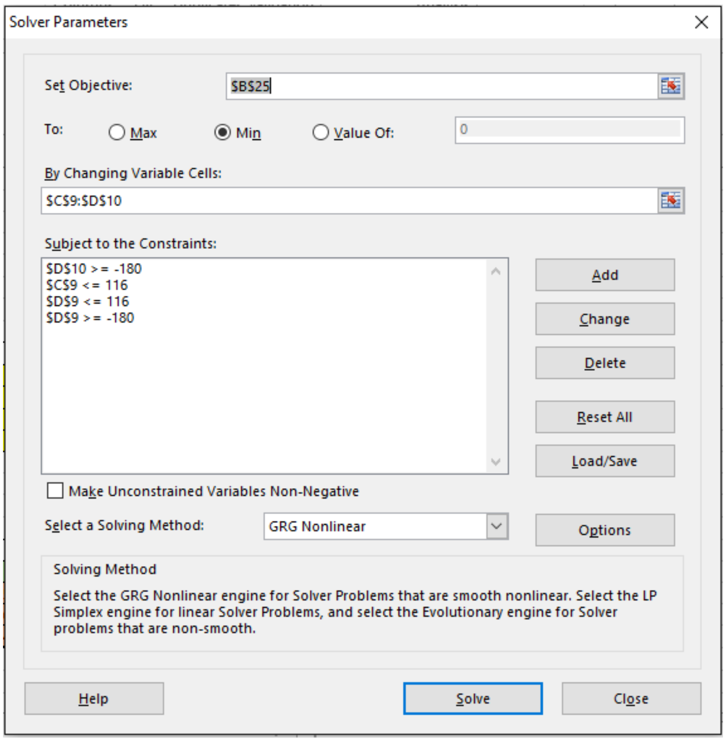


Figure 5-26 Case 1 Excel (SOLVER) Paramater

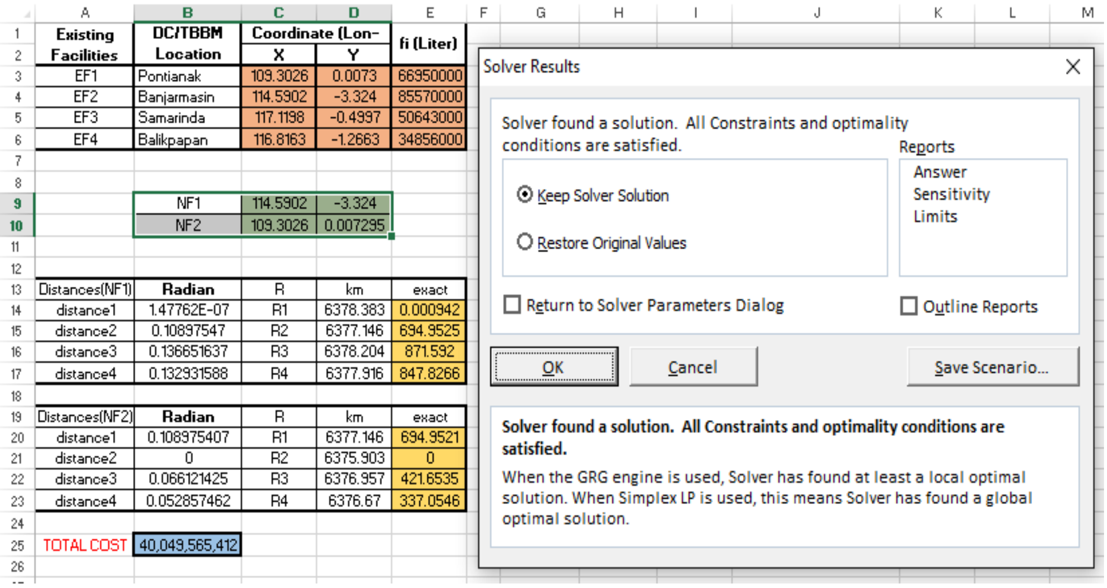


Figure 5-27 Case 2 Result Using Excel (SOLVER)

The NF result was manually calculated considering the closest distance to each EFs. Meanwhile, for Case-2, Banjarmasin and Pontianak were initially defined as NF1 and NF2. A matrix in Table 5-11 presents a strategy to define Banjarmasin manually as an initial NF1. In that position, Banjarmasin only considers the three nearest EFs

(Banjarmasin, Samarinda and Balikpapan). Such consideration is marked by setting capacities values to the matching column and giving 0 values for the column which does not correspond.

Table 5-11 Banjarmasin Manually Set as an NF1

Wji(real)

i/j	1	2
1	66950000	0
2	0	85570000
3	0	50643000
4	0	34856000

Calculation in MATLAB

ALA function will be called to solve iteratively until 2 NFs with minimum TC are located.

```
%% Solve ALA for 2 multi initial location
[NF,TC] = ala([116.8160546 -1.26611378;109.3025548 0.00735222],w,P,'km');
```

Code-Listing 9: Case 2 Formula Written in MATLAB (ALA Function)

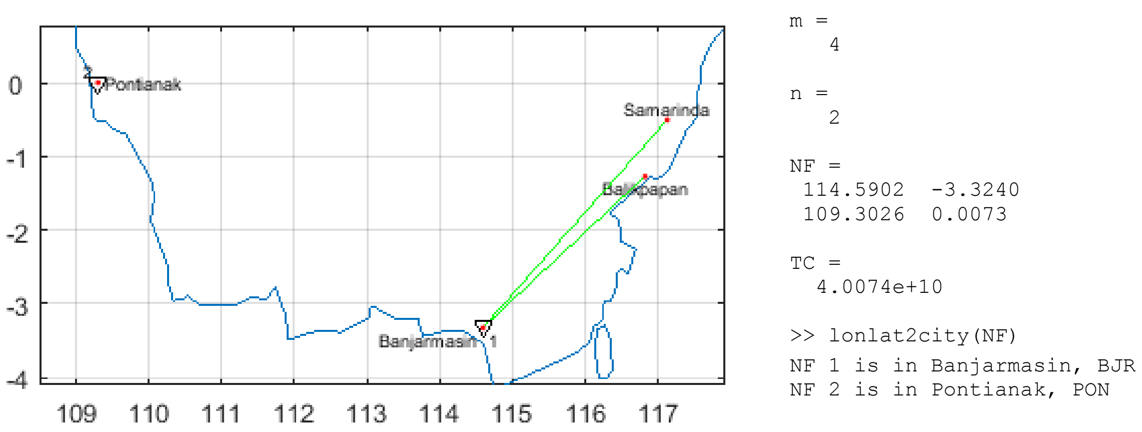
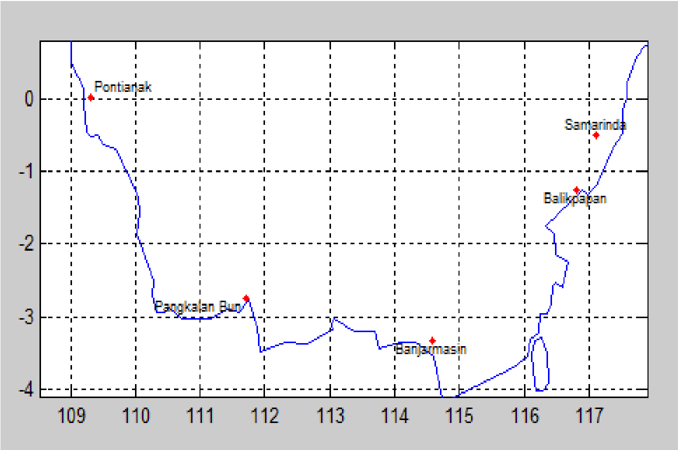


Figure 5-28 Case 2 Result using MATLAB (ALA Function)

Case-3:

There is a study of 3 NFs by considering 5 EFs (Pontianak, Banjarmasin and Samarinda, Balikpapan and Pangkalan-Bun) shown in Figure 5-29. However, the 3 initial NFs are unspecified and randomly chosen.



Location of existing facilities	
Pontianak	[109.3026;0.0073]
Banjarmasin	[114.5902;-3.324]
Samarinda	[117.1198;-0.4997]
Balikpapan	[116.8163;-1.2663]
Pangkalan Bun	[117.7157;-2.7453]

Figure 5-29 Location of Five EFs

Calculation using Microsoft Excel (SOLVER)

SOLVER in Excel will try to minimise using the following TC formula:

```
fx =(I20*F14+J20*F21+K20*F28+I21*F15+J21*F22+K21*F29+I22*F16+J22*F23+K22*
F30+I23*F17+J23*F24+K23*F31+I24*F18+J24*F25+K24*F32)*1.209875
```

Code-Listing 10: Case 3 Total Cost Formula written in EXCEL (SOLVER)

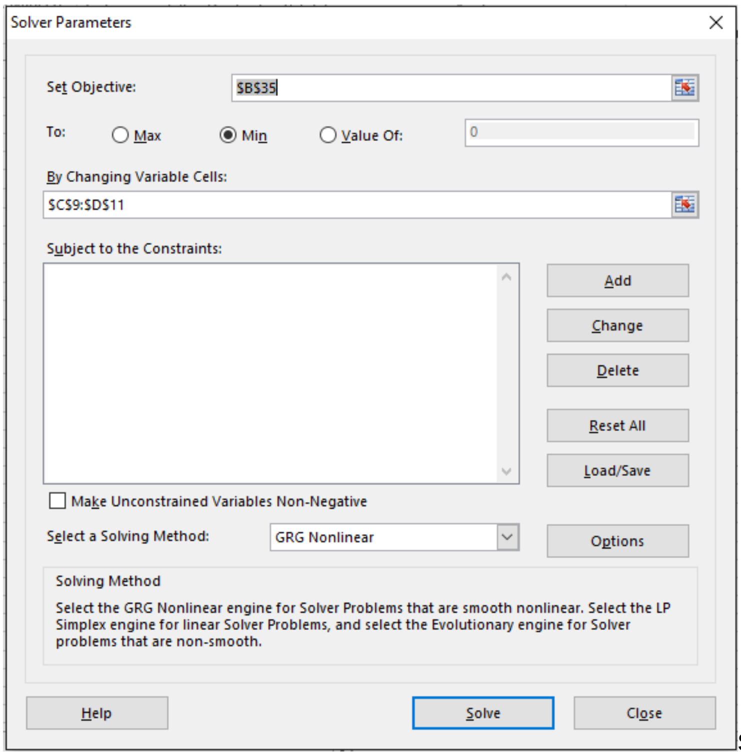
TC was obtained by changing the NF value until it reached the minimum. The financial weight for NF (biodiesel consumption) was defined manually based on the following information:

- The 1st NF should be located nearby Banjarmasin and Pangkalan Bun,
- The 2nd NF nearby Samarinda and Balikpapan,
- The 3rd NF nearby Pontianak.

These weight strategies are described in Table 5-12.

Table 5-12 Financial Weight Consideration for Case 3

i/j	1	2	3
1	0	0	66950000
2	85570000	0	0
3	0	50643000	0
4	0	34856000	0
5	10177000	0	0



S

Figure 5-30 Calculation Design for Case-3 with 6 EFs and 3 NFs using Excel

	A	B	C	D	E	F	G	H	I	J
1	**Existing**	**DC/TBBM**	**Coordinate (Lon-**							
2	**Facilities**	**Location**	**X**	**Y**			Wji(bolean)			
3	EF1	Pontianak	109.3026	0.0073			i/j	1	2	3
4	EF2	Banjarmasin	114.5902	-3.324			1	0	0	1
5	EF3	Samarinda	117.1198	-0.4997			2	1	0	0
6	EF4	Balikpapan	116.8163	-1.2663			3	0	1	0
7	EF5	Pangkalan Bun	111.7157	-2.7453			4	0	1	0
8							5	1	0	0
9		**NF1**	0	0						
10		**NF2**	0	0						
11		**NF3**	0	0						
12							Wji(real)			
13	**Distances(NF1)**	**Radian**	**R**		**d(Xj,Pi) (km)**		i/j	1	2	3
14	distance1	1.907694709	R1	6378.385	12168.01182		1	0	0	66950000
15	distance2	1.999211173	R2	6377.143	12749.25508		2	85570000	0	0
16	distance3	2.043070479	R3	6378.201	13031.11356		3	0	50643000	0
17	distance4	2.038710373	R4	6377.913	13002.7182		4	0	34856000	0
18	distance5	1.948363057	R5	6377.359	12425.41142		5	10177000	0	0
19										
20	**Distances(NF2)**	**Radian**	**R**		**d(Xj,Pi) (km)**					
21	distance1	1.906723131	R1	6378.385	12161.81472					
22	distance2	1.998195445	R2	6377.143	12742.77764					
23	distance3	2.043070436	R3	6378.201	13031.11329					
24	distance4	2.03767245	R4	6377.913	12996.09841					
25	distance5	1.948363057	R5	6377.359	12425.41142					
26										
27	**Distances(NF3)**	**Radian**	**R**		**d(Xj,Pi) (km)**					
28	distance1	1.906723131	R1	6378.385	12161.81472					
29	distance2	1.998195445	R2	6377.143	12742.77764					
30	distance3	2.043070436	R3	6378.201	13031.11329					
31	distance4	2.03767245	R4	6377.913	12996.09841					
32	distance5	1.948363057	R5	6377.359	12425.41142		TOTAL COST	3,804,533,411,152		

Figure 5-31 Case-3 Calculation Design using Excel, all NFs set to Zero

	A	B	C	D	E	F	G	H	I	J
1	Existing	DC/TBBM	Coordinate (Lon-							
2	Facilities	Location	X	Y			Wij(bolean)			
3	EF1	Pontianak	109.3026	0.0073			i/j	1	2	3
4	EF2	Banjarmasin	114.5902	-3.324			1	0	0	1
5	EF3	Samarinda	117.1198	-0.4997			2	1	0	0
6	EF4	Balikpapan	116.8163	-1.2663			3	0	1	0
7	EF5	Pangkalan Bun	111.7157	-2.7453			4	0	1	0
8							5	1	0	0
9		NF1	115	-3						
10		NF2	117	0						
11		NF3	109	0						
12							Wij(real)			
13	Distances(NF1)	Radian	R		d(Xj,Pi) (km)		i/j	1	2	3
14	distance1	0.10902951	R1	6377.146	695.2970483		1	0	0	66950000
15	distance2	1.62288E-06	R2	6375.902	0.010347312		2	85570000	0	0
16	distance3	0.066141212	R3	6376.956	421.7795875		3	0	50643000	0
17	distance4	0.052885554	R4	6376.669	337.2336856		4	0	34856000	0
18	distance5	0.051079465	R5	6376.117	325.6886638		5	10177000	0	0
19										
20	Distances(NF2)	Radian	R		d(Xj,Pi) (km)					
21	distance1	0.136650854	R1	6378.203	871.5869454					
22	distance2	0.066120213	R2	6376.956	421.6456769					
23	distance3	1.2166E-06	R3	6378.013	0.007759499					
24	distance4	0.014381393	R4	6377.726	91.72058485					
25	distance5	0.102045029	R5	6377.172	650.7587363					
26										
27	Distances(NF3)	Radian	R		d(Xj,Pi) (km)					
28	distance1	1.16748E-05	R1	6378.382	0.074466511					
29	distance2	0.108982246	R2	6377.146	694.9956657					
30	distance3	0.136653002	R3	6378.204	871.60068					
31	distance4	0.13293415	R4	6377.916	847.8428938					
32	distance5	0.063855478	R5	6377.362	407.2295191		TOTAL COST	7,885,735,560		

Figure 5-32 Case-3 Result using Microsoft Excel (SOLVER)

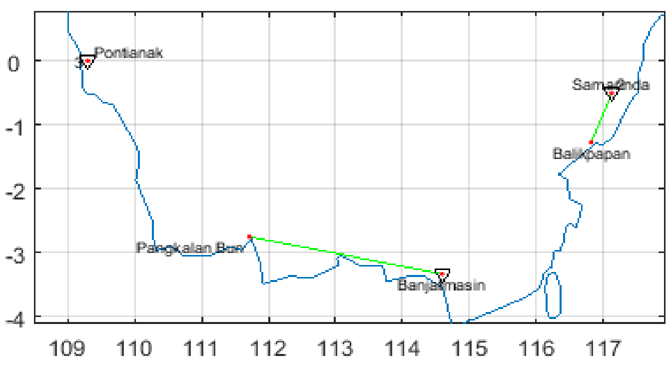
Microsoft Excel reported (see Figure 5-32) that the NFs are located in the following coordinates: [112,42444 -2,8770086], [117.06686 -0.618782] and [109.30274 0.0076343].

Calculation in MATLAB

ALA function is called to solve iteratively for 3 NFs until the minimum TC is achieved (see Code-Listing 10). The initial location of NFs are set to be random: randX(P,n).

```
[X,TC] = ala(randX(P,n),w,P,'km');
```

Code-Listing 11: Case-3 Formula Written in MATLAB (ALA Function)




```
m =
     5

n =
     3

NF =
  109.3026    0.0073
  117.1198   -0.4997
  114.5902   -3.3240

TC =
   7.8833e+09

>> lonlat2city(NF)
NF 1 is in Pontianak, PON
NF 2 is in Samarinda, SMR
NF 3 is in Banjarmasin, BJR
```

Figure 5-33 Calculation and Geographic Simulation Result using MATLAB for Case-3

Case-4:

The Case-4 reviews the relationship between iteration of NFs corresponding to the TC. Some iterations are used to attain the lowest TC in region III.

```
[NF,TC] = ala(randX(P,n),w,P,'km') % Distance in km
nruns = 10; TC2 = Inf;
for i = 1:nruns
[X2i,TC2i,W2i] = ala(randX(P,n),w,P,'km');
fprintf('%d %e\n',i,TC2i);
    if TC2i < TC2, TC2 = TC2i;
        X2 = X2i;
        W2 = W2i;
    end
end
TC, TC2
```

Code-Listing 12: MATLAB Iteration Code to Minimise TC

Iteration is undertaken to be associated with the position of prospective NF approaching the nearest EF. All possible TC can occur because the initial NF is random. The following graphs exhibit such an experiment which used 10 iterative simulations to find minimum TCs in region III (see Figure 5-34).

.

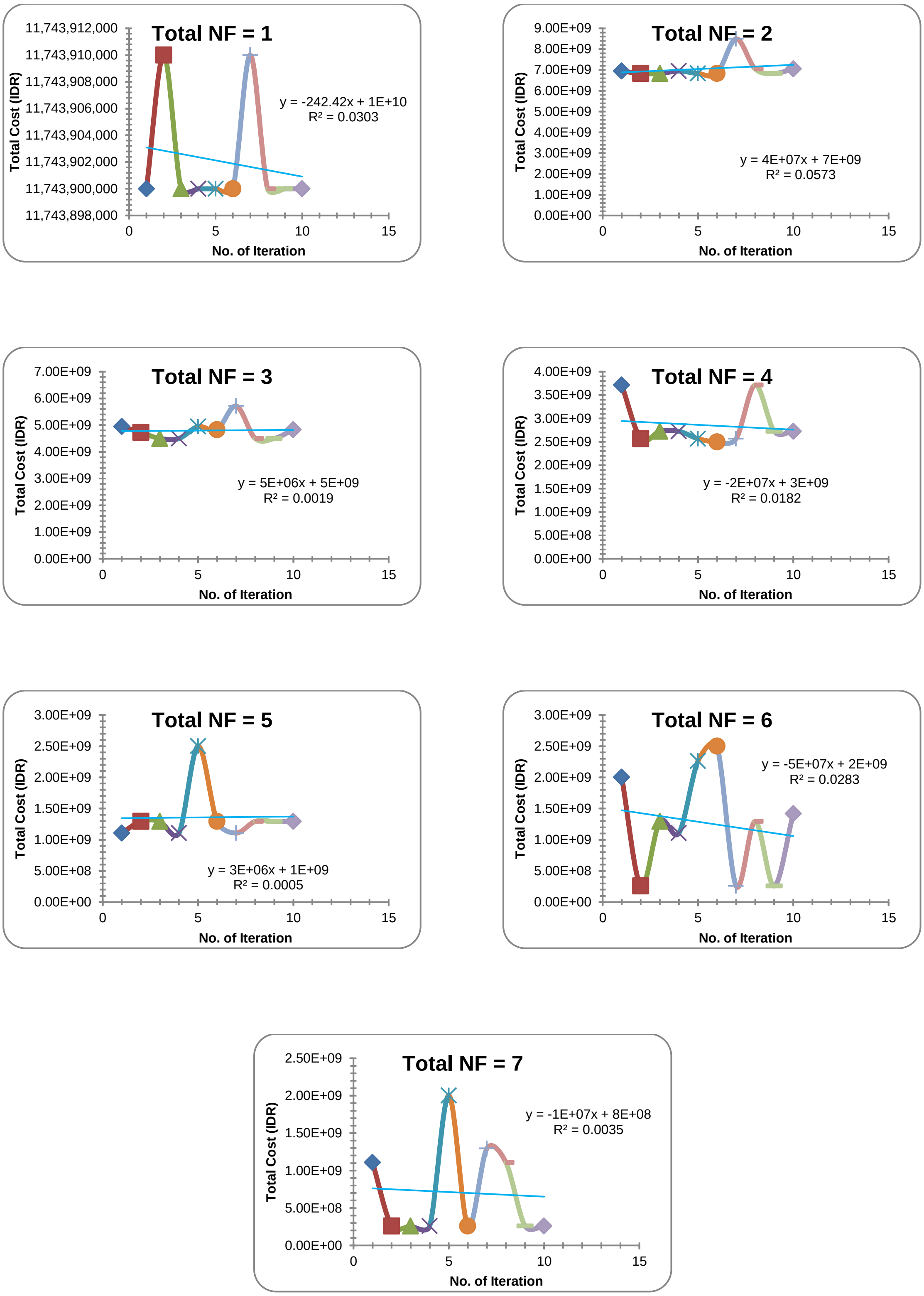


Figure 5-34 Minimal TC in Region III, with Ten Iterations

5.2.4. Analysis

A scenario was created to show how the tool works. Moreover, the case study was conducted to test and verify/validate the MATLAB simulation results by comparing it with the outcome of calculations from Microsoft Excel (SOLVER), varying the parameters and adding some iterations.

Scenario

Scenario-1 is approaching per region calculation, targeting one NF and running the iteration one time. Table 5-9 reveals that by using this method the simulation obtained a NF in every region except regions III and VIII. In those two mentioned regions, NFs found belonged to the two EFs, i.e. in Cikampek and Fak-Fak. Hence, it can be inferred that regions III and VIII already have an optimum number of EFs.

Scenario-2 calculates the total cost by considering DCs in all regions. In this case, three NFs are planned to be built and the TC from a one-time iteration. From this approach, the MATLAB returned locations for NF2 and NF3 which did not belong to the EF but NF1 was located in the EF.

As previously stated, the TC calculation considers four main parameters, i.e. transport cost, DCs consumption and distance. These are the 'weight' parameters for the tool to determine if the new location is really the best candidate that has the lowest cost. Therefore, when covering a broader area, the simulation has produced different results from the calculations which are undertaken in a more focused area. Such disparity happened because of the divergence of measured distance. Table 5-13 compares the results of 'per region' simulation and 'all-region' simulation for the obtained NFs.

Table 5-13 The Output Comparison of the Simulation per Region and Simulation for All Regions Simultaneously

Output	Simulation per Region	Simulation for All Region Simultaneously
NF	NF is 15.47 km W of Kisaran	NF 1 is in Surabaya Group
	NF is 42.15 km N of Baturaja	NF 2 is 51.45 km S of Kolonedale
	NF is in Cikampek	NF 3 is 73.92 km E of Baturaja
	NF is 18.03 km W of Boyolali	
	NF is 16.65 km N of Sanggaran	
	NF is 42.71 km N of Banjarmasin	
	NF is 46.96 km S of Kolonedale	
	NF is in Fak-Fak	

Case Study

Figure 5-35 depicts the graphical results for cases 1-3. Case-1 is only targeting one prospective NF. Such simulation returned a NF location similar to the one for the current EF location (Banjarmasin). In this particular case, the existing EF is already in an optimal location. Therefore, the NF result provides nothing new.

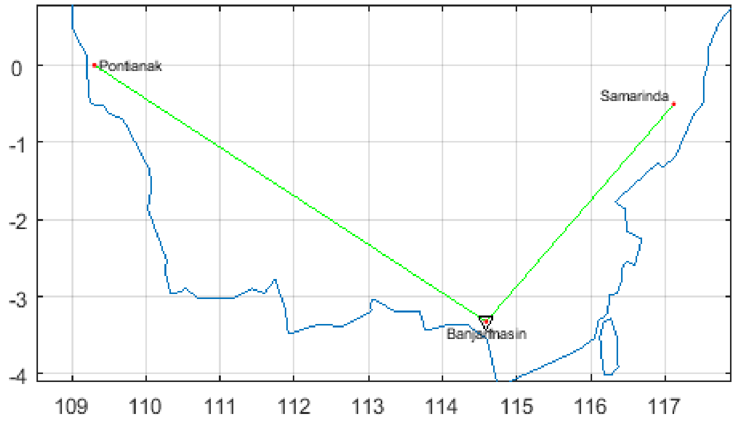
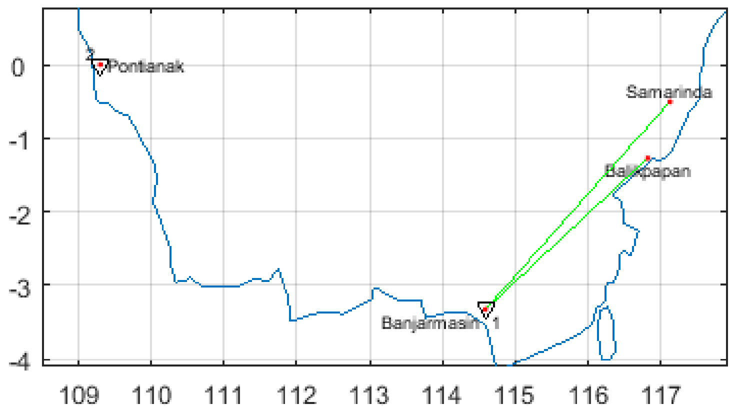
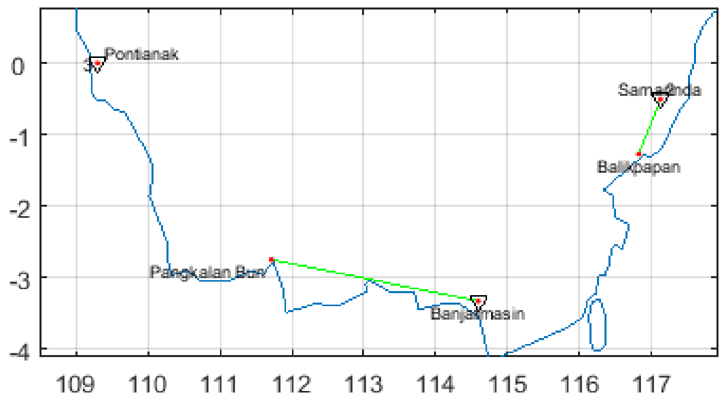
CASE	NF proposal
1	
2	
3	

Figure 5-35 The Graphical Outputs for Case Studies 1-3

Table 5-14 MATLAB - EXCEL Comparison Result for Case Study 1-3

CASE	EF	Set Initial		MATLAB Result			EXCEL Result		
		NF Coordinate	NF Location	NF Coordinate	TC (IDR)	NF Location	NF Coordinate	TC (IDR)	NF Location
1	Pontianak	[109.3026 0.0073]	Pontianak	[114.5902 -3.3240]	8.21760E+10	Banjarmasin	[114.5902 -3.3240]	8.21695E+10	Cannot be automatically generated
	Banjarmasin								
	Samarinda								
2	Pontianak	[109.3026 0.0073]	Pontianak	[114.5902 -3.3240]	4.00740E+10	Banjarmasin	[114.5902 -3.324]	4.00496E+10	Cannot be automatically generated
	Banjarmasin								
	Samarinda	[114.5902 -3.324]	Banjarmasin	[109.3026 0.0073]		Pontianak	[109.3026 0.0073]		
	Balikpapan								
3	Pontianak	Random	Random	[109.3026 0.0073]	7.88330E+09	Pontianak	[114.590 -3.324]	7.88574E+09	Cannot be automatically generated
	Banjarmasin	Random	Random						
	Samarinda	Random	Random	[117.1198 -0.4997]		Samarinda	[117.120 -0.500]		
	Balikpapan	Random	Random						
	Pangkalan Bun	Random	Random	[114.5902 -3.3240]		Banjarmasin	[109.303 0.008]		

In case 2 (see Figure 5-35 in the middle), the calculation proposes two NF locations and both locations fall within the existing EF sites (Pontianak and Banjarmasin). This means that the locations of the EFs are already optimal. Hence, it is unnecessary to build another NF within the EFs.

Furthermore, case 3 (the bottom of Figure 5-35) performs a simulation for three prospective NFs where all of them were located in the same EF locations (Pontianak, Samarinda and Banjarmasin). This means that all EF locations are already optimal and thus unnecessary to build another NF within the EFs.

The numerical results of the simulation using MATLAB and Excel (SOLVER) are summarised in Table 5-14. A paired t-test was performed to determine whether both simulation results were significantly different or not (see Table 5-15). Since $t_{obs} = 0.819 < 12.706 = t_{crit}$ (or p-value = 0.563 > .05 = α), there was no significant difference between the two results. The paired t-test indicates with 95% confidence that any difference between the two groups is due to chance.

Table 5-15 Paired T-test for MATLAB and EXCEL Results

	MATLAB	*Excel*
Mean	23978650000	23967650486
Variance	5.18121E+20	5.17256E+20
Observations	2	2
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	1	
t Stat	0.818716326	
P(T<=t) one-tail	0.281623629	
t Critical one-tail	6.313751515	
P(T<=t) two-tail	0.563247258	
t Critical two-tail	12.70620474	

Case-4 presents the effectiveness of the simulation. The previous cases were only conducted as simulation with a one-time iteration. Using special treatment in MATLAB coding (see Code-Listing 12), some iterations were used to attain the lowest TC in region III. Thus, after a minimum TC was discovered, then the iteration shall be repeated as many times in which each new TC found will be compared to the old TC and so on until a predetermined iteration limit (ten times of iteration).
Figure 5-34 shows six times of iteration in region III to obtain the lowest TC conducted for case-4. Table 5-16 reports a comparison of the MATLAB iterations to obtain the lowest TC point in such an experiment.

Table 5-16 The Speed of MATLAB find a Minimum TC in Region III

Total NF	The Speed of MATLAB find a Minimum TC
	Region III (EF =7)
1	1st iteration
2	2nd iteration
3	3rd iteration
4	6th iteration
5	1st iteration
6	2nd iteration
7	2nd iteration

Based on Table 5-16, MATLAB needs at least 6 iterations in order to generate the lowest TC in the complex NF environments.

5.3. Digitising the Biodiesel Supply Chain Governance

This section proposes a common platform for Indonesian Biodiesel. The platform attempts to follow [REC-1] and [REC-2], i.e., maintain & supervise regulation to achieve predetermined mandate; and maximise market share, seek dominance by developing business infrastructures. One important infrastructure to be built is 'the governance system' in the supply chain. Numerous firms have tried to strengthen supply chain alliances with emerging Internet technology, but they usually fail due to a less determined and lack of governance structure (Ulrich, 2004). Professor Alan McKinnon's from Heriott-Watt University also realised this. McKinnon wrote that the Next SCM will be concentrated on the efforts of change in logistics and supply chains: techniques, technology, business trends and governmental measures (McKinnon, 2008). The essential elements of a successful SCM are fast, accurate information from a broad spectrum of operating fields (Lancioni, 2000).

Governance is growing into the foundation and is key for a high-efficiency operation in a better supply chain, but there are few research results about how to set up a cooperative mechanism and control system among members. Thus, the heterogeneity characteristic of the supply chain should be considered. A global overview of the supply chain examines the obstacles, mechanisms and existing challenges of supply chain conducted from a wider area. In order to make this clear, let's start from the bottom line. Supply Chain Governance is governance for the (Supply Chain) Board which includes responsibility for business continuity, developing a shared sense of values within the organisations, safeguarding corporate knowledge and management of human capital (Aoki, 2000; Farrar, 1999).

Based on this perspective, the author built a platform as a proposal for the biodiesel industry.

5.3.1. General Concept of EvoSCM-B

The supply chain is dealing with inter-networking logistics that cannot be easily handled by ordinary information systems. Current supply chain technology is dependent upon ERP and faces several problems such as risk management, product quality-control, cost-containment, visibility and governance. This paper offers a three step evolution that manages those problems, especially when implemented in the biodiesel industry. Using the strong visibility and governance which is provided by the system, the [REC-1] and [REC-2] could be implemented. The supply chain evolution for biodiesel (**EvoSCM-B**) practices a problem-solving strategy that transitions slowly but not radically. The starting point depends on the current position of the industry. A continuous improvement is slowly changing the system in a systematic way.

The first step is characterised by a central-database supported by a mobile-app and web portal that control a wide range of supply chain activities. Embedded system, web-online tracking, quality monitoring and supply chain governance are used for the second step. Finally, the last step is powered by Internet Protocols version 6 (IPv6) and the Internet of things (IoT). A simple configuration allows for easier integration with hardware/software used in the chain after completion of the second step and also maintaining constant access to ERP, MRP, CRM or other systems. Analysis results showed that even the first and second steps are also using real time and GIS technology. Enabled IPv6 on the IoT will enhance LBS and improve marking-identification on highly efficient supply chains. In the future smarter web, decisions will be made by real-time actions derived from event-driven supply chains and diagnoses.

5.3.2. EvoSCM-B1.0: Integrated Web-Database and Mobile-Apps for Biodiesel Industry

In the first phase, the author suggests a biodiesel firm approaches a governance-system using web-based centralised data processing. This method matches small-size enterprises and meets three types of user structures namely Customer, Supplier and Transporter (or Forwarder). In order to improve the control function and governance, the web-portal is associated with a mobile-app installed on smartphones, including the smartphones that are used by the transporters. Thus, the smartphones pull the data out from raw-material distribution or the end product delivery system. The utilisation of this technique will gather position-data and the quality data of the commodity being shipped. Global overview of the EvoSCM-B1.0 can be seen in Figure 5-38. In order to illustrate the first evolution, the author supported by a small team (Ritesh Rijal and Iqbal Hossain) developed a prototype of a web-database and mobile application that reflect how it works. The design of the system was carried out in the following stages: tool selection, determine general systems connection, create database-table and plan applications, split work-package of programming into several modules and design of mobile-apps menu and the web-appearance.

Tools are the major utility for software development, which provide an interface that helps achieve the desired application requirements. Tools used for web development and the mobile app construction were:

a) **Android-OS**: Android-OS is an operating system environment based on the Linux kernel that the author has chosen.

b) **Android-SDK**: Android software development kit or SDK is a tool that provides a different interface along with the necessary tools and utilities that are needed to write, compile and pack the android application. It can be used to create any mobile application.

c) **IDE**: Integrated Development Environment (IDE) provides a graphical interface design tool, a code compiler and debugger. An IDE also brings an automated environment for formatting the code as the programming language. The android SDK is called by the IDE during planning, development and running the application. In this research, the popular IDE called Eclipse has been used.

d) **Google API**: Google API is the application programme interface provided by Google which has much functionality for different web and mobile applications for location Service and GIS (Geographic Information System).

e) **Java**: Java is a programming language. Java is a very easy to learn and robust programming language. Android SDK uses Java as the programming language.

f) **PHP**: PHP is a general purpose programming language and the most popular server side scripting language for web development. PHP act as an interface between database server and the biodiesel distribution tracking mobile application. Thus, PHP becomes important for tailoring all application into the web services.

g) **MYSQL**: Mysql is one of the most widely used relational database management system tools. Mysql is used for database engines since PHP has a good driver for accessing the Mysql server.

h) **GCM**: GCM stands for Google Cloud Messaging that is provided by Google, which allow the users to send any message or data from the server to the android device and receive a message from the user device via the same route/connection. Pushing notifications on different transaction messages and alerts are the main part of the biodiesel supply chain.

i) **Android Emulator**: Android emulator is the virtual android device that runs the apps on the computer. This can be used free of charge. The free version of the android emulator from **Genymotion** has been used in this research.

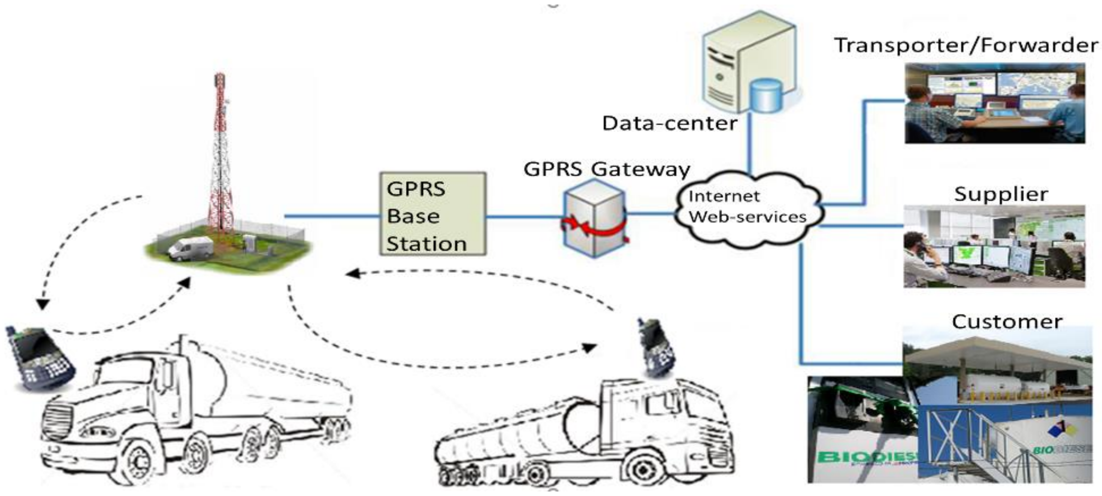


Figure 5-36 The Principles of the Evo-SCM-B1.0

a) Web-Database

The first phase uses a simple application to create a web application and data centres. On the prototype that the author built, PHP and MySQL are used to implement this first phase of EvoSCM on a miniature scale. PHP is hypertext preprocessor that writes a server-side scripting language designed for web development. MySQL is a free SQL database administration method made by Oracle. MySQL Server is developed to access, push, store and process data on a database. The SQL is an abbreviation of 'Structured Query Language' and has recently become the most common standardised language used to manage databases.

The application offers various menus, i.e. Profile, Transaction, Management, My Contacts, Message and Logout. Each customer represents both individuals and companies who can use this service to conduct a product search, for ordering, transactions and delivery of goods. During the delivery, all parties can monitor the position and quality of the product being distributed. The customer marks the goods after they arrive at the destination. Furthermore, the customer clicks the approval button to the mobile-app if they meet the specifications agreed to upfront. Immediately, the current invoice would be automatically generated and sent to the customer's email. The next part further explains some remaining features. The 'transaction' function on the task-pane gives the opportunity to observe a product. All types of users who open the menu 'transaction' are able to access the distribution 'on-route' and quality tracking. By this policy then all supply-chain members can monitor the distribution of goods powered by Google-Maps API. Figure 5-39 reveals web-features of the prototype at a glance.

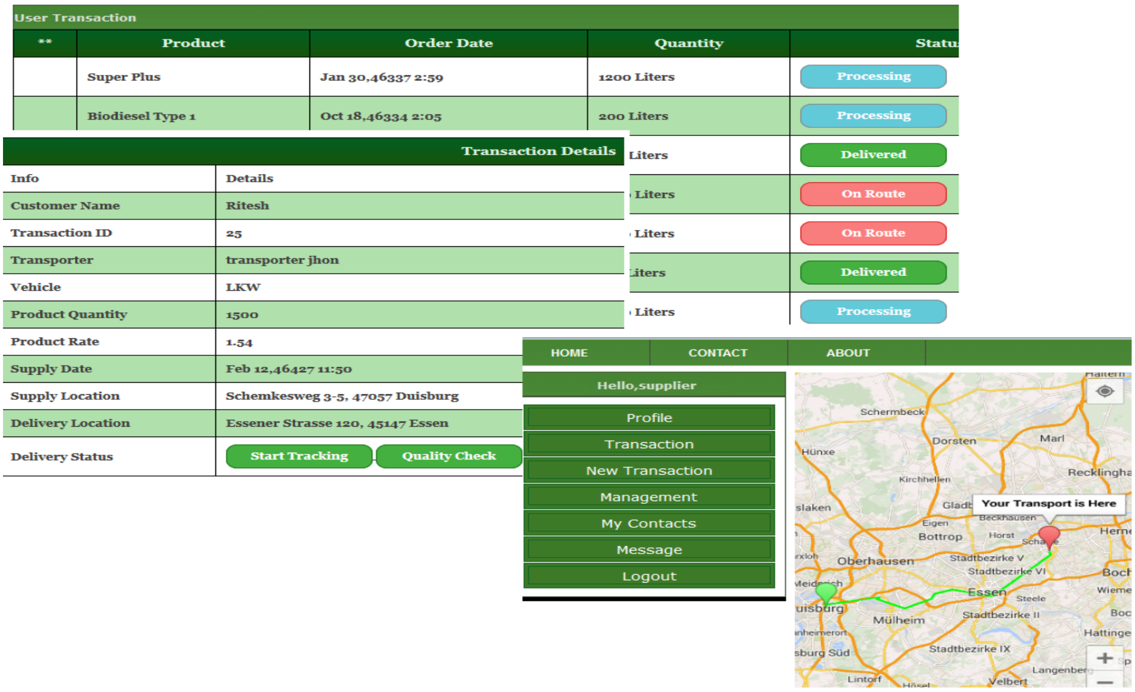


Figure 5-37 Web-Database Screenshot of the 1st Phase Prototype

b) Mobile Application

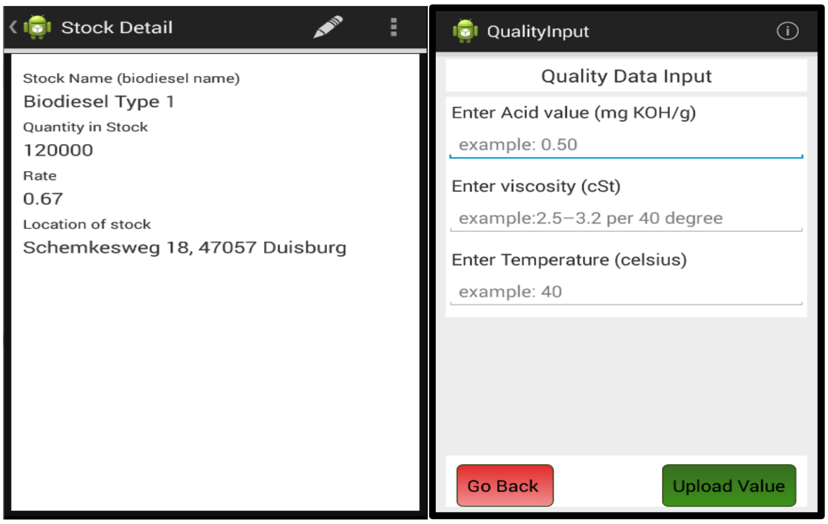
The mobile-app retrieves position data of the shipped product as well. The apps are installed on the smartphones used by transporters. It periodically sends the position assisted with Google Maps API. Google Maps API is a collection of APIs that enable using one's own data on a customised Google Map. It will engage web and mobile applications with Google's powerful mapping platform including satellite imagery, street view, elevation profiles, driving directions, styled maps, demographics, analytics and an extensive places database.

'Biotrack' is the name of the application that has been developed in this research as the tool for biodiesel distribution tracking system and supply chain monitoring. The application has been developed for meeting two different aspects, i.e. the aspect of the supply chain and the aspect of distribution tracking.

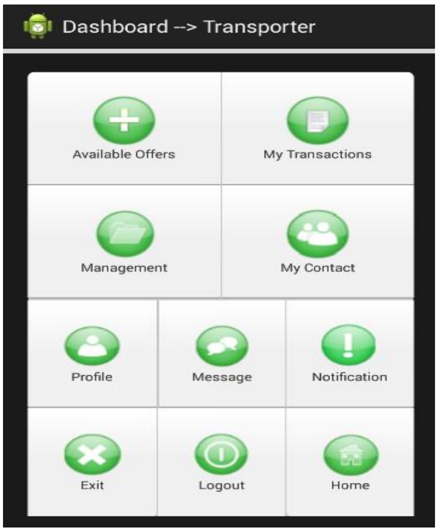
Supply Chain Monitoring Aspect

The transaction is started by stock management of the biodiesel. In this research, the developed application has the capability to track the stock and its location as explained below. The flow of the developed application starts with the registration of the user. A user can be registered in three categories. They are supplier, customer or transporter. A supplier needs to keep track of the stock before the delivery of the order from the customer can be made. Another main part of the storage management is the storage location. Since, the distribution of the biodiesel always starts from the stock location to the delivery location, it is mandatory for a customer to have knowledge about the source of his delivery to be able to track the delivery.

Figure 5-40a depicts the overview of the stock detail. A supplier is able to enter new stock details or update existing details. The main information units have been taken as the entry fields in the application. The stock-name needs to be entered along with the quantity and the quality of the stock. The stock-location has to be entered, since it plays a vital role in delivery tracking.



(a) (b)

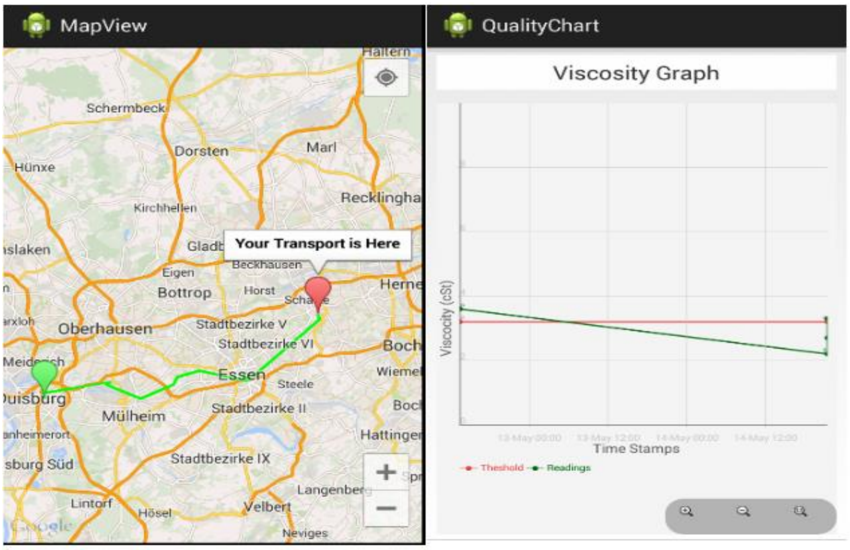


(c)

Figure 5-38 SCM Monitoring Aspect:
a) Stock Detail Screen, b) Quality Input, c) Dashboard

Distribution Tracking Aspect

The distribution tracking-system is the location tracking of the transporter-vehicle which is delivering the product. As already discussed, the quality of the biodiesel degrades when time passes. Hence, the mobile application developed in this mobile-app is capable of tracking both parts, the location of the delivery vehicle (Figure 5-41a) as well as the quality of the biodiesel (Figure 5-41b). The transporter needs to manually enter the acid value, the viscosity or the temperature of the biodiesel time to time (see the input-panel on the Figure 5-40b). It is assumed that these values can be read from the cab of the truck. These quality variable values as well as current-location will be saved in the central-database for further analysis.



(a) (b)

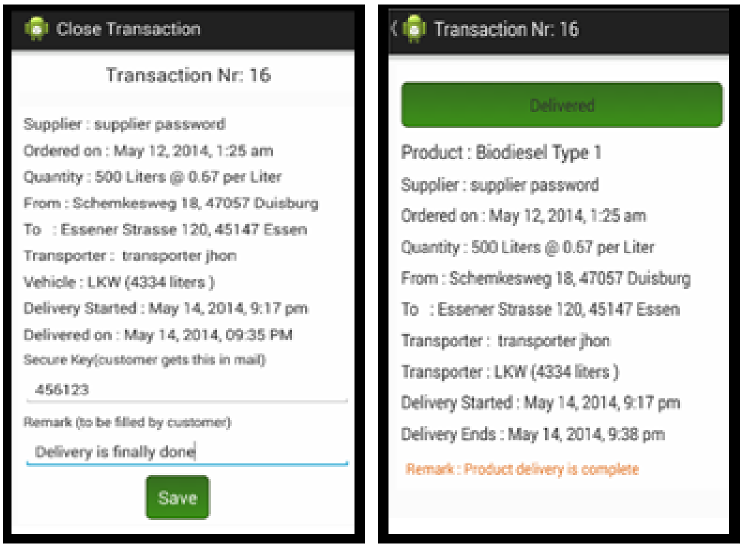
Figure 5-39 Distribution Tracking Aspect:
a) Location Tracking System, b) Quality Tracking

The Main Menu

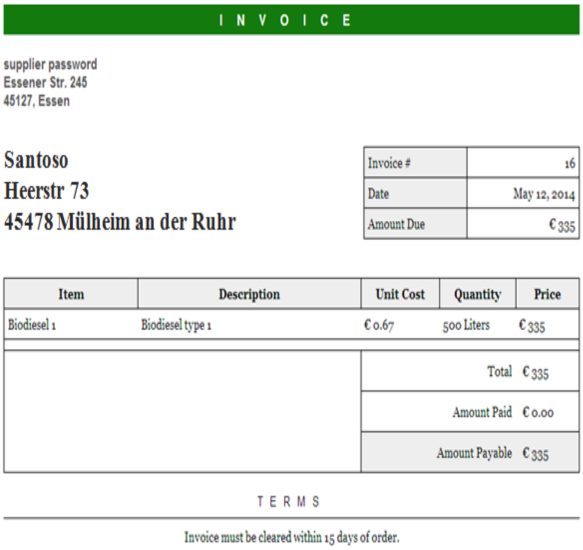
This application starts with a home screen. A user can either log-in to the system or create a new account. Once a user is successfully logged-in, a dashboard with different functionality will appear (Figure 5-40c). Dashboard is the main screen of the application and consists of the following menus: 1) Profile: This feature is just the user profile display page; a user can either see or edit information like email, contact address, telephone number etc. 2) Message: This is the internal implementation of the mailing function in the application. A user can easily send/receive messages with trading partners using this feature. Messages are saved in the Biotrack database. 3) Notification: Notifications are used just in case of emergency. A user can push notification to the server in case of emergency. 4) My Contact: This feature gives access to overview the trading partners whenever they have successfully started any transaction. 5) Management: This feature has been further divided into different sub features. If a user is logged in as a supplier, then he can manage his stocks and his business sites. If a customer is logged in, then he can manage his business location. And finally if there is a transporter, then he can manage his vehicles. User's current location viewing is set as a common feature inside management. 6) Offers: This section also depends on the type of user logged in. A supplier can see if there is a new order placed, whereas customer and transporter can place a new order or apply for new transportation respectively. 7) Transaction: This is the feature which actually deals with the main trading.

Billing and Invoice System

This system is implemented in the background process in the server. An invoice is automatically generated when the supplier accepts the order from the customer. First of all, whenever the supplier accepts the order from the customer then a 20 digit random string including characters and numbers will be generated in the server. Such a generated random number is the digital key of the transaction invoice. This signature is linked with the Transaction-ID so that whenever the customer wants to see his invoice he/she just need to access the link to the digital key sent via the registered email. The system will access the digital key to find the transaction number and hence all the details will be shown. Furthermore, the customer can directly print the invoice.



(a) (b)



INVOICE

supplier password
Essener Str. 245
45127, Essen

Santoso
Heerstr 73
45478 Mülheim an der Ruhr

Invoice #	16
Date	May 12, 2014
Amount Due	€ 335

Item	Description	Unit Cost	Quantity	Price
Biodiesel 1	Biodiesel type 1	€ 0.67	500 Liters	€ 335
			Total	€ 335
			Amount Paid	€ 0.00
			Amount Payable	€ 335

TERMS

Invoice must be cleared within 15 days of order.

(c)

Figure 5-40 Transaction & Billing Feature:
a) Close-Transaction, b) Transaction Status, c) Invoice

The invoice will again be automatically generated for the transportation cost. When the transporter reaches the delivery destination then the customer needs to enter a security key in order to close the transaction (see Figure 5-42) and send it to the server then a new invoice will be auto generated for the transportation cost. The transportation cost is the cost of the transporter-vehicle multiplied by the total distance travelled by the transporter.

5.3.2. EvoSCM-B2.0: Electronic, Sensor and IT-tracking Support

In the second phase, EvoSCM-B2.0 was developed for a mid-size biodiesel enterprise. In this stage, web-portal technology has been established, and all data was centralised to a single database. This phase utilises hardware and sensors as well as additional tools that help the distribution of products.

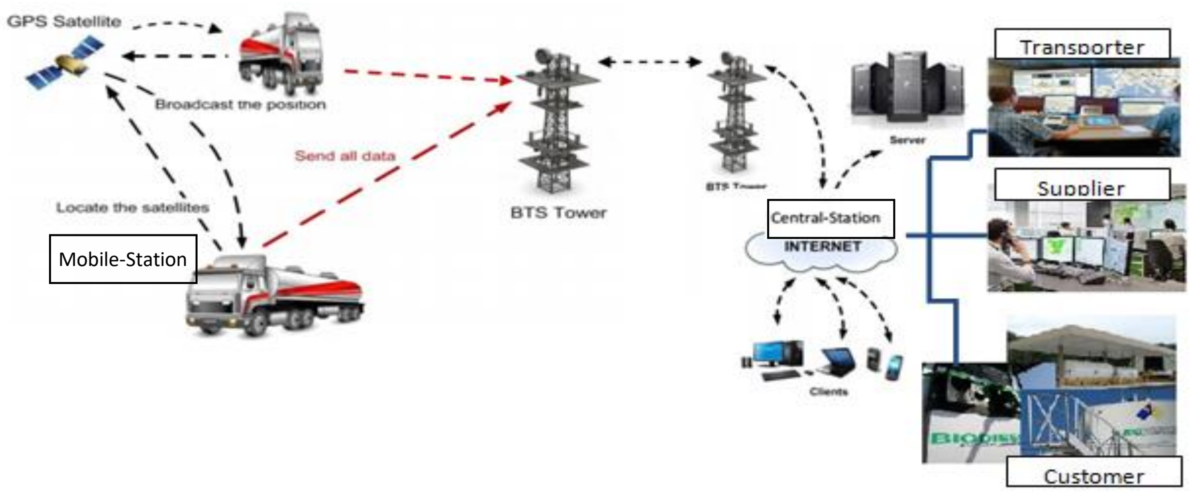


Figure 5-41 The Principles of the Evo-SCM-B2.0

In order to illustrate how it works, the author created a prototype of EvoSCM-B2.0 in a simple form. It manages the supply chain more transparently. Customers and suppliers who use the transporter to deliver products can interact continuously in real time monitoring.

The system is divided into two main parts, i.e. central station and mobile station. Figure 5-43 illustrates the general concept of such a system. Every truck is equipped with a GPS receiver in order to locate the GPS satellites and get the current position of the truck. The position is displayed on the monitor and the driver of the truck can monitor its position accurately. Besides that, inside the truck other communication-data acquisition devices are also installed, i.e. transmitter unit, analog-digital converter, and pH meter sensor. The general overview of the devices is explained in Figure 5-44. All the data both from GPS receiver and analog-digital converter are transmitted to the BTS tower periodically. The blue dashed line in Figure 5-44 displays all the available devices on the truck. Furthermore, Figure 5-45 shows the position of all devices that are equipped on the truck.

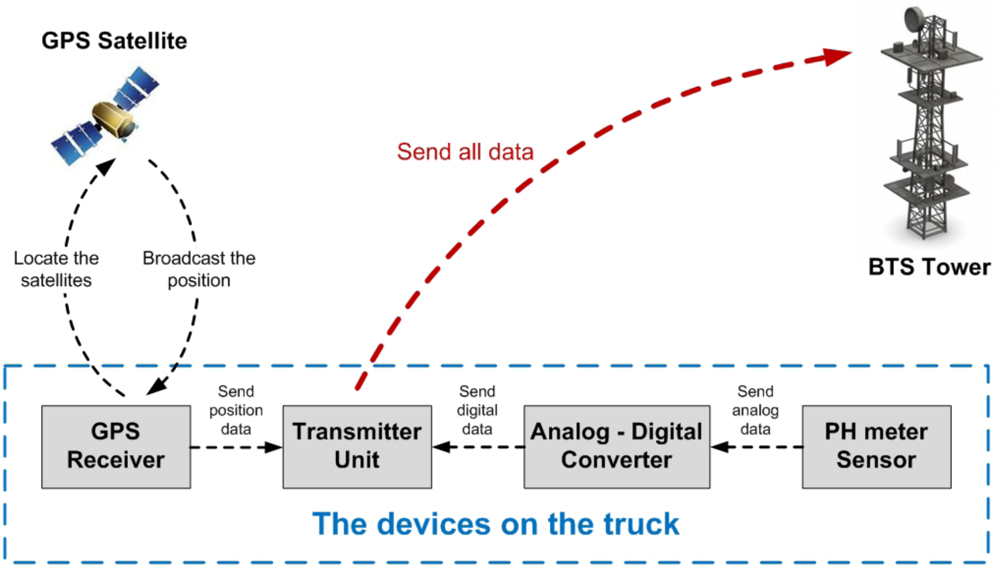


Figure 5-42 Overview of Mobile Unit Device Communication

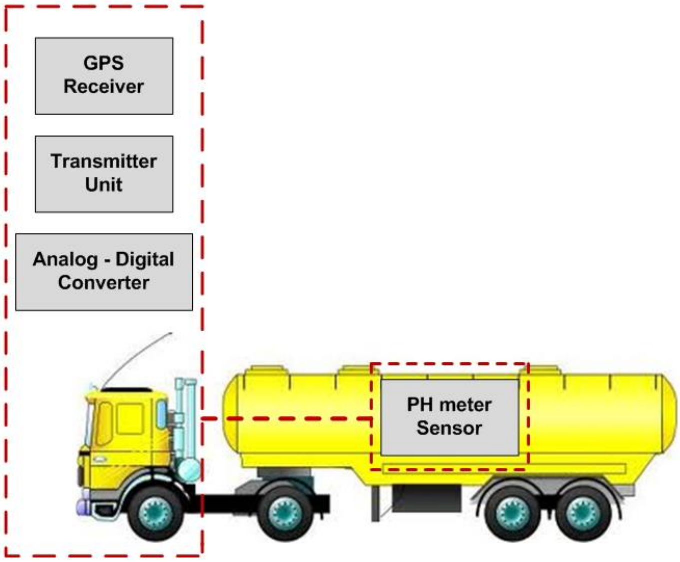


Figure 5-43 Mobile Unit Position

The next part is a central station, as displayed in Figure 5-43. Similar to the mobile station, this station is also equipped with a receiver unit to get the data from the BTS tower. The receiver unit will then send all the data to the server. The server is connected to the network and accessible by the clients. The client can access all the data 24 hours as long as the client has internet access. The authentication password will be prompted to ensure the security of data and clients as well. Detail design of these systems (both mobile unit and central station) are provided in Appendix 6.

The prototype of this design is presented in the following passages. A microcontroller governs the instruments' performances, e.g., pumping biodiesel in and out to the sampling room, sensing, data retrieval, analog to digital data conversion and sending data to the BTS via the GSM module. The realisation of the hardware development can be seen in Figure 5-46 through Figure 5-48.

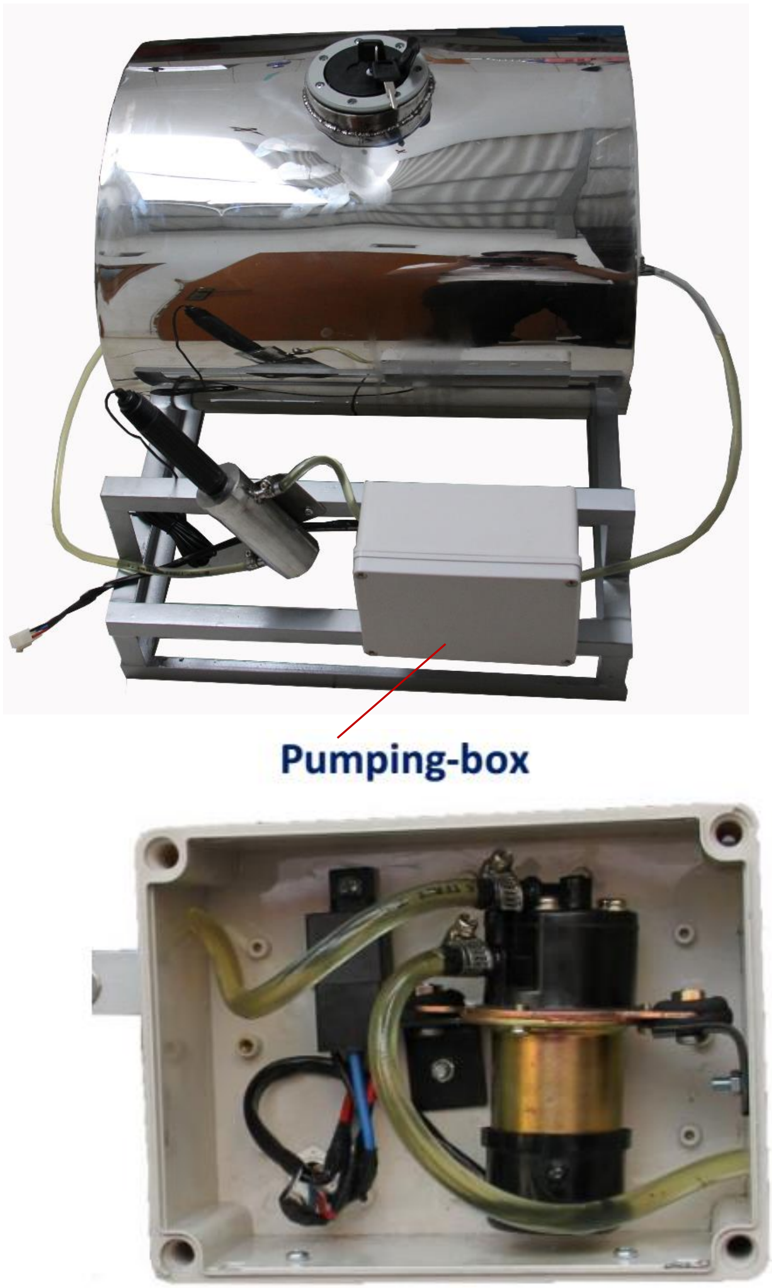


Figure 5-44 Mobile Container Prototype and Zoomed-Pumping Box

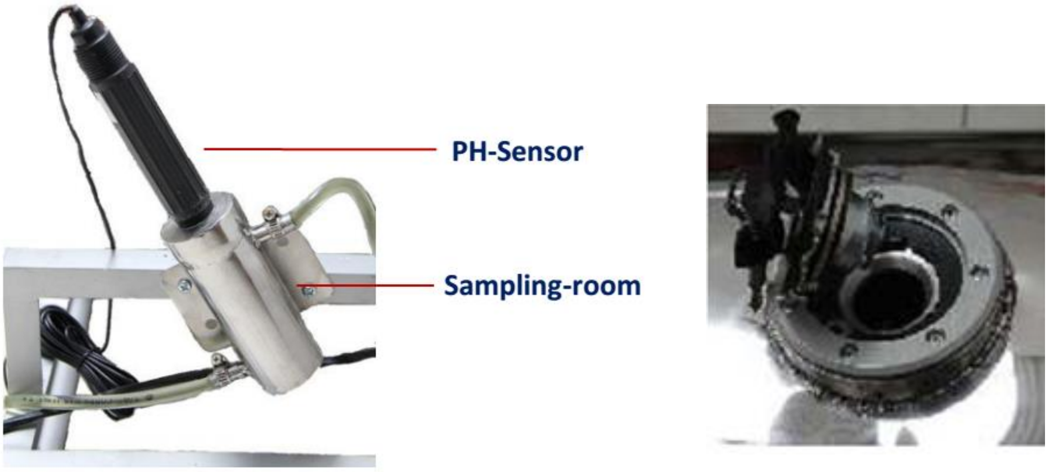


Figure 5-45 Sampling Room, PH-Sensor and Container Cap

Container prototype specification:

Main material: Stainless steel

Container cap: Fixed-locked flap

Container holder: Elbow iron

Equipment:

- Sampling Area
- pH probe
- Pump
- Valve
- Electronic Relay
- Line-in
- Line-out
- Battery for Mobile-unit & pH-transmitter

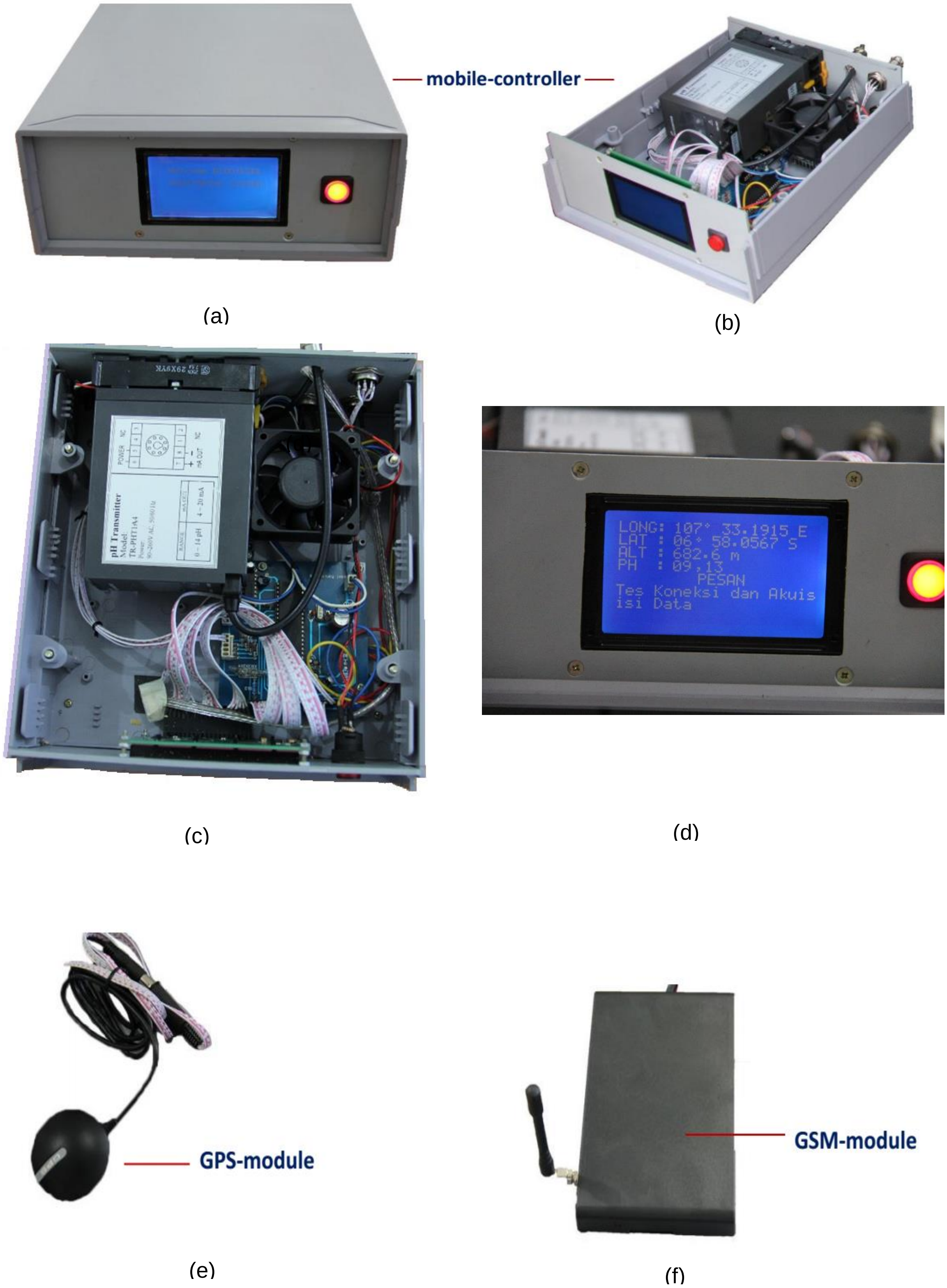


Figure 5-46 Hardware Implementation

The features of the mobile station are:

- Automatic quality-data acquisition (or other parameters) – for outdoor fixed unit (pump-stations, pipe-installation or retailers).
- Data sent regularly to the server (heart-beat pushing data)
- Interaction with the control station admin (sending message & getting response)
- Sensing parameter: pH - sensor
  Optional: temperature, density, viscosity sensor, etc.
- Supporter display technology: Graphic LCD display module (monochrome), Optional: TFT Touch LCD Module (65K or 16M colours), TFT LCD Module + touch panel+ PCB Adapter + SD Socket 240(RGB)x400, Bluetooth (smartphone/notebook connection and data synchronization), programmable input keys, SMS-gateway, GPRSconnection, Anti-corrosion boxes, etc.
- Powered by Microcontroller: Microchip - dsPIC30F4011/4012
- Comm. module: GPS Module: GlobalSat BU-353, GSM Module: Wavecom

Using the process and architecture that have been attached earlier, an online application of the tracking system was constructed, as shown in Figure 5-49.

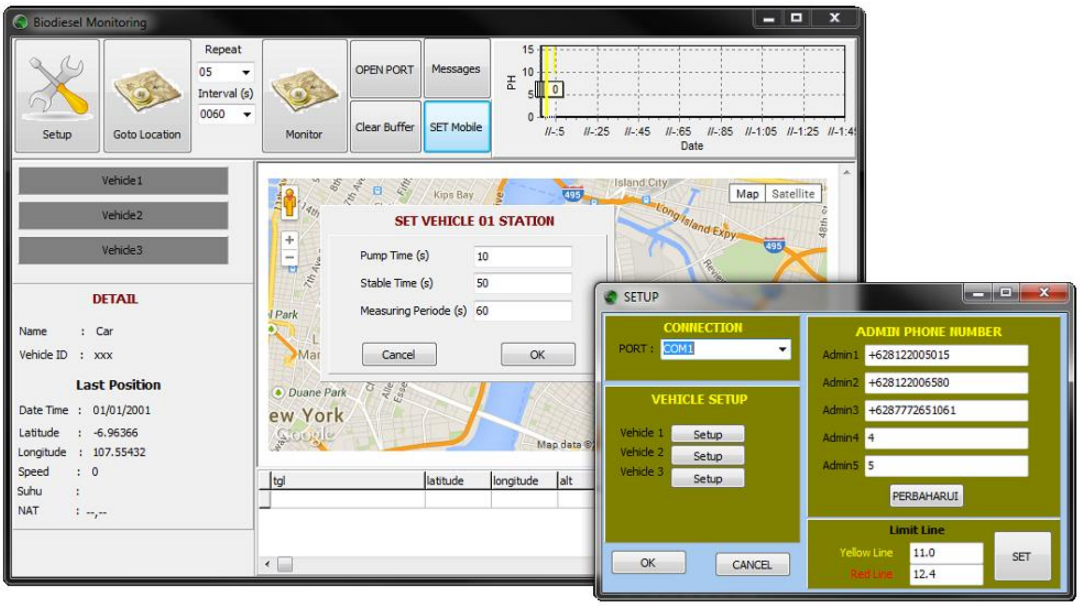


Figure 5-47 Software Implementation

The features of the software are:

1. Setup: Set the port of each modem that is used by mobile station
2. Goto Location: Request a report last position of the mobile station
3. Monitor: Request a report from the mobile station periodically
    - interval is set in seconds (interval)
    - regulated by the repetition (repeat)

Repeat and interval are used to regulate the amount of repetition of the report and the report period.

5. Located in the right up-corner is a graph of PH
6. Vehicles 1, 2 and 3 to determine which container is monitored
7. Message: Send a message to the mobile station

Software Developer Specification:

Main-engine: Delphi 7 - Internet Programming: Sockets and Indy
Database: Microsoft Access
Digital Map: Google Map API

The mobile and central stations use the communication protocols given in Appendix 7.

5.3.3. EvoSCM-B3.0: Biodiesel Supply Chain Powered by IPv6 and IoT

According to Mannole (2014), 14 billion out of 1.6 trillion objects were connected to the internet in 2014. Manole predicted that in 2020, it will be more than 50 billion of 1.8 trillion total things connected. The upcoming era will be marked by 3 notions, i.e. connectivity, instrumentation and sustainability. The supply chain will also be influenced by such a trend. The actors who are involved in the value chain will be smarter, more intelligent, interconnected with a number of devices and more aware of the environment. There are many sensors and actuators that will be used to connect many things to the internet. Rifkin (2015) reported that companies are establishing sensors throughout their business corridor to monitor and track the movement of goods and services.

The following lists the current best practices of sensor utilisation.

1. UPS employs Big Data to manage the connection to their 60,000 transport carriers in the US. The company implants sensors in the vehicles to observe the potential of failure or fatigue. Thus, it can be replaced before a costly malfunction on the road occurs.
2. The US Embassy in Beijing put sensors atop their building. It informs hour to hour fluctuation data of carbon emissions nearby. The system publishes such data on the internet periodically, warning people about dangerous pollution. That soft diplomatic approach has successfully driven the Chinese government to reduce carbon emissions caused by coal-powered plants and automobile traffic and energy-intensive factories in the region.

3. Many IBM sensors are in the air and on the ground in Rio de Janeiro. Those sensors are used to predict heavy rains and mudslides up to two days in advance.
4. In Dubuque, Iowa, there is a home water monitor controlled by digital water meters and software. It is installed to monitor water use patterns and inform homeowners of possible leaks as well as approaches to reduce water consumption.
5. Computer vision software employed by GE to analyse facial expressions for severe pain, the onset of delirium or other hints of distress. Such information is applied by the hospital to alert nurses.

From these examples, people can see the role of sensors for a specific purpose which are published on the internet, thus making everything connected. Sensors have been part of the cyber-physical system which is at the frontline in determining the success or failure of connecting something (see Figure 5-50).

Rifkin (2014) noted that there are 13 billion sensors connecting appliances and objects to human beings. The sensors which connecting people to the resource flows in nature also exist. Thus, many sensors inform about varying circumstances, such as the front office on current inventories in the warehouses, and troubleshooting dysfunctions on the production lines. Another sensor broadcasts the changes in the electricity usage by businesses and household appliances. Using this system, the price of electricity can be managed. Sensors in retail outlets inform the sales and marketing departments about which items are being looked at, handled, put back on shelves, or purchased to measure consumer behaviour. Other sensors trace the location of products dispatched to retailers and consumers and keep tabs on the amount of waste being recycled and processed for reuse. The supply chain inventories, production and distribution processes analysed periodically by smart data is powered by sensors placed along the value chains.

Moreover, IBM plans to grow their sensors up to 30 billion sensors by 2017. By 2030, it is projected to increase up to 100 trillion sensors that connect everyone in one vast neural network.

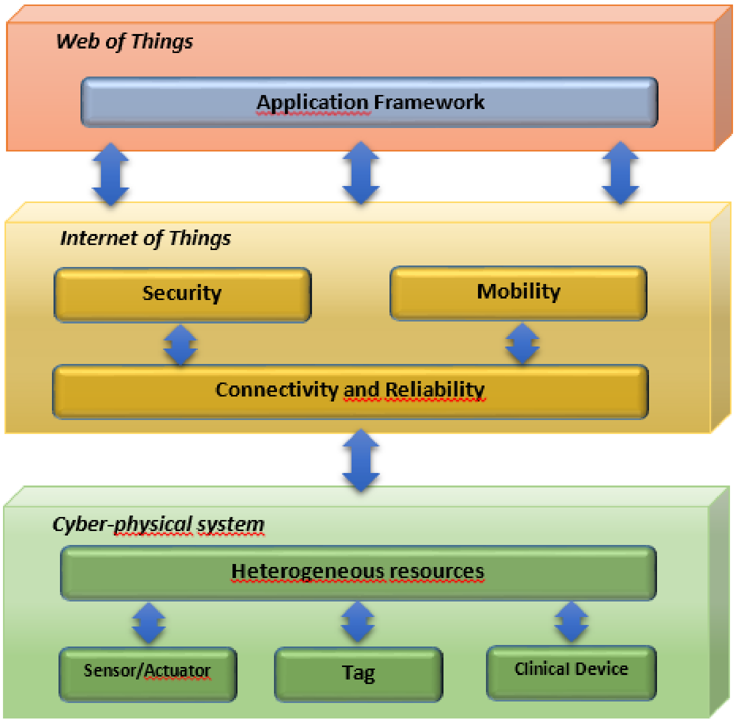


Figure 5-48 Internet of Things—Architecture (Jara, Ladid, & Skarmeta, 2014)

Ubiquitous censorship, combined with the app's connectivity and intelligence devices have tagged a new industrial revolution. The fourth industrial revolution has begun supported by cyber-physical system (see Figure 5-51). This system enables all objects to be connected, monitored and controlled over the Internet (well known as the IoT).

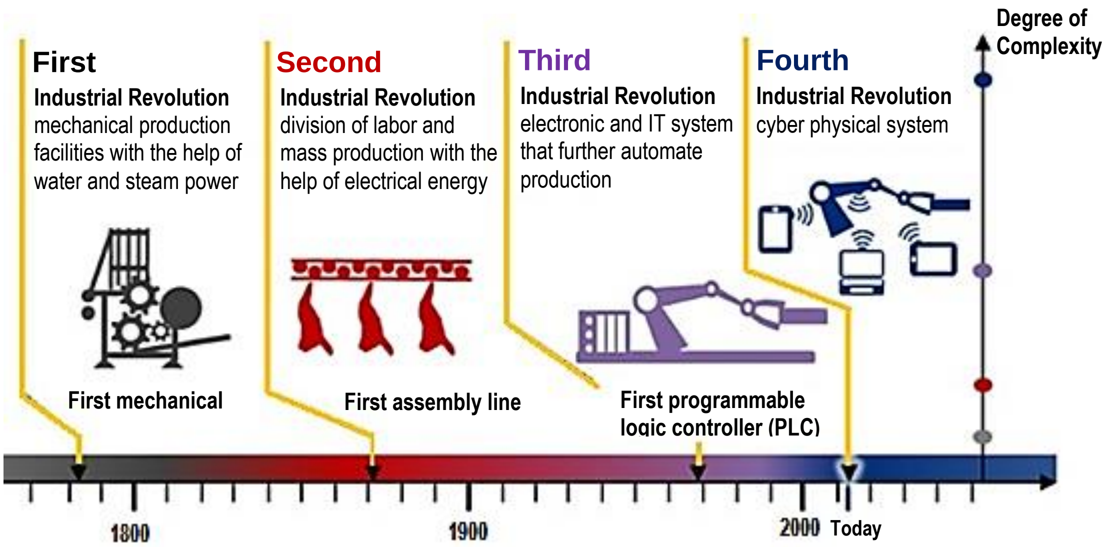


Figure 5-49 Industrial Revolutions (Wahlster, 2015)

IoT is a theory that connects animals, people or any objects such as assembly-line, energy grids, wholesaler facilities, and transport systems to the Internet. Global architecture of IoT is described in Figure 5-50.

IPv6 provides unique identifiers to the things and the IoT carries data over a network. Hence, the things will have a digital-ID with a huge number of IPv6 addresses possibly controlled from anywhere. Trucks, pallets or even casing of every product can be monitoring precisely. The stock market and inventory problem could be easily overcome. IPv6 will complete the sensors and actuators communicate to the internet.

The web-services and data-centre or ERP becomes 'smarter' using IPv6 and IoT. It is called 'Web of Things' (see Figure 5-52) and occupies the following features: object identification, network of things, high speed wireless network monitoring by sensors. The last IPv6 capability is an advanced application setting and other hardware configurations are growing 'greener' due to the low-power consumption. Global internet society (World Wide Web Consortium or W3C), which develops web standards, defined a web service as supporter software for interoperating various systems across the internet (W3C, 2004).

Other systems communicate with the web using specific protocols in conjunction with other web-related standards. There are many attributes of web service that can be related to the supply chain, i.e. independent, modular, distributed and dynamic. Over the network, such applications can be described, published, located, or invoked to create products, processes that govern supply chains. In the case of logistics, numerous sensors and e-Tags (electronic-tag) on the IPv6 platform will be deployed in the field.

The concept is similar to the early days of making a cellular network, but in this case, the network extension will be made towards the wireless sensor network nodes using the IPv6 platform. Sensor nodes connect the real world into global information networks through base stations (access-points: WiFi-AP). An existing e-tag RFID, 0.16 mm2 in size, will be planted throughout the product or its packaging or it could be on a pallet or container level. Communication between the e-tag sensor nodes will use radio-frequency, and then it is passed to the IPv6 network using wireless internet. Figure 5-52 illustrates how the sensors communicate to the internet, through sink (or master) node and the gateway.

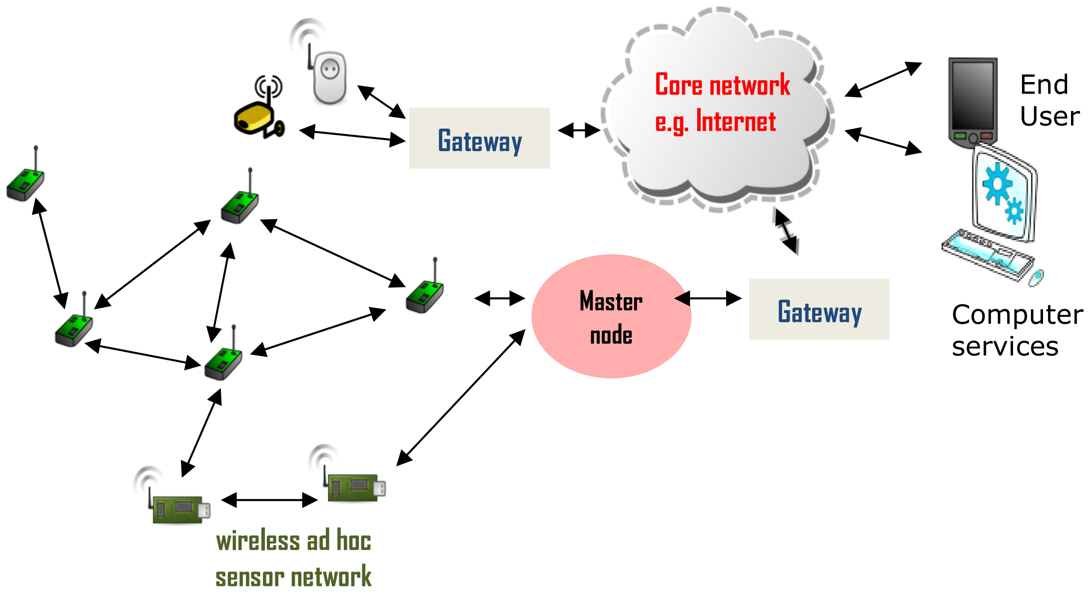


Figure 5-50 Wireless Sensor (and Actuator) Network (Barnaghi & Foh, 2013)

IPv6 network is easier to configure. Neighbour-discovery finds other IPv6 systems and auto-configuration will enable more automated set up of the systems. Thus, this network will also keep constant access to ERP, MRP (Manufacturing Resource Planning), CRM (Customer Relationship Management) or other existing systems. Code for IPv6-enabled network is already built into the current versions of Windows XP, MacOS, Linux, and many forms of Unix. Moreover, every router made by Cisco Systems Inc. comes ready to run IPv6. On the other hand, slowly but surely, RFID tags have decreased in price. In the near future, they will be produced in mass and pop up on a huge market, such as embedded on shopping-bags, pallets, product-casing or even containers. Container-trucks with built-in RFID readers will maybe emerge in a few years. It would enhance LBS and improve marking-identification for a highly efficient supply chain. A concept of IoT in the biodiesel supply chain supported by IPv6 network, SAN, WAN and RFID tag is described in Figure 5-53. The capability to assign unique IPv6 addresses to the things within the logistics operation will perform end-to-end visibility. It will enhance tracking of resources through the system, improve inventory management/control, decrease costs, and offer intelligence of higher order to the supply chain stakeholders. This is the ultimate achievement of the proposed supply chain evolution in the field of biodiesel named 'EvoSCM-B3.0'.

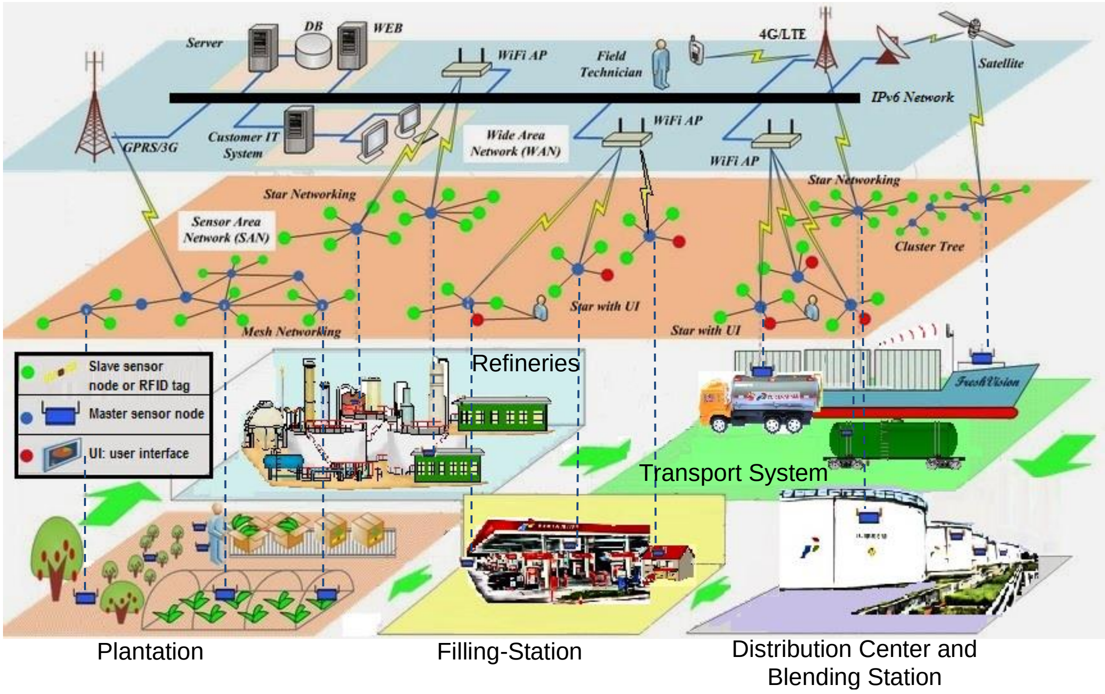


Figure 5-51 The Principles of the EvoSCM-B3.0

5.4. Master plan for Biodiesel Supply Chain

From cultivation to production, distribution and retail, biodiesel goes through a very long process (see Figure 5-54). As mentioned earlier, Indonesia is the world's largest archipelago with more than 6,000 inhabited islands and a total area of over 1.9 million km² (World Bank, 2012). However, the value chains of the process are not so close. It can be among different cities, different islands or even different continents. In the case of Indonesia, the issue of land utilisation and distribution becomes important.

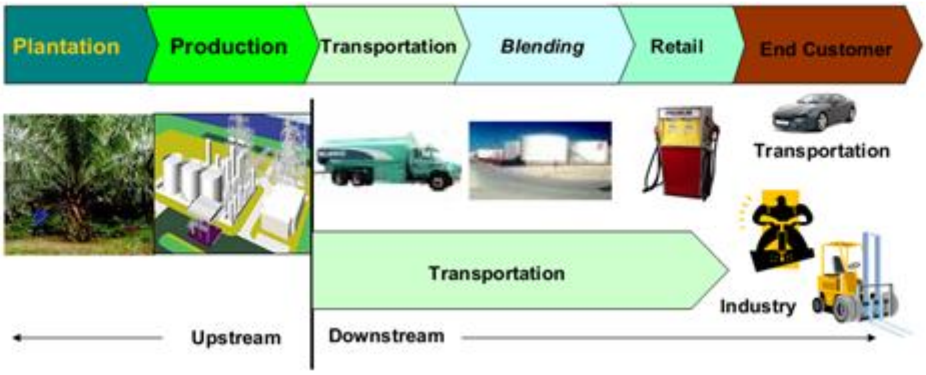


Figure 5-52 Biofuel Value Chain and Distribution

Judging from these data and taking a look at the energy balance, the shortest distance for shipping is good for cultivation of energy plants. The most effective use of fallow land seems to be near the big energy users, which in this case is around Jakarta area, e.g. Karawang, Bogor or Banten. The establishment of plantations in Sumatra would have the technical and logistical advantage that the international seaport of Singapore is only 400 km from Selat Panjang. Jakarta is about 600 km further away. In fact, there are five biodiesel suppliers of Pertamina (private biodiesel plants) located in Sumatera island. This means that they already are on the right path since a lot of plantations are nearby. A calculation of potential savings must be made in the Planning & Analysis Phase. It was generally noted by WWF-Deutschland (2007) that the energy balance for the cultivation of oil palm is positive. WWF-Deutschland (2007) reported that the plantations should be created only on the cleared and unused fallow lands. Thus, no valuable rain forest has to be deforested. According to the previous discourses, the following section designs an integrated concept that involves multiple value chains and distribution.

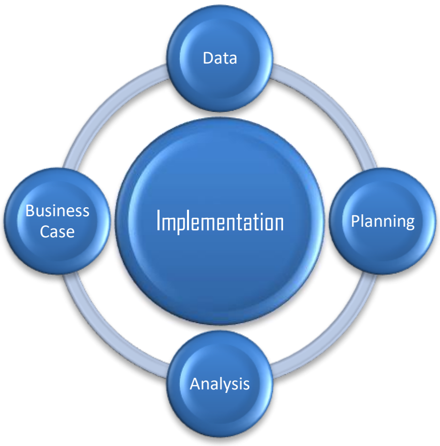


Figure 5-53 Integrated and Sustainable Biodiesel Development Concept

Figure 5-55 explains the concept of sustainable biodiesel development which includes: 1) Data Collection, 2) Planning, 3) Analysis, 4) Business Case, 5) Implementation.

The first-step gathers data and reviews the existing position. Afterwards, planning and analysis should be executed in the second and third steps. In the fourth step, 'the Business Case' will take place. The last step includes an outlook of the Implementation. All entities in this concept are linked together in order to ensure sustainability. Furthermore, description along the value chain is also important. It provides instructions and orientation for the whole development. The flow chart visualisation was created to depict the relationships between the individual chains given in the detailed-chronological order of those 5 steps (see Appendix 8). Meanwhile, the summary review of those order is displayed in Figure 5-56.

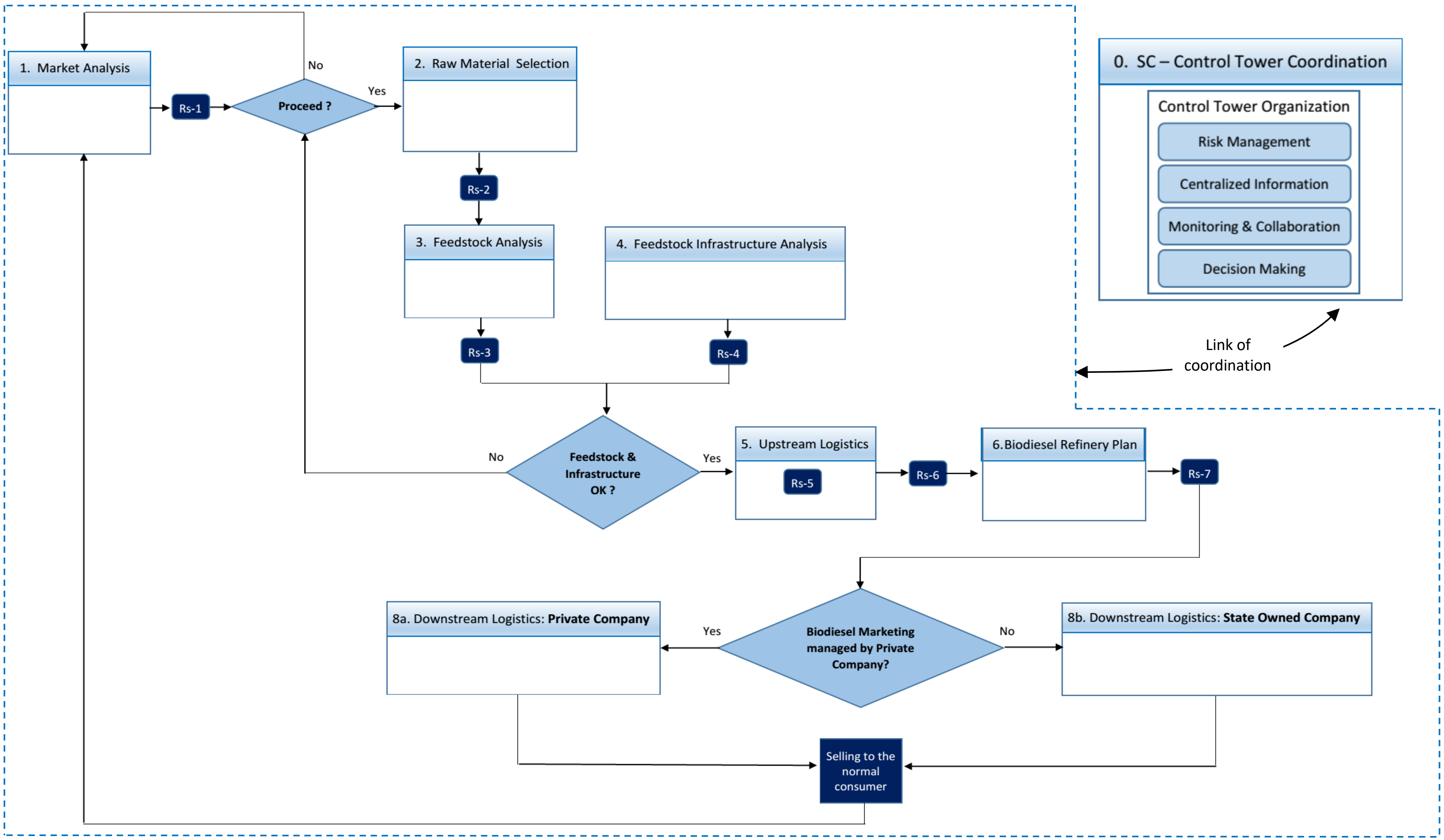


Figure 5-54 Summary of the Proposed Sustainable Biodiesel Development

Result

Rs-1	▪ Production Rate ▪ Blending Ratio ▪ Carbon footprint
Rs-2	▪ National Feedstock Decision ▪ Decision to produce the 1st, 2nd or 3rd generation of Biodiesel
Rs-3	▪ The requirement analysis of selected feedstock
Rs-4	▪ The infrastructure analysis of selected feedstock
Rs-5	▪ Feedstock has already processed and ready to deliver into biodiesel refineries
Rs-6	▪ Logistic Concept of Upstream Logistic ▪ Feedstock handled & transported into biodiesel refineries
Rs-7	▪ Detailed biodiesel refineries operation ▪ Quality management ▪ Eco-production

Glossary

Rs	Result
IT	Information Technology
Spec	Specification
Op	Operation
SC	Supply Chain
DC	Distribution Center

Figure 5-55 Result and Glossary of the Proposed Sustainable Biodiesel Development

6. Discussion

6.1. Overview

The studies that have been conducted in the previous chapters will be explained and discussed in this chapter. Such discussion includes analysis of design, performance, testing, as well as a description of the master plan for biodiesel supply chain improvement. The thesis so far has conducted the following sequences:

a) Positioning and strategic analysis: GE/McKinsey Matrix
b) Facility Planning Simulation: ALA Procedure using mixed-integer linear programming (MILP) in MATLAB powered by geocoding-function M_MAP
c) Simulation Validation: Microsoft Excel (SOLVER)
d) Experimental research and prototyping to propose a Common Platform of Biodiesel Supply Chain Governance: EvoSCM-B
    - EvoSCM-B1.0: Integrated Web-Database and Mobile-Apps for Biodiesel Industry (Prototyping)
    - EvoSCM-B2.0: Electronic, Sensor and IT-tracking Support (Prototyping)
    - EvoSCM-B3.0: Biodiesel Supply Chain Powered by IPv6 and IoT (Concept Design)

f) Masterplan for digital biodiesel supply chain

The research results (i.e. GE/McKinsey analysis, Simulation, Experimental research and prototyping: EvoSCM-B, Masterplan for Biodiesel Supply Chain) present a digitalisation pattern for the biodiesel supply chain for sustainable development. That matter is addressed and discussed in the next section below.

6.2. Discussion-1: Simulation

The simulation results proposed a new location for biodiesel DCs (TBBM) by considering existing DCs (TBBM). The decision algorithm for the new position was based on the ALA procedure. In the end, it must be considered whether it is economically necessary to construct a NF or to keep the current available existing DCs.

There was a result proposed where NF = EF. This indicated that the existing location is already optimal and there was no need for NFs (see Figure 6-1).

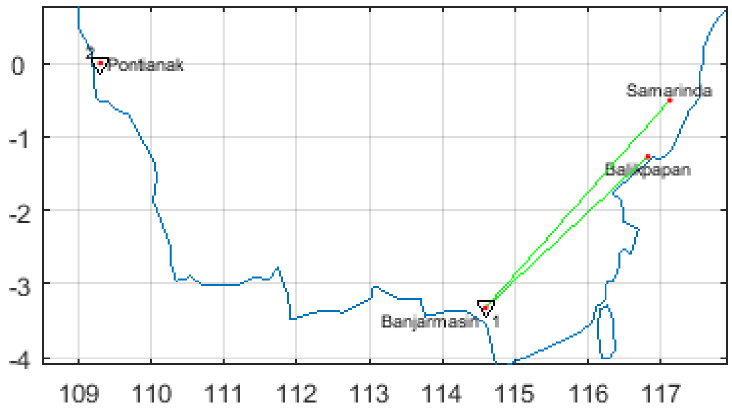


Figure 6-1 Region VI, the Proposed NFs are EFs

When NFs are located in a new position, this place should be taken into consideration when building NFs because this has an optimal result for distribution (see Figure 6-2).

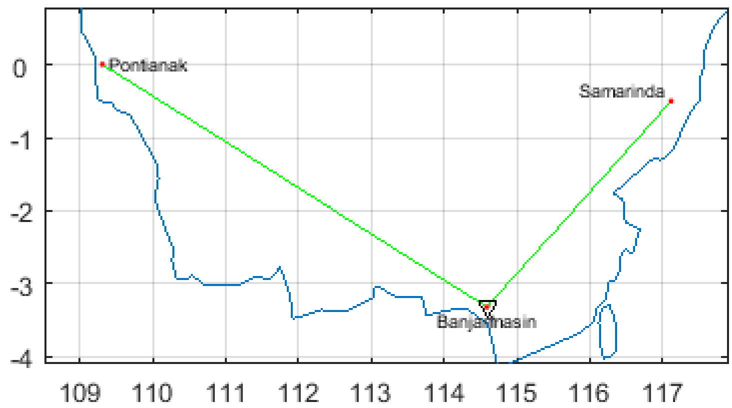


Figure 6-2 Region I Simulation for 1 NF, the Proposed NF Result is Located in a New Location

Besides determining the optimum location of NFs, the tool also calculated the minimum TC. Case Study-5 conducted ten iterations to find this minimum. Thus, the simulation ran nine times after the first TC was calculated. Table 6-1 clearly shows the minimum value obtained by this approach.

Table 6-1 Iteration vs Total Cost

Number of iteration	Region 3 (NF=4) Total Cost (IDR)
1	3,714,152,000
2	2,567,270,000
3	2,724,561,000
4	2,724,561,000
5	2,567,270,000
6	2,499,458,000
7	2,567,270,000
8	3,714,152,000
9	2,724,561,000
10	2,724,561,000

In the last part of the simulation analysis, the author benchmarked the MATLAB and Excel results for the case studies. The author employed paired t-test for MATLAB and EXCEL comparison (see Table 5-15): $t_{obs} = 0.819 < 12.706 = t_{crit}$ (or p-value = 0.563 > .05 = α). According to this result, there was no significant difference between the two results. This experiment revealed that the MATLAB simulation was valid. The paired t-test revealed that with 95% confidence there was no difference between the two data results.

The optimisation of NF locations resulted from this simulation can be used to assist biodiesel distribution planners. The manager may apply it to plan the distribution strategy and decision-making. The minimum TC and number of NFs significantly influenced the supply chain design (see the Masterplan of Biodiesel Supply Chain). This simulation tool can also be used in other facility location studies, e.g. between DCs (TBBMs) and filling station/biodiesel retail outlets (SPBU: Stasiun Pengisian Bahan Bakar Umum). The desired parameters or the distribution scenario can be modified for smaller sections. It can be applied to the feedstock infrastructure as well as upstream logistics infrastructure design.

6.3. Discussion-2: The Common Platform of Biodiesel Supply Chain Governance

Enabling IT for the SCM not only means creating a website for the company, putting information on the internet and then being done. A website is not a mere information gate for product marketing but evolves with the information system and governance tools. Coming soon, high-tech warehouses, smarter containers, and any other everyday objects can be linked to the Internet powered by IPv6. However, not all companies are ready to face the rapidly changing technological advances. Enterprises still need to look at the strategy of technology transition using continuous improvement. Therefore, this section offers a concept of evolution (EvoSCM-B) in the governance structure using a web-based managing supply chain for biodiesel as a common platform.

The web-portal can be managed separately by a third party (with high authority under state management) offering services of ‘governance’ for the supply chain. Alternatively, it could be managed by one of the major downstream industries that dominates the supply chain. Such a web-portal can literally act as a ‘control tower’ which monitors the whole supply chain process.

All supply chain members have to register on the web-portal, with clearly defined roles and awareness, to accept and comply with the entire transaction procedure. The proposed method grants flexibility as well. Any regulations that are appropriate for the business are clearly defined from the very beginning. The duties and responsibilities of each member supply chain are unmistakably declared.

In order to carry out this idea, the system pursues a straight course over the software development lifecycle. A software development lifecycle (SDLC) is a process that the software undergoes from its analysis to the post implementation phase. SDLC is also known as system development life cycle or software development process. EvoSCM modifies the V-model of SDLC as the development method to follow. Supply chain and governance structure are inserted in the model to produce desired requirements and definite coordination (see Figure 6-3).

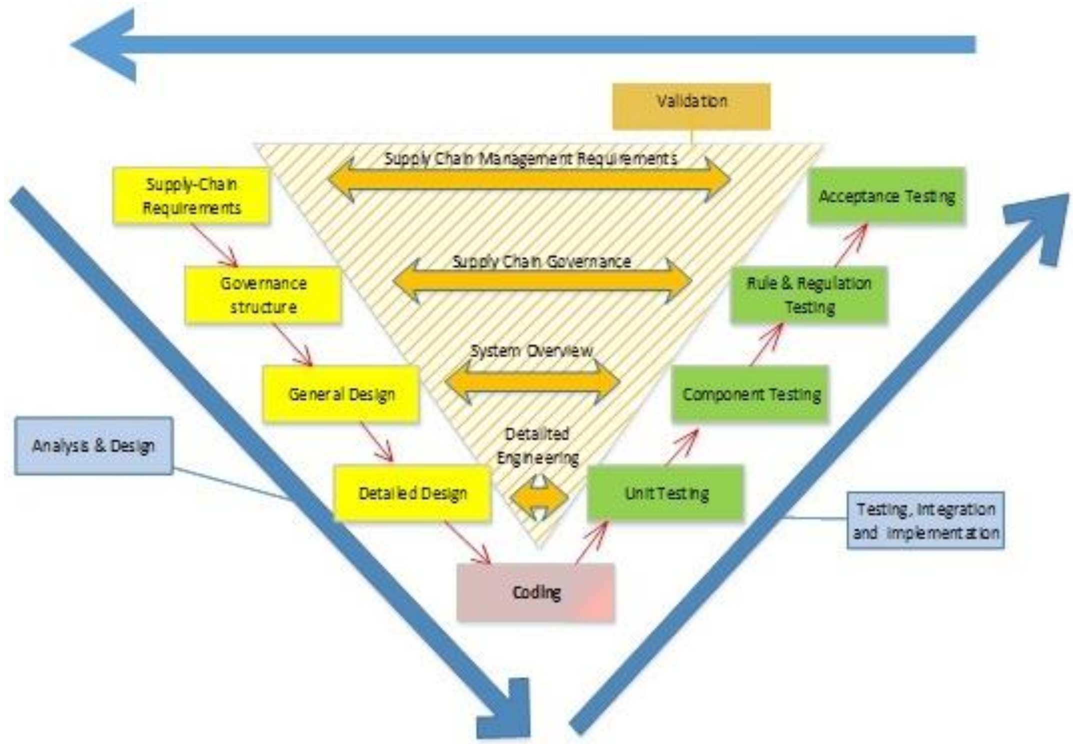


Figure 6-3 Modified V-Model of SDLC

The development-method shown in Figure 6-3 strengthens the partnership board. A relationship in the ‘digital-contract’ will more firmly bind and strengthen. This method can be applied anywhere and be addressed to any logistics strategy in accordance with the original purpose desired. The initial requirements of the system-design are determined upfront, adjusted to the desired logistics strategy. Furthermore, validating the requirements to match with the governance structure uses a rule-testing regulation.

The system developers conduct these initial steps before they go into the general system-design software. Thus, the whole-system is fitted to the community vision. It will be flexible, whether it is used to adjust the vertical or horizontally integrated manufacturer or implemented using a push-pull supply chain strategy. The system also can be designed specifically to a contractual, transactional or relational governance of the supply chain. All requirements can be customised in accordance with the agreement at the beginning including the terms of efficient logistics. Therefore, the principles of good governance, e.g. Efficient, Accountable, Transparent, Responsive, Equitable and Inclusive, could be fulfilled. A sample governance structure will be discussed further in sub-chapter 6.4.3 (see Figure 6-5 Governance Structure of Biodiesel Supply Chain - Case Study: Indonesia (modified from (Zhang, 2009))

The first-phase uses very basic tools and applications; for example, it uses a mobile-app in the system because smartphones have become universal. So, the implementation of this idea will not generate significant trouble. Likewise, the database and web-services that I have made use conventional tools such as PHP and MySQL. EvoSCM encourages the utilisation of such tools for a small scale business. When the web is already used by a firm to market a product, then it can be equipped with the features that consist of transactions, monitoring and governance. Web and centralised databases using MySQL and mobile-app are a unique approach because they are easy, cheap and flexible.

On the other hand, the role of a mobile-app in controlling supply chain processes is very vast. For example, a manager of a vehicle spare parts company has received a notification on his mobile-app. The manager just looks through the app to see if the stock is still there. When the stock is ready, he pushes the accept button and the transaction is complete. As another example, after goods arrive in the destination, the transporter asks for approval from the customer. It can be done directly from a smartphone and immediately the invoice will be automatically sent to email. This system will be easily inserted and implemented everywhere even for the home industry. Coupled with the centralisation of data between customers, suppliers and transporters based on GIS, the monitoring of the product becomes more thorough and systematic.

In the second phase, employees use some devices and sensors. Data collection is not only inserted manually by the operator of the smartphone but directly obtained by the automatic sensor or camera. In this phase, the firms are expected to already have their own data-centres with an established information system but not yet the vision of their products. Their systems also have not been incorporated into the structured information with other entities in the supply chain networks. In order to perform a test bed of the proposed system, simple applications based on PHP and MySQL on the server-side connected to a mobile-station on the client side have been done. The mobile unit is plugged into a prototype tank-container that is assumed to transport liquid biodiesel (see Figure 6-4).

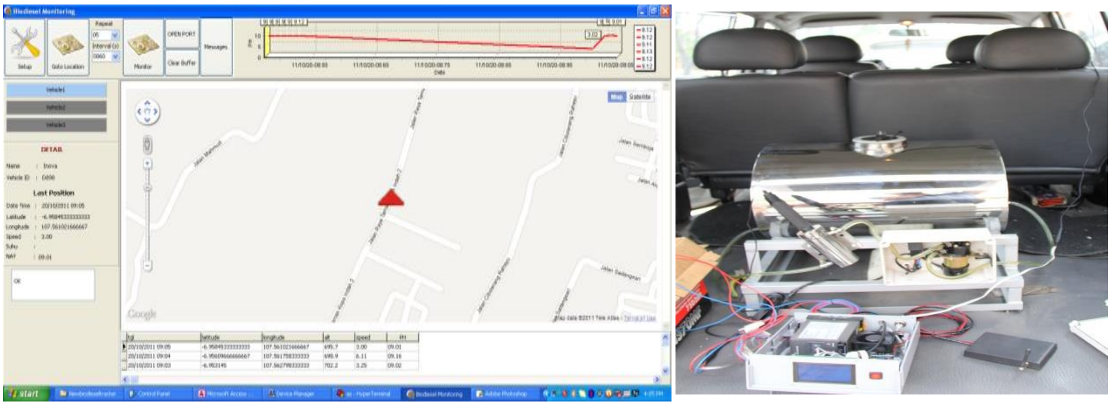


Figure 6-4 Data-retrieval Testing during Transport

The data collection and GIS function tests have been conducted for ±78-km trip. 10 litres of biodiesel have been placed in the tank-container and sampling data collection set data acquisition every 15 minutes. The test also performed administrative data retrieval such as message delivery from the customer to the transporter, and the request to the supplier invoice issuance at the end of the trip. The examination yields several conclusions as follows: the system provides nearly real-time data acquisition, the auto-alarm is generated when the quality exceeds the threshold, MySQL stores data periodically and automatically classifies the position and quality data. A variety of commands set a digital connection from the control centre to individual monitoring sites through the network, such as collecting the data, modifying the data, a remote session, instrument control, message, etc. (see Figure 6-4).

The last phase of EvoSCM is called smart web-supply chain as shown in Figure 5-63. Numerous Sensors and e-Tags (electronic-tag) on the IPv6 platform will be deployed in public. The concept is similar to the early days of making a cellular network, but in this case, the network extension will be towards the wireless sensor network nodes using the IPv6 platform. Sensor nodes connect the real world into global information networks through base stations (access-points). An existing e-tag RFID, 0.16 mm2 in size, will be planted on the product or its packaging or it could be on a pallet or container level. Communication between the e-tag sensor nodes will use radio-frequency, and then be passed to the IPv6 network using wireless internet. The IPv6 network is easy to configure. Neighbour-discovery finds other IPv6 systems and auto-configuration will enable more automated set up of the systems. Thus, this network will also maintain constant access to ERP, MRP, CRM or other existing systems.

The code for IPv6-enabled network is already built into the current versions of Windows XP, MacOS, Linux, and many forms of Unix. Moreover, every router made by Cisco Systems Inc. comes ready to run IPv6. On the other hand, slowly but surely, RFID tags have decreased in price. In the near future, they will be produced in mass and pop up on a huge market, such as embedded on shopping-bags, pallets, product-casing or even containers. The trend of container-trucks with built-in ID readers will maybe emerge in a few years. This would enhance LBS and improve marking identification in a highly efficient supply chain.

6.4. Discussion-3: Masterplan for Digital Biodiesel Supply Chain

This section discusses and analyses an integrated concept of a biodiesel supply chain as depicted in Figure 5-55. The process is made using a spin procedure to ensure the sustainability of the system. This master plan can also be viewed like a SCOR (Supply Chain Operational Reference) model that specifically designed for the biodiesel industry. It will integrate the concepts of business process, analysis, marketing, and monitoring process into a cross-functional framework.

6.4.1. Data Collection, Planning and Analysis

Data collection, planning and analysis are presented in chronological order in Figure 5-56 (detailed in Appendix 8). The following paragraphs describe those figures briefly.

1. Market Analysis

The market study requires an analysis of the current distribution of the demand for fuel by the customer. The customers are divided into three groups, i.e., filling station network, larger companies and trade (export). The filling station network supplies private and business customers. On the other side, the larger companies need exclusive contracts due to their high demand. The trade describes an overall amount of biodiesel that can be sold abroad. In all three groups of purchase, the behaviour and quantities must be pre-determined. Those approaches define the criteria of manufacture, production levels and distribution ratios of biodiesel. Such information needs to be continuously updated, as there is an interaction between the government and groups of customers or society. The market-analysis results in a: 1) complete report of biodiesel production rate (for the national target), 2) blending ratio of fossil-diesel and biodiesel and 3) the emission threshold and the carbon footprint standard.

2. Raw Material Selection

This step identifies the major national feedstock commodities that are widely owned, sustainable and manageable for mass production. In the biodiesel field, there are two types of common feedstock for the 1st and 2nd generation of biodiesel, i.e. crop or waste-frying oil (WFO). The crops vary, depending on the most dominant local material. North and South America tend to use soja bean and Germany uses rapeseed or sunflower plants. Southeast Asia tends to use palm oil or jatropha. The third-generation biodiesel is being developed using microalgae feedstock or biomass feedstock which comes from residual plant materials.

Types of chosen feedstocks have to be easy to obtain, sustainable and ready to be produced in a large scale within the farming industry. The results of this step are: 1) the decision of national feedstock and 2) the decision of biodiesel processing technology (1st, 2nd or 3rd generation of biodiesel).

3. Feedstock Analysis

The criteria for the selection of plants are considered as follows: energy content, necessary knowledge on the cultivation of biofuel plants, shelf life and perishability, climate conditions and soil requirement. The first criterion is energy content/energy yield. The growing area has to be created as a common basis for further steps. Another aspect that must be taken into account is the experience of farmers. It is desirable to make a selection regarding the type of training needed and the time required. The investigation of shelf life and perishability is incorporated into the collection of plants. The criteria that involve the subject of logistics and any further processing are to be observed since they are involved in the next interface in the value chain. The next factor influencing the choice of plants is the climate conditions that affect the growth of plants. The required hours of sunshine and rainfall are particularly noteworthy and necessary. The possibility of irrigation also has to be considered. As a final criterion, the respective infrastructure requirement must be reviewed. This step provides a feedstock requirement analysis.

4. Feedstock Infrastructure Analysis

The following items have to be worked out for feedstock infrastructure analysis: geographical location, climate-induced-effects on soil, infrastructure (logistics connections, water and electricity access), land-owner and possible acquisition of fallow land.

The important thing for fallow land consideration is the geographical location, climate and properties of the soil. The infrastructure is dependent on this criterion. Accordingly, the proposed simulation tool is urgently needed. Both the logistical link (road, possibly rail) and the presence of water and electricity supply networks may vary according to location. It might possibly have to be created or modified based on the requirements. The result of this step is a complete infrastructure analysis of selected feedstock.

5. Feedstock Processing

The feedstock processing deals with several questions, i.e. where is the fallow land, which energy crop species should be grown? Which type of cultivation should be used for the plants? How should they be harvested? In the case of WFO as a feedstock, then the question is: How can people collect that oil and manage it as a feedstock for biodiesel refinery?

Each type of energy plant results in a specific type of cultivation. Then the next step is the actual agricultural processing initiated by the cultivation of the soil and the seeds all the way up to harvesting. All necessary details such as irrigation and fertilisation must be determined explicitly. The coordination of the results of the work on technology and agricultural processing steps leads to the different kinds of crops received (e.g. oilseeds). Then it must be clarified how an intermediate storage of the crop is designed. Besides that, when the government has decided to use WFO or other residual things, then a waste management plan has to be created. Moreover, the planner has to also consider a design for a silo or interim storage where the feedstock is temporarily stored after processing. The result of this step is the feedstock readiness to be delivered to the biodiesel refineries.

6. Upstream Logistics

Upstream logistics ensures adequate transport between cultivators (or collectors for WFO) and processing sites (or biodiesel refineries) which produce the biodiesel. According to the previous work, suitable plants for cultivation and soil and fallow land conditions are fixed. Furthermore, a selection of the transport medium should be possible, mainly trucks, railways, pipelines or shipping. It should be noted that the distance of carriage affects the transport medium. It is also necessary to record which transport containers/tank can be used, since they influence each other with regard to a loading system. In the selection of the transport medium, an analysis and assessment of the infrastructure must be made. This step generates the following final results: 1) concept of upstream logistics and 2) the method of feedstock handling/transport.

7. Biodiesel Refinery

At this stage, the facilities that match the criteria of the logistics concept and recommendations for the plants have to be determined to generate the desired fuel. When all factors have been calculated, and a relevant logistics concept has been found, the analysis of possible biodiesel facilities can begin. For the purpose of delivering the goal at this stage, the following factors have to be considered:

a. Biodiesel-plant blueprint: Plant layout, plant specifications and feedstock, reagent storage, and handling.
b. Processing plant operations: Required infrastructure, health and safety issues, pressure vessel regulations, feedstock collection and provenance, plant operation, side products.
c. Bio-diesel total production costs: Fixed and basic costs, feedstock costs, methanol and catalyst costs, consumables cost, electrical power consumption, labour costs and production cost.
d. Significant Considerations: Weather and pumping problems, fluid transfer (from the settling vessel), washing and filtering, eco-friendly (environmental issue), social, politic and security issues.

8. Downstream Logistics

Downstream logistics is concerned with transportation from the biodiesel facility to the customer. Efficient and cost-saving logistics must be in place in order to keep the price of the final product low.

Based on the location of the purchaser and the manufacturer the decision for the appropriate transport medium has to be made. Such location analysis can also be estimated by the proposed simulation tool previously presented. When the method of transport is discovered and adapted to the container of a carriage, the next step is the selection of the loading/unloading system.

The development of a logistics concept can be formed after all these factors have been established. Then, the company transports the product to retailers and large consumers. Finally, the retailer sells biodiesel to the end user.

In fact, each country has different rules for downstream logistics and marketing. In this masterplan, the author had two alternatives where the downstream logistics can be managed by the government or private sectors. The design concept described above is intended for a private company. In the case of a state-owned company operation, the following actions have to be considered:

a. Public Auction: The state-owned company buys the B100 from the private sectors via an auction method, and the price of the product includes the transport cost.
b. DC-Operation: Biodiesel handling, blending, shore-tank management, quality control, service and maintenance
c. Distribution: Biodiesel handling, transport selection, quality control, routing and scheduling
d. Retailer and Large Consumer: State-owned filling station, private filling station, state-owned power plant, industrial consumer, exporter.

6.4.2. Business Case

Besides the data, planning and analysis (points 1-3), the proposed biodiesel circle development concept also has the business case and implementation (see Figure 5-55). The business case is the transition between points 1-3 (data collection, planning and analysis) to the last point (implementation). Nevertheless, it needs well prepared prerequisites, i.e. a useful and comprehensive documentation of all previous points. There should be an accurate description of each point as well as a recommendation so that the business case can be realised.

The tasks of the business case highlight the best combinations of both monetary and non-monetary criteria. Monetary aspects include cost and benefit comparisons regarding the possibility of the implementation and risks regarding time. The non-monetary criteria include above all the entire energy balance, which deals with CO2 and other pollutant emissions as well as a comparison of the energy input-output. This consideration will ensure that the project is eco-friendly and sustainable targets are met. The final weighting of these two perspectives has to be made to reach the best balance between profitability and environmental aspects.

6.4.3. Implementation

The implementation deals with the real action plans, after all the factors have been analysed, summarised and different choices represented in the business case have been decided.

The first consideration for implementation is the governance structure. All stakeholders, including the government, the society (company, filling station, trader) and the accreditation board have to understand and agree to the national governance structure of the biodiesel supply chain.

According to Figure 5-56 (detailed in Appendix 8), several business stages occur in the biodiesel supply chain system, i.e. 1) market analysis, 2) feedstock production, 3) feedstock logistics, 4) biodiesel production, 5) biodiesel distribution/upstream logistics and 6) biodiesel selling/transactions. In order to ensure a well-managed implementation rate, the stakeholder should form a national biodiesel board that agrees on the division of roles between the biodiesel actors for those stages which should be clearly defined and can be managed by the private sector (liberalisation) or taken over directly by the government who is responsible (see Table 6-2). Only after can people begin to conduct (or implement) their action plans and control end-to-end visibility from upstream to downstream in order to implement the concept of sustainable biodiesel development as mentioned earlier.

Table 6-2 The Role Distribution in the Biodiesel Industry (Case Study: Indonesia)

No	Biodiesel Business Stages	In charge	Involves
1	Market Analysis	National biodiesel board	The government (the ministry of energy and the state owned companies involved), the society (company, filling station, trader) and the accreditation board
2	Feedstock production	Public and private sectors	Plantation companies owned by the government and private
3	Feedstock logistics	Public and private sectors	Logistic companies (public or private)
4	Biodiesel production	Private sectors	Biodiesel refineries
5	Biodiesel distribution	State-owned company /Private Sectors	Public and private transporter, state-owned DC (Distribution Centre)
6	Biodiesel selling	State-owned company	Public and private filling stations, state-owned transporter.

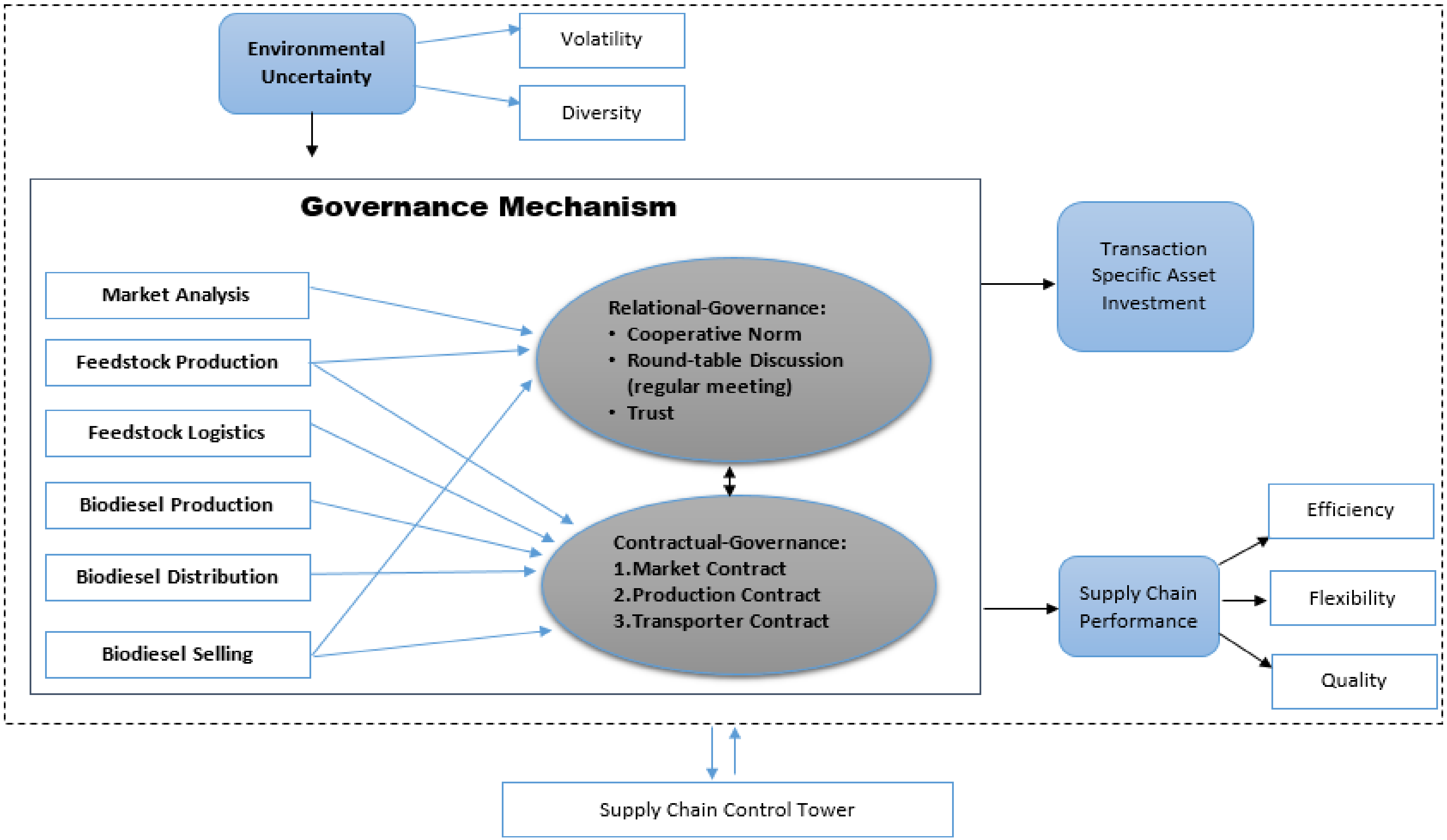


Figure 6-5 Governance Structure of Biodiesel Supply Chain - Case Study: Indonesia (modified from (Zhang, 2009))

Figure 6-5 shows a conceptual framework of the governance structure in the Biodiesel Supply Chain (Case Study: Indonesia) modified from Zhang (2009). Such a structure defines the institutional matrix where transactions are arranged. It models a two-dimensional governance structure in the biodiesel supply chain, where transaction cost economics (TCE) theory and relational theory are linked to build the governance relationships.

As depicted in Figure 6-5, the system is affected by environmental uncertainty. In an extremely unpredictable environment, supply chain actors may attempt to set a positive governance structure in order to manage a chaotic situation. Derived from the previous research results, such as (Geyskens, 1998), (Claro, 2003), (Cannon & Perreault, 1999), Ganesan (1994), Klein (1990) and Zhang (2009), the environmental uncertainty can be classified into diversity and volatility. Environmental diversity is the degree of various complex environmental components, while the environmental volatility refers to the rapid changes of market and demand.

Zhang (2009) argued that in a high degree of uncertainty, the chain actors (consumers, supplier, producer and retailer) are trying to work mutually during the time of crisis, e.g. using contracts to safely conduct their business or selling a product jointly for the same markets. Thus, the mutual collaboration engages in a binding structure that can be a contractual governance or relational governance.

Contractual-governance relates to any agreements (written or oral) used by individuals or companies or any institutions to decrease risk and uncertainty in relationships. In the case of Indonesia, there are several types of contracts, e.g. feedstock supply contract, biodiesel production and supply contract (based on the auction result) or marketing contract (based on the buying & selling condition).

Relational governance describes an informal set of relationships and social norms. Hence, contractual governance includes the real, explicit and formal facets of relationships, while relational governance works with soft, tacit and informal aspects based on trust and honesty.

The governance structure depicted in Figure 6-5 is suited for the biodiesel business-stages for the case study in Indonesia. It may use a contractual or relational governance (or both of them) in each stage of the business. The structure has also related the Transaction Specific Investment (TSI) that concentrates on the aggregation of assets that are tough and costly to shift from one transitional partner to another; therefore, asset specificity arises.

Asset specificity relates to the permanent investments that are undertaken in support of particular transactions. Extremely asset-specific investments express the costs that have very limited or no value outside the relationship. (Claro, 2003) reported that asset specificity can stimulate relational governance.

According to Williamson (1985), asset-specific investments are divided into five types, i.e. site specificity, physical asset specificity, human asset specificity, dedicated assets and brand name capital. Williamson defined those assets as follows:

- Site specificity is held in a situation when, for instance, supplier and customer are located close to each other in order to economise transport and inventory costs. Thus, its concerns the site (location) in order to reduce the price.
- Physical asset specificity: investments by a supplier in capital goods that are arranged particularly for the transaction (e.g. investments in equipment, tools).
- Human asset specificity: investments in appropriate knowledge that have been acquired to use in explicit transactions (e.g. training of sales – people specifically for a certain partner).
- Dedicated assets: investments in generic assets that exceed the level of investments the firms would use if it did not engage in the specific transaction-relationship.
- Brand name capital: investments that become out-of-date if no longer using the brand name products.

At the level of implementation, a measurement of performance is a must. Assessment of a supply chain is a vital part of the survival of supply chain members and network structures that are built. Indeed, the efficiency and cost optimisation become the primary way to maintain sustainability. When supply chain structures are lacking in these two areas, it will cause short or long term problems. Performance measures can also be used for risk management. Risks that have been mapped since the beginning of the design can be detected during the process. At this time, the risks and performance of the system can always be measured and controlled.

The structure that I put forward in this implementation was modified from a framework that was proposed by Zhang (2009). In terms of supply chain performance measurement, the author summarises the few available literatures, such as (Claro, 2003), (Han, 2006), (Aramyan, 2007) and Lu (2007). Considering and combining these previous studies, there are three main pillars in the supply chain performance measurement, i.e. Efficiency, Flexibility and Quality:

. Efficiency: Final product price, profitability (value added), sales growth.

. Flexibility: Volume flexibility, delivery flexibility.

. Quality: Customer satisfaction with product quality.

6.4.4. Digitalisation

The digitising demand has arisen because of the insistence of the industrial and market field, such as automation of manufacturing, global world effect, more creative people in choosing products and environmental issues. Currently, manufacturing technology has gradually been moving towards automation. Producers who do not follow this trend will be crushed in the market competition. People are increasingly asking for product quality and precision. The connection between consumers is also increasingly globalised; the impression of a product felt by the consumers in one part of the world will be perceived quickly by people from other regions. Also, environmental awareness has strengthened. Products that are not environmentally friendly and leave a larger carbon footprint will not have a place in the hearts of consumers. Competition is not only considered at the producer level but also at the supplier level even among countries. Currently, those who are mastering the information and digital technology will manage a more qualified product and more efficient process. It will gradually shift the manufacturers' and suppliers' perception. A supply chain process that cannot adapt to this situation will lose in the tough competition. Biodiesel is a big industry whose major policies are controlled by the state. It is an obligation of the state to set the controls and the right options for this issue by digitising the supply chain.

In the preceding discussion outlining Figure 5-56 (detailed in Appendix 8), the readers became familiar with the part of the work-package called: 'SC - Control Tower Coordination'. This section is a controller, as well as coordinator of the entire supply chain and connected to each entity in the biodiesel business who becomes a member of the supply chain.

The control should be handled by a government agency that has high authority management in the government. Particularly, it is essential for developing countries with no standards in the management of biodiesel. It is also feasible to govern the country which has less awareness about environmental conservation. In this business, besides maintaining the sustainability of supply of feedstock, a supplier has to think about a way out of the environmental issues that emerge. Every country needs to have a body (National Biodiesel Board) that has the capability of a control tower. Such a board will always maintain the quality and sustainability without ignoring the rights of the environment.

The digitalising idea in this thesis incorporates some of the concepts as mentioned earlier, namely Modified-SDLC, EvoSCM-B and Governance Structure. Considering Figure 6-3 (Modified-SDLC), the procedure to conduct digitalisation can be described as follows:

1. Collect data on existing information systems owned by each supply chain member. From this activity, the stakeholder obtains data about the types of information systems of each actor in the supply chain; it can be a type of web-service, database, communication systems, or perhaps some of them already have an ERP.
2. Bringing together stakeholders to the table and discussing the requirements for the system. The current condition of each supply chain entity should be taken into account. The scheme is built to be able to accommodate all of the platforms in existing information systems. It is necessary to create a distributed agent that is capable of retrieving data from multi-platforms. Moreover, the agents have to combine and autonomously send data periodically to the control tower. At the beginning of system development, all actors in the supply chain do not have the same capability for IT. Therefore, it is necessary to implement EvoSCM-B for continuous improvement. The intelligent agents must be designed to be compatible and still perform their function when running in the first, second and third of EvoSCM-B.
3. Creating a governance structure, as explained in Figure 6-5. The structure illustrated in that figure is just an example of the case study in Indonesia. It can follow the unique local content of each country/region when implemented in other places.
4. Creating the general design of the entire system including the control tower information that monitors and controls all activities. The general concept of the network interface and the internet layer has been presented in Figure 5-63. Moreover, the system developer has to prepare the concept of TCP settings on the transport layer and the concept of distributed multi-agent systems in the application layer. The developers can use Figure 5-56 (detailed in Appendix 8) as a reference for the connection between the modules and intelligent agents.

5. Derive the general design which has been made into a bundled package of detailed designs.
6. Implement the entire design into code that accommodates all of the requirements.
7. Conduct testing in each unit/module/agent that has been created.
8. Perform testing of the components by involving all the relevant information systems
9. Conduct testing of the governance structure that has been set (rule and regulation testing).
10. Complete the system testing when going online.
11. Validate and if necessary the government may review and repeat the process periodically (annually or every 2 years) for continuous improvement.

The detailed design, coding and testing procedures from 5 to 10 require particular attention which is not possible to describe in this report. This will be one direction for future research. A model of a supply chain control tower that oversees a broad range of information systems will be created and should be implemented in a pilot network. Alternatively, a pilot network can be represented in simulation models of a multi-agent system.

7. Conclusion and Outlook

7.1. Conclusion

This research has attempted to assess whether a digitalisation and governance mechanism can be inserted in the supply chain, particularly in the biodiesel field. The general theoretical literature on this subject was examined using several methods within a diversification approach. The study sought to answer the following question: ‘how does one manage biodiesel supply chains in order to fulfil industrial and public requirements toward sustainable development using the digitalisation and governance mechanism?’. Biodiesel should be considered a business entity associated with raw materials, production processes, blending-stations, distribution and marketing points that are not only between regions but also linking countries or even inter-continents. Before going any further and deeply understanding the root causes, people need to know the position, the strengths and weaknesses of each player. Furthermore, the right strategy in developing the biodiesel business must be determined. For this reason, the author employed the GE/McKinsey Matrix. Based on such positioning analysis, Germany and Indonesia were located in Cell-1 [High Attractiveness – High Strength]; Argentina, Brazil and US were located in Cell-4 [Medium Attractiveness – High Strength]; China was located in Cell-9 [Low Attractiveness – Low Strength]. The advantages and disadvantages of each assessed country were clearly visible from this analysis. Furthermore, appropriate strategies can be derived from such analysis as well as translated into several experimental studies and the conceptual design of an IT-based supply chain.

In order to obtain empirical findings, a case study in Indonesia was undertaken. This country was chosen not only for being one of the largest biodiesel producers, but also because of the complexity of the logistics system. Indonesia is the largest archipelagic country with around 17,000 islands spread across more than 5,000 kilometres from west to east. The land area is 1,860,360 km² and the sea area 5,800,000 km². It has more than 237 million people (2010). The geography and uneven population distribution pose a major challenge in developing infrastructure and tackling inequalities, particularly related to the biodiesel supply chain. In the case study of biodiesel in Indonesia, the four recommendations [REC] generated from the GE/McKinsey matrix analysis were:

[REC-1] Maintain & supervise regulation to achieve predetermined mandate.

[REC-2] Maximise market share, seek dominance by developing the business infrastructures, e.g. the construction of warehouses, distribution centres, blending stations, multimode transports or biodiesel refineries.

[REC-3] Invest and expand the potential development of higher biodiesel concentration (B10, B15 or B25).

[REC-4] Conduct research on advanced biodiesel.

The author introduced three proposals to execute the recommendations that have been set up, i.e., simulation tools for biodiesel facility planning (addressing [REC-2]), The Common Platform of Biodiesel Supply Chain Governance (addressing [REC-1], [REC-2]) and a master plan for Digital Biodiesel Supply Chain (addressing [REC-1], [REC-3], [REC-4]).

The simulation-tool proposed a new location for biodiesel DCs (TBBM) by considering EFs (TBBM). The decision algorithm of the new position was based on an ALA procedure. In the end, a consideration was made whether it was economically necessary to construct a new facility or to keep the current available existing DCs. Such an approach was very relevant to [REC-2]. In the last part of the simulation analysis, the author benchmarked the MATLAB and Excel results for three case studies. The author employed a paired t-test for the MATLAB and EXCEL comparison (see Table 5-16): $t_{obs} = 0.819 < 12.706 = t_{crit}$ (or p-value = 0.563 > .05 = α). According to this result, there was no significant difference between the two results. This experiment showed that the MATLAB simulation was valid. The paired t-test with 95% confidence proves that there was no difference between the two results. Thus, the optimisation of NF locations resulted from this simulation can be used to assist biodiesel distribution planners. The manager may apply it to plan distribution strategies and decision-making. The minimum TC and number of NFs significantly influenced the supply chain design (see the Masterplan of Biodiesel Supply Chain). It can also be implemented in another facility location, e.g. between DCs (TBBMs) and filling station/biodiesel retail outlets, etc. The desired parameters or the distribution scenario can be modified for a smaller/larger area.

The second proposal presented the common platform for Biodiesel Supply Chain Governance. This section offered a concept of evolution (EvoSCM-B) in the governance structure using a web-based managing supply chain of biodiesel. This approach was proposed assuming that IT skills possessed by the Supply Chain members are not the same, therefore technology transitions that adopt continuous improvement gradually (evolution) were recommended. Such a system applies web and data centres (control tower) that improve supply chain governance structure as a backbone. The web-portal can be managed separately by a third party (with high authority under state management) by offering services of ‘governance’ for the supply chain. Alternatively, it could be managed by one of the major downstream industries that dominates the supply chain. Such a web-portal can literally act as a ‘control tower’ which monitors the whole supply chain process. All supply chain members have to register on the web-portal, with clearly defined roles and accept and comply with the entire transaction procedure. Hence, the suggested method grants flexibility as well as governance. Any regulations that are appropriate for the business are clearly defined from the very beginning. The duties and responsibilities of each member in the supply chain are unmistakably declared. EvoSCM-B modified the V-model of SDLC as the development method to follow. Supply chain, governance structure and sustainability concept were inserted in the model to produce desired requirements and definite coordination.

The first step of EvoSCM-B was characterised by a central-database supported by mobile-app and web portal that controlled a wide range of supply chain activities. Embedded system, web-online tracking, quality monitoring and supply chain governance were used for the second step. Finally, the last step was refined by the emerging trend of ‘Smart Web Supply Chain’ powered by IoT and IPv6. Each step of evolution was matched against the size of the company user. EvoSCM brings global and long-term benefits along the supply chain members parallel with the customer’s satisfaction. The ease of access to information at all levels of the supply chain will further facilitate distribution of roles and governance. It defines the role of each entity in the supply chain very efficiently. The implementation of the rules becomes more convenient and monitored all the time because formalisation of collaboration is conducted in a digital way. Besides that, product shipping will be more easily detected and estimated. The system generates real-time data from the market, hence analysis and intelligent forecasts for logistics market and business information could be regularly taken in order to carry out scientific management and decision making for logistics. Market analysis and forecasting are then clearly achieved by using linear regression, neural networks and other methods. Therefore, decisions will be made by real-time actions derived from event-driven supply chains and diagnoses.

The third proposal presented a master plan for a digital biodiesel supply chain consisting of the following agenda:

1. Data Collection, Planning and Analysis presented in chronological order in Figure 5-56 (detailed in Appendix 8).

Tasks that exist at this point are divided into eight work packages, namely: Market Analysis, Raw Material Selection, Feedstock Analysis, Feedstock Infrastructure Analysis, Feedstock Processing, Upstream Logistics, Biodiesel Refinery, and Downstream Logistics.

2. Business Case.

   This is a transition of the earlier analysis to the last point (Implementation). The tasks of the business case highlighted the best combinations of both monetary and non-monetary criteria. Monetary aspects include cost and benefit comparisons as well as the possibility of the implementation and risks on the time function. The non-monetary criteria include above all the entire energy balance, which deals with CO2 and other pollutant emissions as well as a comparison of the energy input-output.

3. Implementation

   The implementation point deals with the real action plans, after all the factors have been analysed, summarised and different choices represented in the business case have been decided. This part includes the division of roles in the supply chain as well as the governance structure. It also provides information that is important at the implementation level.

4. Digitalisation

   This section suggests the value of digitalisation by using the 'SC - Control Tower Coordination'. It also explains the role of the control tower as a controller, as well as coordinator of the entire supply chain. The digitising idea in this thesis incorporated some of the concepts mentioned earlier, namely Modified-SDLC, EvoSCM-B and Governance Structure. At the end of this section, the author described the procedure to conduct digitalisation referring Figure 6-3 (Modified-SDLC).

The results from literature studies, simulations, IT-prototyping, theoretical arguments, and conceptual design comprise the lessons learned for digitalisation of the biodiesel supply chain. Currently, a number of companies implement ERP to manage their business, but unfortunately, they have not been able to reach the entire value chain. Desirable digitalisation must integrate IT systems of all SC members. A control tower must be built to accommodate such an idea and monitor the whole process. Therefore, the best-standardised quality and sustainability can be achieved. The author also offered a transition concept in the implementation, because, in reality, the members of the supply chain have different information system standards. Through this thesis, the author presented a procedural technique to assess the biodiesel industry, solve their problems and propose an enhancement using some approaches. That procedure combined business modelling/analysis (using GE/McKinsey), simulation, conceptual design and IT. The results and theoretical model have also been validated through a focus group discussion attended by experts from the state-owned oil company and bioenergy business associations in Indonesia. Such results have also answered the research question.

7.2. Research Outlook

After validating the examination results and considering focus group discussions that I held, there are four important future works to conduct:

1. Future research should create a consortium involving all stakeholders. One of the obstacles in this research was the difficulty in obtaining data since the information was strictly protected. Biodiesel, particularly the type generated from palm oil (case study for Indonesia), has been linked to sensitive issues in politics and national security such as forest fires. Therefore, biodiesel has also become a national security problem. The policy of purchasing price is also very confidential since it has been set based on an auction system. It forces the producers to reduce the cost of production and transportation up to a certain level. The cost figures are really hard to find because it is very sensitive information. The involvement of stakeholders in the study will ensure all parties have a common interest in the development of the biodiesel industry. Linking the research to the related companies will ease access to such confidential and sensitive data.
2. The output of the research that has been produced in this thesis can be developed into Detail Engineering Design (DED). Further research can begin to focus on that design and implement all of the recommendations into a supply chain control tower in a mini system completed by a test-bed for examination.
3. Alternatively, further research can design a model for simulation using a multi-agent system that represents the DED. The researchers can experience difficulties in finding a business entity that allows their network and information systems to be tested. This can be avoided by using simulation.
4. The author also plans to model the real field-problem using a stochastic simulation. There are several uncertain parameters such as various and complex environmental components as well as the rapid changes in the market and demand. This modelling approach will obtain probabilistic simulation performance indexes which produce output that more closely follows reality since the various opportunities were speculated.

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Appendix

1. International Biodiesel Testing Standards
2. The Comparison of Multiple Supply Chains for Liquid
3. GE Matrix Factors Examination
4. GE Matrix Score and Position
5. Biodiesel Capacities per Fuel Terminals / Distribution Centres
6. Detailed Design of EvoSCM-B2.0 Prototype
7. The Mobile and Central Station Communication Protocols
8. Detailed-chronological Order of Integrated and Sustainable Biodiesel Development Concept

Appendix 1: International Biodiesel Testing Standards

Table A1-1 International Biodiesel Testing Standards

Region/Country	Standard	Description
Austria	ON C 1190	Austrian Biodiesel Fuel Standard for Rapeseed Oil Metyl Ester
	ON C 1191	Austrian Biodiesel Fuel Standard for Fatty-Acid Metyl Ester
Australia	Fuel Standard (Biodiesel) Determination 2003	Australian Biodiesel Quality Standard
Brazil	ANP 225	Brazil provisional specification for Biodiesel
Europe	EN 14214	European Standard that describes the requirements and test methods for FAME
	EN 14213	European Biodiesel Heating Oil Standard
Germany	DIN E 51606	German biodiesel quality standard
India	IS 15607	Bureau of Indian standards for blend stock FAME (B100)
Indonesia	*SNI*-04-7182-2006	Indonesian Biodiesel Standard
Japan	JASO M360	Japan standard for fatty acid methyl ester (FAME) blending
Malaysia	MS 2008	Malaysian Palm Mehtyl Esters (PME) standard
South Africa	SANS 1935	South African standard for Biodiesel Production, Quality Management System - Producer Requirements
Sweden	SS 155436	Sweden Standard for Vegetable Fatty-Acid Metyl Ester
United States	ASTM D-6751	US standards and specifications for biodiesels blended with middle distillate fuels

Appendix 2: The Comparison of Multiple Supply Chains for Liquid

The following discussions compare four different operational configurations that occur in a company. It is assessed during evolves its supply chain for liquid, based on (Klatch, 2005) invention. Klatch proposes the optimal supply chain for liquids that mix the existing/new technological abilities with new/changing personal or commercial needs that result in business advance. First, supply chain on a standard approach that uses traditional operations and does not distinguish liquid from a non-liquid product is presented. This configuration becomes a “baseline”; that compare to other concepts and approaches related to liquid logistics. Then, after the company establishes this traditional approach as a common baseline, they would be able to review their types of configurations, whether it is Adapted Supply Chain, Supply Chain for Liquids, and Optimal Supply Chain for Liquids. Each configuration is shown in the order of a complete loop. The following 14 steps of the traditional supply chain standard are considered for basic configurations models: 1. Production, 2. Bulk Storage at Producer, 3. Packaging, 4. Cartonizing/Palletizing, 5. Producer Warehousing, 6. Trucking, 7. Distributor Warehousing, 8. Delivery, 9. On-Site Handling & Storage, 10. User/Consumer, 11. Product/Package Recycling, 12. Customer's Purchasing, 13. Distributor's Inventory Control & Dispatch, 14. Producer Order.

a. Typical Supply Chain Configuration

Each step of basic configuration is assumed to model the discrete products, with no attention to the liquid products. As discussed earlier, the liquid will be seen as non-liquid products. Non-liquid industries commonly arrange this approach. It means that their core of business was not in the liquid area. The liquid is only produced as an indirect supporting product. The steps of the traditional configuration standard are presented in the Figure A2-1 and it complies with the 14 steps of traditional supply chain standard.

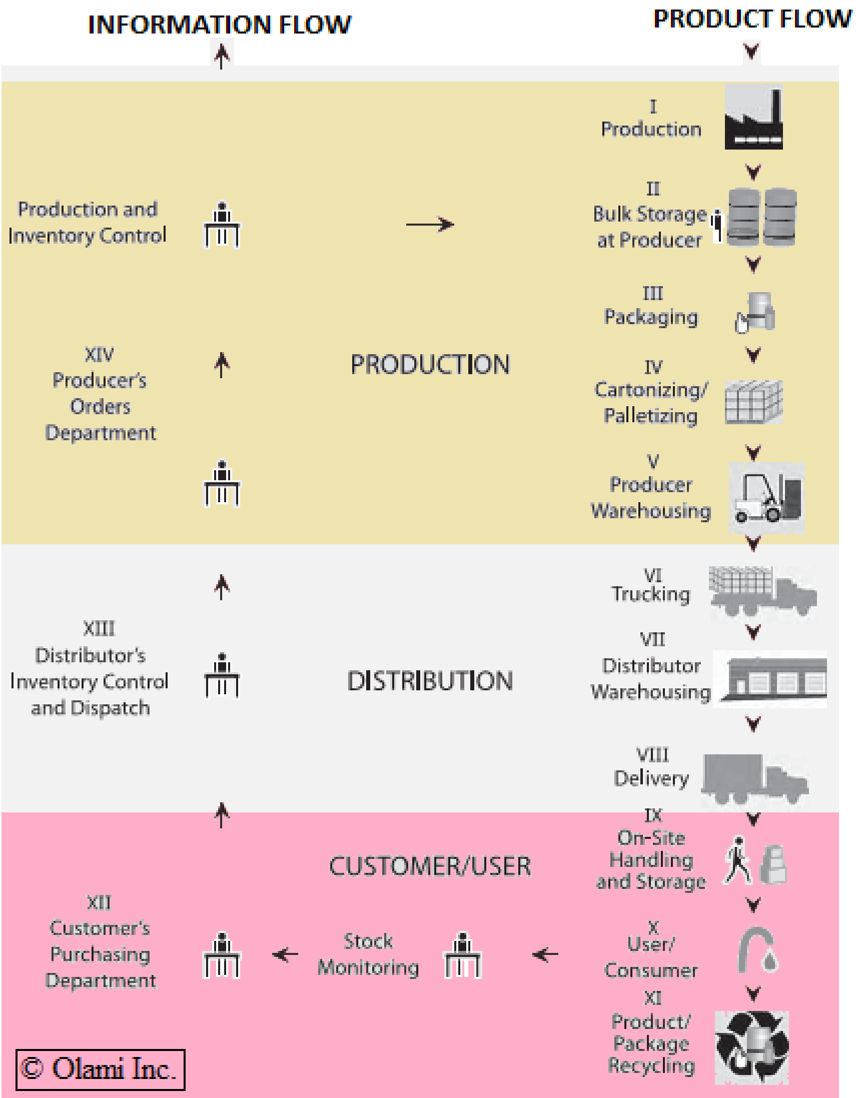


Figure A2-1. Typical Supply Chain Configuration (Klatch, 2005)

b. Adapted Supply Chain Configuration

An adapted supply chain is aimed some incremental benefit using relatively low effort. This approach is more evolutionary rather than revolutionary. The primary attention is to ask the following questions, "Within what we are doing now, how can we improve the system while minimizing effort or disruption?" This approach should be designed such that the results of this step will build toward the ultimate goal while minimizing inefficient activities. Several points on the Supply Chain baseline are rearranged to improve the effectiveness. The business will be moved from relatively small liquid containers to larger bulk or semi-bulk containers. The shipping containers will be increased in volume, and some peripheral changes will be made, but the basic utilisation methodology will be similar. Adapted supply chain configuration is mapped into the baseline flow in the Figure A2-2.

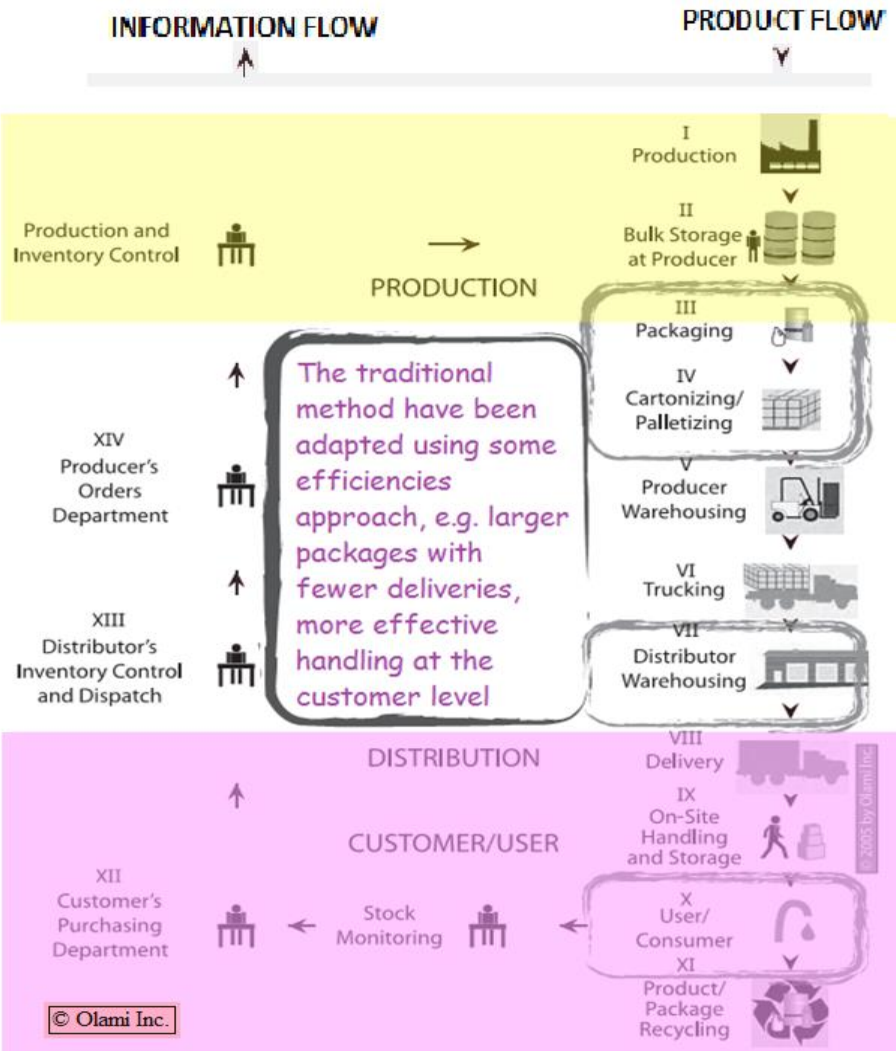


Figure A2-2. Adapted Supply Chain Configuration (Klatch, 2005)

In the adapted supply chain configuration, distribution system acknowledges the trade-off between packaging and delivery efficiency rather than being tied to "whatever the customer orders." In fact, under optimal supply chain for liquids, a vendor -managed inventory-type situation occurs in which the supplier initiates the replenishment cycle. For some cases, reductions in pricing as reflected in lower per-unit price in larger packaging may be put in place and will be a partial trade-off for reduced distribution costs. The customer might be taking some modest incremental steps toward Supply Chain for Liquids as well. For instance, in an environment where employees carry two-gallon jugs to different points in the user facility, larger containers could support the introduction of a dispensing system that would make the employees' work more efficient.

Adapted supply chain comes as an intermediate step in evolves from the supply chain toward the optimal supply chain for liquids. Thus, any steps taken within the adapted supply chain framework will be defined in terms of how they fit into the overall logistics enhancement plan. This action is a much more productive approach than having the players in the logistics flow sit down and design the next step each time a logistics-flow enhancement is made.

The implementation approach of the adapted supply chain configuration depends on the industry, the product, and the relationships between the supplier and the customer. Larger package sizes could be used and adapt the customer's internal distribution system, as described in the previous scenario or some other incremental movement toward supply chain for Liquids might be involved. The adapted supply chain stage represents an improvement for the supplier and for the customer that improvement gains operational efficiencies and cost reductions. In the longer-term strategy, adapted supply chain can lead to large improvement and effectiveness in the marketplace. Successful movement from supply chain thinking to Adapted supply chain thinking lies on capabilities for the remainder of the effort have been proved, such as the ability to execute, coordination among the different players in the supply stream, and the leadership to envision and execute such a movement.

c. Supply Chain for Liquid Configuration

The supply chain for liquids configuration is not taken only merely to change the type of container but represents the point where the logistics paradigm changes. Although this stage is fully arranged in advance on the path to optimal supply chain for liquids, this is the phase in which entirely "change management" is most critical. Thus, the reforms are not only taken on the physical aspects. The fundamental approach of doing business is altered along with a change of function performed by many entities through the process. The replenishment process is still driven by a “pull” approach based on customer requirements, but instead of the customer initiating the order, the replenishment order is issued directly from the supplier based on data received from the customer site. Just like the other method mentioned before, the supply chain for liquids stages are also carefully planned in advance. The plan consists of equipment plan, procedure, personnel, process, and information-flow elements. The only different was lying on the movement. It is no longer packaging that is being moved, but the product. The transportation method, the way liquids are held and used on-site, made the information flow was altered during this stage.

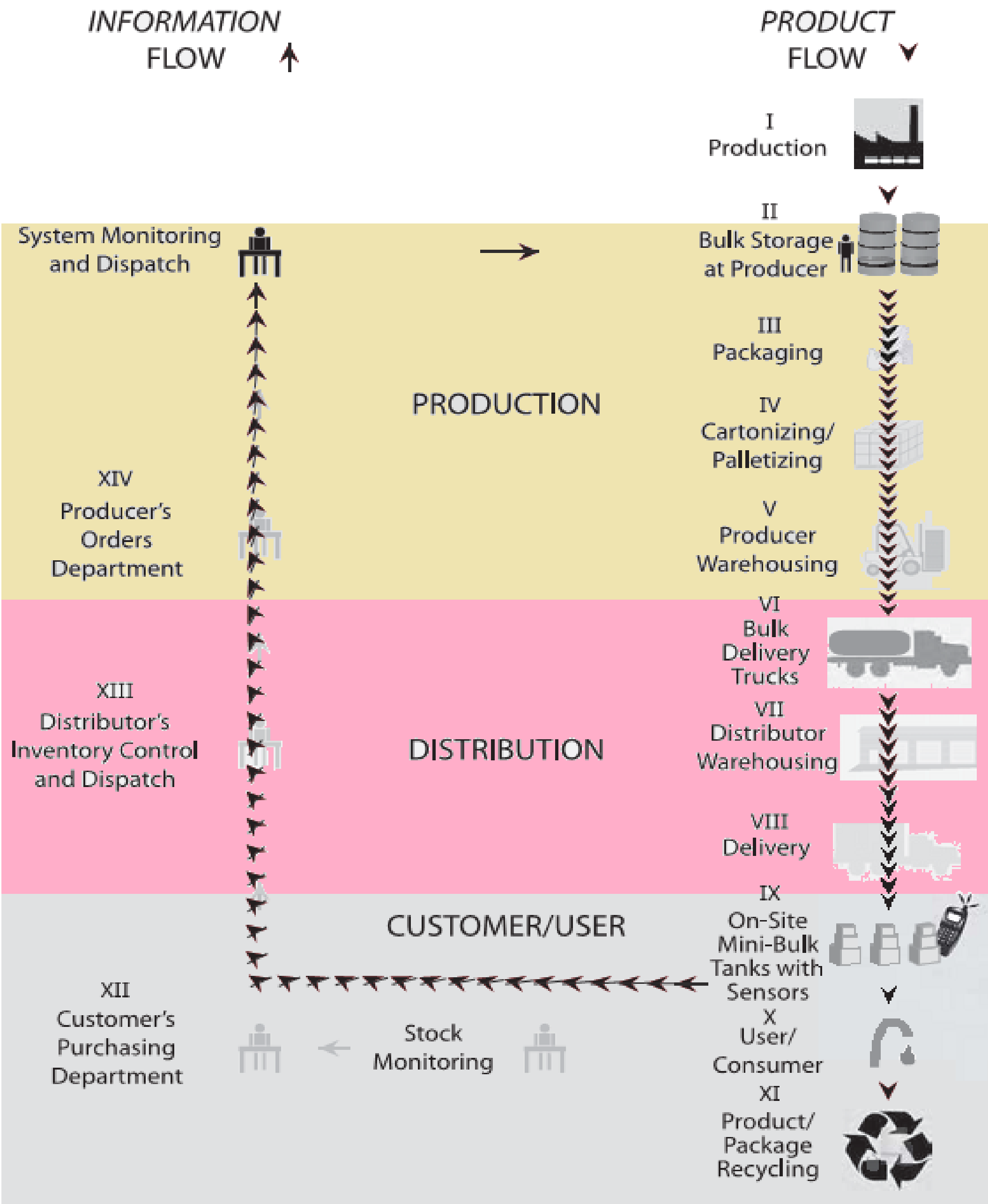


Figure A2-3. Supply Chain for Liquid Configuration (Klatch, 2005)

The supply chain for liquids scenario is exposed in Figure A2-3. Package-based distribution is replaced by a liquid-based distribution method. The liquid is put in bulk tanks at the production site and transferred to compartmentalized bulk trucks for transport. At the customer site, the liquids are not delivered as in a standard discrete-based method (with containers physically transferred into the customer facility) but rather passed directly from the delivery truck through a port in the facility wall and into mini-bulk tanks on the customer site. From the mini-bulk tanks, the liquids are fed directly to the dispense point, so the first non-bulk handling of the liquid since production is when the end user dispenses the liquid and is ready to use it. The on-site mini-bulk system equipped with liquid-level sensors that read and report product quantity-on-hand information at the frequency defined for the system.

This whole system has been developed as a flow, and none of the individual parts would work as effectively (or in some cases, work at all) if the entire flow did not "fit together" from a physical-flow and information flow perspective. Moreover, the supply chain for liquids method is compared to the 14 standards mentioned earlier. The transition elements and transformation of the steps will define their impact on the overall process. There are two main difference of this approach in compare to the earlier configurations.

1) The loading and unloading processes are replaced by one single hit of supply chain for liquid methods. The trucking, distributor warehousing, and delivery are succeeded by modern dynamic transportation and delivery of liquid products. The order of the supply chain sequence is made more efficient by skipping some steps. Initially from bulk storage at the producer site, the liquid product is directly loaded into the trucks (without packaging, cartonising and stored in the producer warehouse). Later, the liquid is straightly sent to the mini bulk-tank without transit to the distributor storage (see Figure A2-3). In order to achieve this adjustment, company has to have:
   a) Total visibility of inventory balances all along the supply chain for liquids, including the liquids that being held at the customer site;
   b) Minimum inaccuracy and uncertainty that usually leads to holding of stock at points along the supply chain;
   c) Special techniques that manage the transportation and delivery processes far more efficient than is possible using discrete-based approaches;
   d) Extended distance delivery methods

2) The overhead associated with inventory management is eliminated. The information flow is an integral part of the supply chain for liquids and is designed to integrate with the product flow and with the equipment in both directions. The computer provides data to feed the information flow, and the information-flow triggers actions related to the equipment. Sensors on the tank are used at the customer site to monitor liquid levels. This information is transmitted to the central room as frequently as defined by the user. When using this method, the manual user-site inventory-monitoring and -ordering function is eliminated. Therefore, Customer's

Purchasing Department, Distributor's Inventory Control & Dispatch and Producer Order Department are significantly removed (see Figure A2-3).

d. Optimal Supply Chain for Liquid Configuration

Optimal supply chain for liquids can be divided into two aspects. The first aspect is associated with the internal operation of the supply chain for liquids, and the second relates to the external results that have been obtained through achieving optimal supply chain for liquids configuration. The internal operation of the supply chain for liquids system relates to the operation and interaction of all the players along the supply chain flow. Optimal supply chain for liquids means having fulfilled the plan that was originally laid out in looking at the entire logistics flow.

The optimal supply chain for liquids system has the full product and information flow working in close synchronization. It uses all the elements such as equipment, procedures, technology, and resources in a unified system. RFID (Radio Frequency Identification) for liquids and CPFR (collaborative planning, forecasting, and replenishment) approach. Therefore, besides the original plan, the information flow ensures that the status and condition of the physical product is well monitored and quick responded. Naturally, a supply chain for liquids is a dynamic system that can handle the fluctuations and challenges of the logistics flow. A company that has achieved the optimal supply chain for liquids level of performance has the internal mechanisms in place to handle all of these variations that occur in the logistics process. The external element is dealing with a new position for the company in the marketplace and its relationships with customers and competitors.

Appendix 3: GE Matrix Factors Examination for Selected Countries

1) Industrial Attractiveness

This segment explores the major players of world biodiesel industry such as United States, Argentina, Brazil, China, Germany, and Indonesia to the factors which are affecting biodiesel market attractiveness.

a. Market Penetration

Market penetration is the level at which the products are recognized and purchased by customers in particular markets. At this rate, the company's sales expressed as a percentage of total sales for the industry. This part has carried out a comparison to the market penetration of selected countries that are known as major biodiesel producers. The rating of market penetration is arranged on the Table A3-1.

Table A3-1 Rating of the market penetration assessment

Market Penetration (Million Liters)	**Rating**	**Score**
0 – 500	LOW	0.0
500 – 2000	MEDIUM	0.5
> 2000	HIGH	1.0

The comparison results of market penetration on the selected countries are expressed in the Table A3-2.

Table A3-2 Biodiesel Market Penetration of Selected Countries by 2011-2013

Country	**Market penetration**				**Assessment**	
	2011	**2012**	**2013**	**Average**	**Rating**	**Score**
Argentina [I]	850	980	1010	947	MEDIUM	0.5
Brazil [II]	2673	2717	2917	2769	HIGH	1.0
China [III]	221	273	324	273	LOW	0.0
German [IV]	3653	3964	3747	3788	HIGH	1.0
Indonesia [V]	286	637	996	640	MEDIUM	0.5
US [VI]	4401	4494	6297	5064	HIGH	1.0

[I] (USDA-Argentina, 2014)
[II] (USDA-Brazil, 2014)
[III] (USDA-China, 2014)
[IV] (USDA-Europe, 2014)
[V] (USDA-Indonesia, 2014)
[VI] (US-EIA, 2015)

b. Agriculture Value Added to the Percentage of GDP (Gross Domestic Product)

According to the (Worldbank, 2015), the agriculture sector includes forestry, hunting, cultivation of crops and livestock production and fishing. The vegetable oil that used to produce biodiesel is part of this farm sector. The share of agriculture to the GDP reflects the strength of vegetable oil production as well as the market demand. The GDP determined the monetary value of all the finished goods and services produced. The value added is defined as the net output of an agriculture sector after summing up all outputs and deducting the intermediate inputs. The depletion of fabricated assets and degradation of natural resources are ignored in this calculation. This section serves data of the Agriculture Value Added to the Percentage of GDP (see Table A3-4.). The rating of that value added data is arranged as described on the Table A3-3 to make selected countries assessment.

Table A3-3 The rating of the value added assessment

Value Added (%)	**Rating**	**Score**
0 – 5	LOW	0.0
5 – 10	MEDIUM	0.5
> 10	HIGH	1.0

Table A3-4 Agriculture Value Added to the Percentage of GDP *)

Country	**2011 (%)**	**2012 (%)**	**2013 (%)**	**Average (%)**	**Assessment**	
					Rating	**Score**
Argentina	7.49	6.70	7.38	7.2	MEDIUM	0.5
Brazil	5.12	5.27	5.63	5.3	MEDIUM	0.5
China	9.53	9.53	9.41	9.5	MEDIUM	0.5
Germany	0.82	0.77	0.79	0.8	LOW	0.0
Indonesia	13.51	13.37	13.39	13.4	HIGH	1.0
United States	1.36	1.29	1.45	1.4	LOW	0.0

*) All the data are taken from (World-Bank, 2015)

c. Domestic Consumption

The Domestic consumption assessment is measuring how does the biodiesel is using by the selected countries. The data does not take into account who operate sales and who absorbs biodiesel in the market. All matters related to the sale systems and operations as well as the mandate are discussed in other sections of this thesis.

Table A3-6 data are dealing with the biodiesel uses for transport sector during the 2011-2013 period on the selected countries. This data provides information regarding the interest of domestic market of each country that are evaluated. Prior the examination, Table A3-5. sets the rating and score of such assessment.

Table A3-5 The Rating of the Domestic Consumption Assessment

Domestic Consumption	Rating	Score
0 – 1000	LOW	0.0
1000 – 3000	MEDIUM	0.5
> 3000	HIGH	1.0

Table A3-6 The Biodiesel Domestic Consumption for Transport Sector on the Selected Countries by 2011-2013

Country Name	2011 Million Liters	2012 Million Liters	2013 Million Liters	Average	Assessment	
					Rating	Score
Argentina (I)	850	980	1010	946.6667	LOW	0.0
Brazil (II)	2,613	2,795	2,900	2,769	MEDIUM	0.5
China (III)	738	929	1,129	932	LOW	0.0
German (IV)	2854.35	2916.12	2601.76	2790.74	HIGH	1.0
Indonesia (V)	358	670	1,048	692	LOW	0.0
US (VI)	3354.52	3403.26	5408.75	4055.51	HIGH	1.0

(I) (USDA-Argentina, 2014), (Regúnaga & Rodriguez, 2015)
(II) (USDA-Brazil, 2014), (Beckman, 2015)
(III) (USDA-China, 2014)
(IV) (UFOP, 2015)
(V) (USDA-Indonesia, 2014)
(VI) (US-EIA, 2015), (Beckman, 2015)

d. Number of Export Destinations

Benchmarking the number of biodiesel export-destination reflects how much the market interest. Table A3-7 initially determined the ratings used by the assessment and Table A3-8. shows the list of biodiesel export destinations. The summary of export destinations number is given by Table A3-9.

Table A3-7. The Rating of the Number of Export Destinations Assessment

Number of Export Destinations (Countries)	Rating	Score
0 – 5	LOW	0.0
5 – 10	MEDIUM	0.5
> 10	HIGH	1.0

Table A3-8. Biodiesel Export Destination of the Selected Countries

No.	Export	Country of Origin					
		Germany	US	Indonesia	Argentina	Brazil	China
1	Country Destination	Belgium	Australia	Spain	Spain	Belgium	-
2		Bulgaria	Canada	Belanda	Italy	Spain	
3		Denmark	Cayman Island	Italia	Netherland	Netherland	
4		Finland	Ecuador	Malaysia	Belgium	Singapore	
5		France	Gibraltar	Singapore	France	Argentina	
6		Greece	Malaysia	Australia	Finland		
7		UK	Peru	Taiwan	Germany		
8		Ireland	Spain	China	US		
9		Italy	Taiwan	Albania	Peru		
10		Latvia	Trinidad & Tobago	US	Poland		
11		Lithuani	Nigeria	Puerto Rico	North Africa		
12		Luxembourg	Peru	Africa			
13		Malta	Mexico				
14		Netherla	Philippine Jamaica				
15		Austria					
16		Poland					
17		Romania					
18		Sweden					
19		Slovakia					
20		Slovenia					
21		Spain					
22		Czech Re					
23		Hungary					
24		Cyprus					
25		Slovakia					
26		Slovenia					
27		Spain					
28		Czech Republic					
29		Hungary					
30		Cyprus					

Table A3-9. The Summary of Biodiesel Export Destinations Number

Biodiesel Country Origin	Number of Export Destinations	Rating	Score
Argentina (I)	11	HIGH	0.5
Brazil (II)	5	MEDIUM	0.0
China (III)	0	LOW	0.0
German (IV)	30	HIGH	1.0
Indonesia (V)	12	HIGH	0.5
US (VI)	14	HIGH	0.5

(II) (USDA-Argentina, 2014), (Idígoras, 2011)
(III) (USDA-Brazil, 2014), (Beckman, 2015)
(IV) (USDA-China, 2014)
(V) (UFOP, 2015)
(VI) (USDA-Indonesia, 2014)
(VII) (US-EIA, 2015), (Beckman, 2015)

e. The Biodiesel Trade Balance

The balance of trade calculates the difference of the economic value of exports and imports over a specific period (O'Sullivan & Sheffrin, 2003). Normally, it is defined as a correlation between a financial rate of imports and exports from the whole nation economic. However, in this thesis, the balance (export minus import) only counted for biodiesel trade volume in million liters. Judging from this balance, people can measure market attractiveness. A positive balance, that known as a trade surplus when exporting biodiesel more than is imported, means great market attractiveness. In the other a way around, a negative balance that is referred to as a trade deficit or less export than import, means inadequate market attractiveness.

Table A3-11 shows the biodiesel export-import and its gap during the 2011-2013 on the selected countries. This data will provide information regarding the trade-balance of each country that are appraised. Preceding the examination, Table A3-12 sets the rating and score of such evaluation. The average of the trade balance, as well as the assessment scores, are summarized by the Table A3-12.

Table A3-10 The Biodiesel Trade Balance Assessment Rating

The Trade Balance (Million Liters)	Rating	Score
-500 – 500	LOW	0.0
500 – 1000	MEDIUM	0.5
> 1000	HIGH	1.0

Table A3-11 The Biodiesel Trade Balance of Selected Countries (Million Liters)

Country Name	2011			2012			2013		
	Export	Import	NX	Export	Import	NX	Export	Import	NX
Argentina (I)	1910	0	1910	1770	0	1770	1296	0	1296
Brazil (Ii)	6	18	-12	0	0	0	39	0	39
China (III)	0	0	0	0	20	-20	0	50	-50
German (IV)	1581	1085	496	1428	896	532	1849	663	1186
Indonesia (V)	1440	0	1440	1515	0	1515	1356	0	1356
US (VI)	278	77	201	486	136	350	743	1296	-553

(I) (Idígoras, 2011), (USDA-Argentina, 2014), (Regúnaga & Rodriguez, 2015), (Idígoras, 2011)
(II) (USDA-Brazil, 2014), (Beckman, 2015)
(III) (USDA-China, 2014)
(IV) (UFOP, 2015)
(V) (USDA-Indonesia, 2014)
(VI) (US-EIA, 2015), (Beckman, 2015)

Table A3-12 The Assessment of Biodiesel Trade Balance Average 2011-2013 for Selected Countries

Country Name	NX Av. (Million Liters)	Assessment	
		Rating	Score
Argentina	1658.67	HIGH	0.5
Brazil	9.00	LOW	0.0
China	-23.33	LOW	0.0
Germany	738	MEDIUM	0.0
Indonesia	1437.00	HIGH	0.5
United States	-0.67	LOW	0.0

2) Business Strengths

This section examines selected primary biodiesel countries (i.e. United States, Argentina, Brazil, China, Germany, and Indonesia) based on the following factors that reflecting their business strength.

a. Standardization/Accreditation

Quality assurance is one of the essential criteria for determining the right property of a product. The establishment of the quality management system is part of the parameter for assessing the strength of a product. A product that has a reliable certification scheme and managed nationally by the government or the community guarantee the strength of the product. Thus, it more securing the business and ensure the customer satisfaction. In this section, the biodiesel quality management system is represented by the existence of standardization and accreditation. The standardization means the characteristic or quality standard that provider has to achieve to produce or blend the biodiesel. While accreditation is the quality management system and fuel management practices for every biodiesel value chain, such as sampling, storage, testing, blending, shipping and distribution.

Table A3-13. The Assessment Rating of Biodiesel Certification

Biodiesel Certification		Rating	Score
Standardization	Accreditation		
No	No	LOW	0.0
Yes	No	MEDIUM	0.5
Yes	Yes	HIGH	1.0

Table A3-14. The Biodiesel Standardization/Accreditation over Selected Countries

Country	Standardization	Accreditation		Assessment	
				Rating	Score
Argentina [I]	IRAM 6515-1	RTRS		HIGH	1.0
Brazil [II]	ANP Resolution 45/2014	ISO 9001 & ISCC	ANP	HIGH	1.0
China [III]	GB/T20828-2007	-		MEDIUM	0.5
German [IV]	DIN EN 14214	AGQM		HIGH	1.0
Indonesia [V]	SNI. 04-7182-2006	Pertamina-BQS		HIGH	1.0
United States [VI]	ASTM D 6751-07b	BQ-9000		HIGH	1.0

[I] (World Energy Council, 2010), (Querini, 2011), (RTRS, 2012)
[II] (World Energy Council, 2010), (Rodrigues & Accarini, 2008)
[III] (Goto, et al., 2010), (USDA-China, 2014),
[IV] (UFOP, 2007), (VDB, 2007), (UFOP, 2008), (AGQM, 2014)
[V] (Wirawan S. S., 2007), (PERTAMINA, 2011)
[VI] (NREL, 2009)

Abbreviation:

IRAM:	Instituto de Racionalización Argentino de Materiales
RTRS:	Round Table for Responsible Soy Association
ISO:	International Organization for Standardization
ISCC:	International Sustainability and Carbon Certificate
ANP:	Agência Nacional do Petróleo, Gás Natural e Biocombustíveis
DIN:	Deutsches Institut für Normung e.V

AGQM:	Arbeitsgemeinschaft Qualitätsmanagement Biodiesel e. V.
SNI:	Standar Nasional Indonesia
Pertamina-BQS:	Pertamina-Biodiesel Quality Management System
ASTM:	American Society for Testing and Materials
BQ-9000:	Biodiesel Quality – 9000 (US Biodiesel Accreditation Program)

b. The Infrastructure of Biodiesel Industry

Infrastructure is an integral part of a business. The strength of the infrastructure will provide a substantial contribution of the vitality of an industry. In measuring the biodiesel industry infrastructure, the author proposes a set of evaluation indicators. Furthermore, based on these evaluation score, people can classify the evaluated countries ratings as written on the Table A3-15.

Table A3-15 The Assessment Rating of Biodiesel Industry Infrastructure

No	Total Score of Facility Assessment	Rating	GE Matrix Score
1	1 – 150	LOW	0.0
2	150 – 300	MEDIUM	0.5
3	300 – 500	HIGH	1.0

The following brief description will discuss related information of each selected countries that refers to the biodiesel industry infrastructures and supply chain. Afterwards, the summary of total infrastructure scores is given by Table A3-17 that used evaluation indicators as seen in the Table A3-16.

1) Argentina

In Argentina, mostly (91 percent) of biodiesel raw materials are transported by truck; only just 8 percent distributed by rail and barge solely 1 percent (Pozzolo, Ferrari, Hidalgo, & Curro, 2007). The Argentine has privatized the railroads since the 1990s and still raising investment in rail infrastructure while the trucking businesses remain a strong influence on that investment (Ramamurti, 1997). (USDA-Argentina, 2014) reported that the myth on high transport expense to transport agricultural commodities for export has resulted in farm-to-port transport cost that usually coupled to the cost of fuel. Figure A3-3 presents the actual infrastructures and logistics of Argentina biodiesel.

Figure A3-3 Infrastructure and Logistics for Biodiesel Distribution (GBEP, 2013)

It is noted that the road transport using truck is 60 percent costly than railway transport by train even this kind of transport mode offers flexibility for a distance of less than 300 km (Goldsby, 2000), (Franco, 2010), (Tomei & Upham, 2011). In fact, there is a seasonality in transport demand. A high demand for transport is frequently coinciding with the harvest. Unfortunately, such behavior has discouraged the incentive for investment in the fleet of a carriage. That is why that the average age of the fleet is estimated about 20 years (Pozzolo, Ferrari, Hidalgo, & Curro, 2007). Silo bags that capable of holding up to 210 tonnes of soybeans for up to one year have reduced storage losses. Using this facility, Argentina successfully decrease significant delays during harvesting with trucks waiting to unload their cargoes (USDA-Argentina, 2014).

2) Brazil

Brazil Biodiesel is growing fast and replaced 5 percent of the diesel utilization (Lima, 2012). The biodiesel supply chain consist of three fundamental and integrated processes, i.e., (1) supply; (2) production; and (3) distribution. These procedures implement the basic structure of supplying and converting feedstocks into biodiesel, blending and distributing the final product. Although such processes seen as a regular supply chain process, the biodiesel supply chain in Brazil performs some unique points. Some countries leave this matter to an independent institution based in the community (producer, trading company, fuel stations, sponsors, etc.) that is coordinated by national biodiesel board. However, Brazilian biodiesel is mostly driven by government initiatives and controls widely that are not only intended to develop the supply system but also to achieve social goals as well. The Brazil Government created family-based farming for the supply chain and job creation in impoverished regions of the country. It is proven that some government policy can directly affect the infrastructure and the dynamic behavior of the supply chain, such as the total biodiesel demand, feedstock origin, maximum biodiesel price at the fuel distribution level, etc. (Padula, 2012).

(Sauer, 2008) noted that there are three critical points must be considered regarding biodiesel supply logistics: 1) The location of the production, 2) The consumption centers, 3) The sites where biodiesel is blended with petrodiesel. The issue of which agent will blend the biodiesel with the petrodiesel become a crucial factor in assuring the required quality for this fuel. (Sauer, 2008) argued that the fewer the number of blending agents, the less possible defects in the operative procedures. The process of collecting biodiesel at the production sites for shipment to the blending stations represents an additional demand for inflammable cargo shipments. (Sauer, 2008) recommend that biodiesel be blended with petrodiesel by the distributors.

(Sauer, 2008) added, that since 2008, all biodiesel sold by Petrobras Distribuidora (BR) are including B2 or 2% of biodiesel. In every state of Brazil, 5,000 service stations are ready to sell and accepted by 3,350 major customers. Petrobras Distribuidora (BR) has invested R$ 35 million in its operations and logistics infrastructure, adapting its bases and terminals network. BR set up a modification of logistics structure for biodiesel, starting with collections at all the production plants, storage facilities, blending equipment and extending through shipment to the end customers (see Figure A3-4).

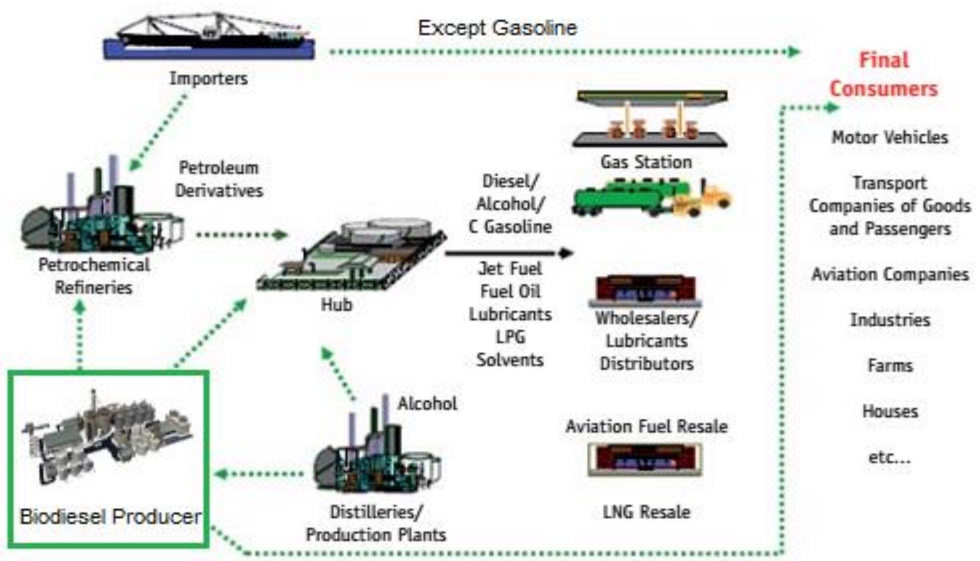


Figure A3-4 Biodiesel Supply Chain in Brazil (Sauer, 2008)

Brazilian biodiesel supply chain is facing some challenges to fix its bases, such as integrating the various transportation modes with production plants and conflict with other products for trucking. Another defiance is remaining on the availability of the B100 product monitoring. It is related to the agricultural inputs, regarding adjusting harvest and market conditions (Lima, 2012).

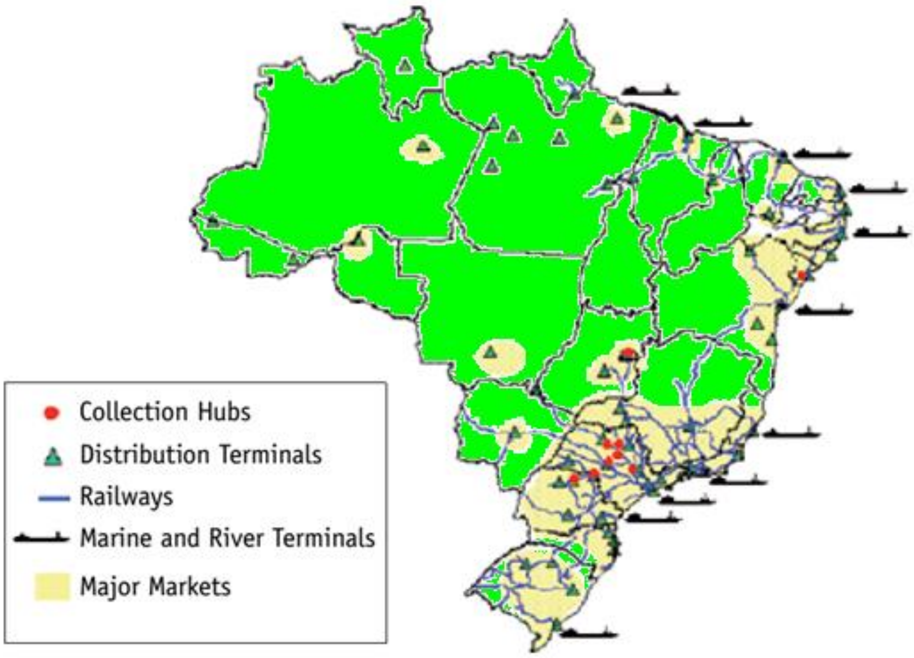


Figure A3-5. Biodiesel Production Units, Collection Hubs, Terminals and Transport Modes in Brazil (Sauer, 2008) (Padula, 2012)

Biodiesel production units, logistics and supply chain infrastructures in Brazil, as shown in Figure A3-5, have accumulated in regions with larger availability of soya. Hence, 40% of the biodiesel production capacity is established in its Central-West region, which indicates a similar proportion with the biofuel supply (MME, 2011). The biodiesel production decentralization and Southeast region markets extension has prompted the development of agricultural activities committed to the raw material supply for biofuel production and promoted activities in the remaining production chain links, downstream and upstream of the agro-industrial process (IBP, 2012).

3) China

Bioenergy is part of China's long-run strategic energy plan. The 12th Five Year Plan (2010-2015), set an aim of produce one million tons of biodiesel and four million tons of fuel ethanol by 2015. The biodiesel target has achieved, but ethanol production in 2015 is only reached 2.43 million tons (USDA-China, 2014).

There are two essential challenges biodiesel producers face in China, i.e. the competition of waste oil and restricted sales channels. The Chinese government has tried to fight on a misapplication of waste cooking oil (also known as "gutter oil"). The illegal food shops reuse this waste oil due to very high-profit margins (around 150 to 240 percent). This condition generates a heavy competition for the waste oil stream product. The scarcity of the products on the market (due to Government restrictions) make biodiesel facilities are difficult to obtain feedstock at a reasonable price.

Moreover, state-owned oil companies prevent biodiesel from being sold to most consumers. China National Petroleum (CNPC) and SinoPec, which operate over 90 % of gas stations in China, unfortunately, do not sell biodiesel. Hence, biodiesel producers are forced to deal with the oil brokers or sell directly to end customers. Such condition prompting utmost biodiesel for transport is sold at private gas stations either the small cities or in the rural area (USDA-China, 2014). (Voegele, 2015) reported that small-scale operators dominate biodiesel industry in China. Mostly, the industry relied on the animal fats or waste cooking oil as feedstock. There are several names of biodiesel pioneers in China, i.e. Hainan Zhenghe Bio-Energy Co. Ltd in Hebei, the Sichuan Gushan Oil, Fat Chemical Co. and the Fujian Zhuoyue New Energy. China's biodiesel industry is reported rapidly growing. Nowadays at least 12 operational biodiesel plants with at least another 26 planned or under construction, including some plants that have annual production capacity of more than 100 000 tons. At the very beginning, the passion of biodiesel business opportunity has increased the involvement of overseas-listed private Chinese companies, the largest of which are Gushan Environmental Energy, China Biodiesel International Holdings and China Clean Energy. It is summarized that before 2006, the Chinese Biodiesel has produced in the low quality and used principally as a solvent or as an additive to coal in thermal power plants or rural industrial cafeterias where coal is typically used for cooking (USDA-China, 2013).

Nevertheless, newer and larger participants are producing biodiesel that can be accepted as a transport fuel. It is sold directly to the customers in the local area as there are no official distribution channels. At that time, there is no mandatory national biodiesel standard in China. Therefore, it cannot be blended by the CNPC and SINOPEC and sold in petrol stations. However, only one of the larger biodiesel makers, Gushan Environmental Energy, is selling biodiesel to the retail petrol stations (GSI, 2008). (GSI, 2008) has also reported that there are foreign investments in the China's biodiesel. D1-Oils-Plc, a global producer of biodiesel based in the United Kingdom, has studied of producing jatropha crops in China. Other UK company based Sunshine Technology Group is investing in a jatropha-based biodiesel plant in Yunnan and Biolux International Austria has funded a plant using imported rapeseed in Jiangsu. Rising vegetable oil prices have ruled out biodiesel production from vegetable oil by 2008. It made China becomes a net importer of vegetable oils. Therefore, while some vegetable oil based biodiesel factories have been assembled, lack of cooking oil and hiking palm oil prices led many plants have shifted to adopt cooking oil as a biodiesel raw material (Biofuels International, 2008). This rising price problem also affected some company to halt their production or switching business to use B2 or B3 as a chemical solvent rather than for transport fuel (Goto, et al., 2010).

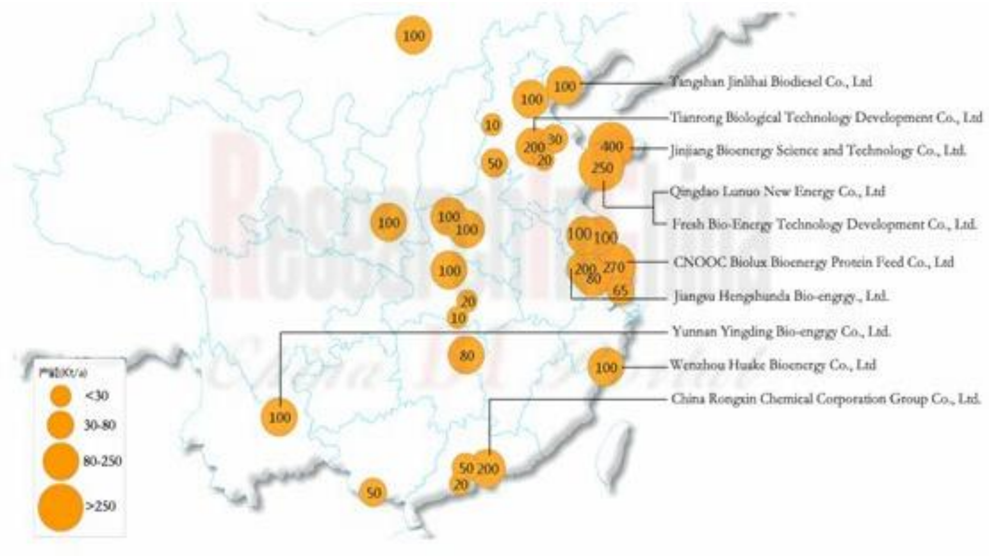


Figure A3-6. Capacity Distribution of Leading Enterprises in China Biodiesel Industry by 2013 in Kilo-Tons (Research-In-China, 2014)

Currently, Chinese Biodiesel production capacity is considered at 4.25 billion liters. It means that their production 6 percent increase from the previous year. Nevertheless, this capacity is estimated at only 27 percent of the Chinese maximum production capability due to the shortage of collection channels of the feedstock that mainly from waste frying oil. It can be noticed that from 54 biodiesel plants, only less than half of the producers have still performed (USDA-China, 2014). Some of the survivors are shown in the Figure A3-6. Moreover, the state-owned oil company/CNOOC (after five years of net losses) decided to suspend its biodiesel pilot project in the Hainan province. The NYSE (New York Stock Exchange) listed Gushan Group also withdrew from the biodiesel market in China after encountering several years of heavy financial losses (Hornby, 2014).

4) Germany

(Reinhardt, 2007) reported that Germany had 26 Biodiesel plants with a total capacity of about 1.2 million tonnes per year in 2005. From these plants, only two plants with over 200,000 t/a total capacity are so-called annex plants that are connected to oil millhouse. These two plants process the feedstock completely from the farmer (mill) rather than the others that mainly taken rapeseed oil from the suppliers. In fact, there was also a smaller number plants convert oils from other oil plants such as used cooking oils or animal grease.

According to the (UFOP, 2007) Union zur Förderung von Öl- und Proteinpflanzen (Union to promote oil- and protein plants), in 2006, the trade of biodiesel through German gas stations increased to 2,000,000 m³. At that time, biodiesel available at the personally owned filling stations and the primary petroleum companies, such as Shell, Aral and Esso/Exxon (see Figure A3-7).

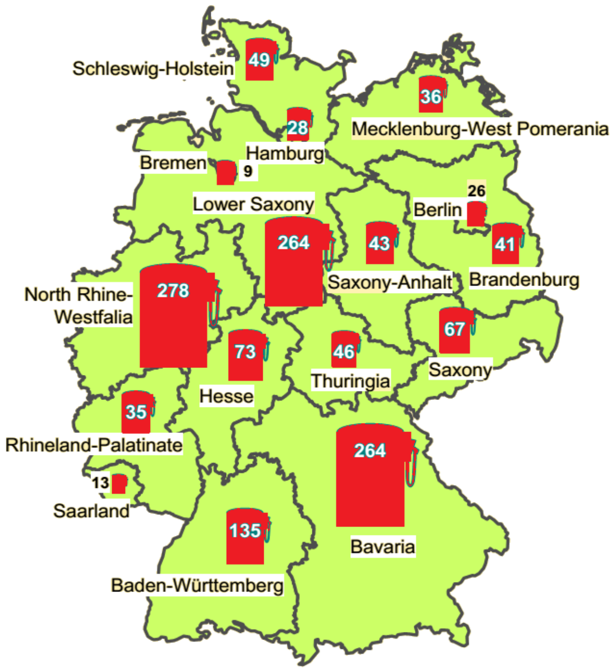


Figure A3-7 The Biodiesel Filling Stations Across Germany (Reinhardt, 2007) (UFOP, 2008)

Regarding biodiesel facilities and infrastructure, Germany has the longest experience. They have built a biodiesel community that manage the quality assurance since 1999 called AGQM. As depicted in Figure A3-8, the Board of biodiesel examiners consists of Producers, Trading Company and Sponsors (UFOP, 2008). AGQM has made many Standard Operation Procedures (SOP) for handling biodiesel from upstream to downstream. Those standards have become a quality assurance service to measure biodiesel quality at the pump stations.

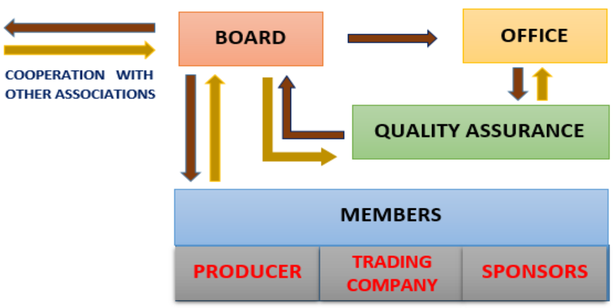


Figure A3-8 The AGQM Structure (AGQM, 2014)

Since 1999 AGQM has been submitting a quality management system for the entire German Biodiesel business. The purpose of its service is the steady improvement of the Biodiesel quality. AGQM supports producers and traders with independent checks, technical service and additional measures regarding the technical standards (UFOP, 2014). (APEC, 2011) reported that some German biodiesel production facilities placed close to blending station and feedstock plantations. Germany has been leading in the number of filling stations selling biodiesel as B100 for many years. There is no other country had more fuel stations for pure biodiesel than Germany. The Arbeitsgemeinschaft Qualitätsmanagement Biodiesel e. V. (AGQM) estimates that the number of filling stations selling biodiesel until 2005 measured to about 1,900 and 1406 of them are certified by AGQM (Reinhardt, 2007), (UFOP, 2008). The coverage area of the German network of 1,900 biodiesel filling stations is further apart from each other than 50 km (Reinhardt, 2007). The filling stations deployment in Germany can be seen in the Figure A3-7. Lately, (AGQM, 2015) sets a poll among its 437 licensees and the results shown that only 88 firms are still involved in retailing biodiesel. There are around 1,200 filling stations operated by the licensees, however about 250 stations are remains. This negative growth is triggered by the high taxation on biodiesel that is not proportional. Furthermore, the managing committee of AGQM decided to terminate the quality assurance at the biodiesel filling stations. In the other hand, the quality management at the level of the biodiesel producers and traders, members of AGQM, and to wholesale businesses will remain in impact.

5) Indonesia

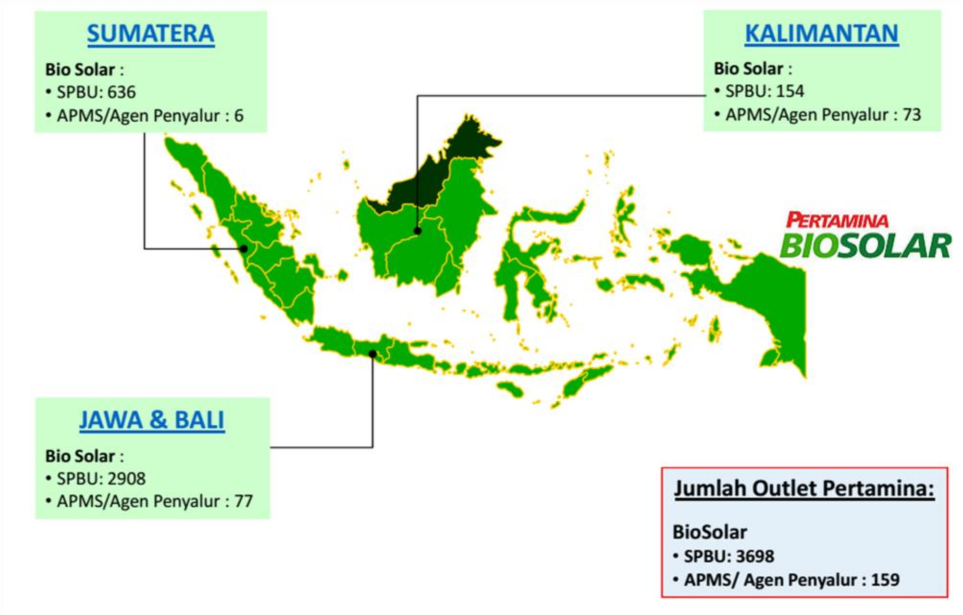
As reported by (Rusdiana, 2014), Indonesia has implemented biodiesel blending B10 on transport and industrial sector and B30-B60 on the power-plants. The Government of Indonesia (GoI) is nowadays in the preparation stages to implement B-20 on 2016. This arrangement conducts an engine testing together with the Automotive Engine Principals, Scholar Association's Universities and research institutions. Finally, as the official mandate, the implementation of B25 will be directed on 2025. The GoI implement one-door policy in providing biodiesel, known by the trade name "Biosolar", that is managed by Pertamina (Indonesian Mining and Oil State Owned Company). The entire filling stations managed by Pertamina but in order to earn B100 (pure biodiesel or FAME), the GOI open the tender opportunities from private suppliers The Pertamina private suppliers, its locations and capacities are depicted on the Figure A3-9.

Figure A3-9 The Biorefiners/Suppliers of PERTAMINA'S Biodiesel, its Location and Capacity

(PERTAMINA, 2011) published some remarks that can be put forward for biodiesel infrastructure data:

a. All Biodiesel Distribution Centers (TBBM) in Java and Bali already have the infrastructure for blending and storage.
b. Several TBBMs in Sumatra equipped by Biodiesel infrastructure, i.e. TBBM Medan Group -Medan, TBBM Long-Lampung, TBBM Dumai, Siak TBBM-Pekanbaru, TBBM Kertapati - Palembang
c. Trucks & barges dominate the biodiesel transport mode. Small numbers of biodiesel railway infrastructures exist in the south part of Sumatera.

Figure A3-10 presents the number of biodiesel filling stations in Indonesia. All the stations only located in Island of Sumatera, Jawa, Bali and Kalimantan. Besides filling stations, there is also exist wholesalers on the same islands. Total stations that sell biodiesel is 3698 and the wholesalers of 159.



Notes

Original	Abbreviation	English
SPBU	Stasiun Pengisian Bahan Bakar Umum	the Biodiesel Filling Stations
APMS	Agen Penyalur Minyak Solar	the Biodiesel Wholesalers

Figure A3-10 The Biodiesel Filling Stations and Wholesalers in Indonesia (Trikora, 2013)

6) The United States (US)

The United States has 231 biodiesel stations excluding private stations. In the US, Biodiesel production/refineries take place near feedstocks plantation. The B100 that produced is typically shipped by rail to where the product blended with fossil diesel and distributed to the pump stations (Rusco, 2012).

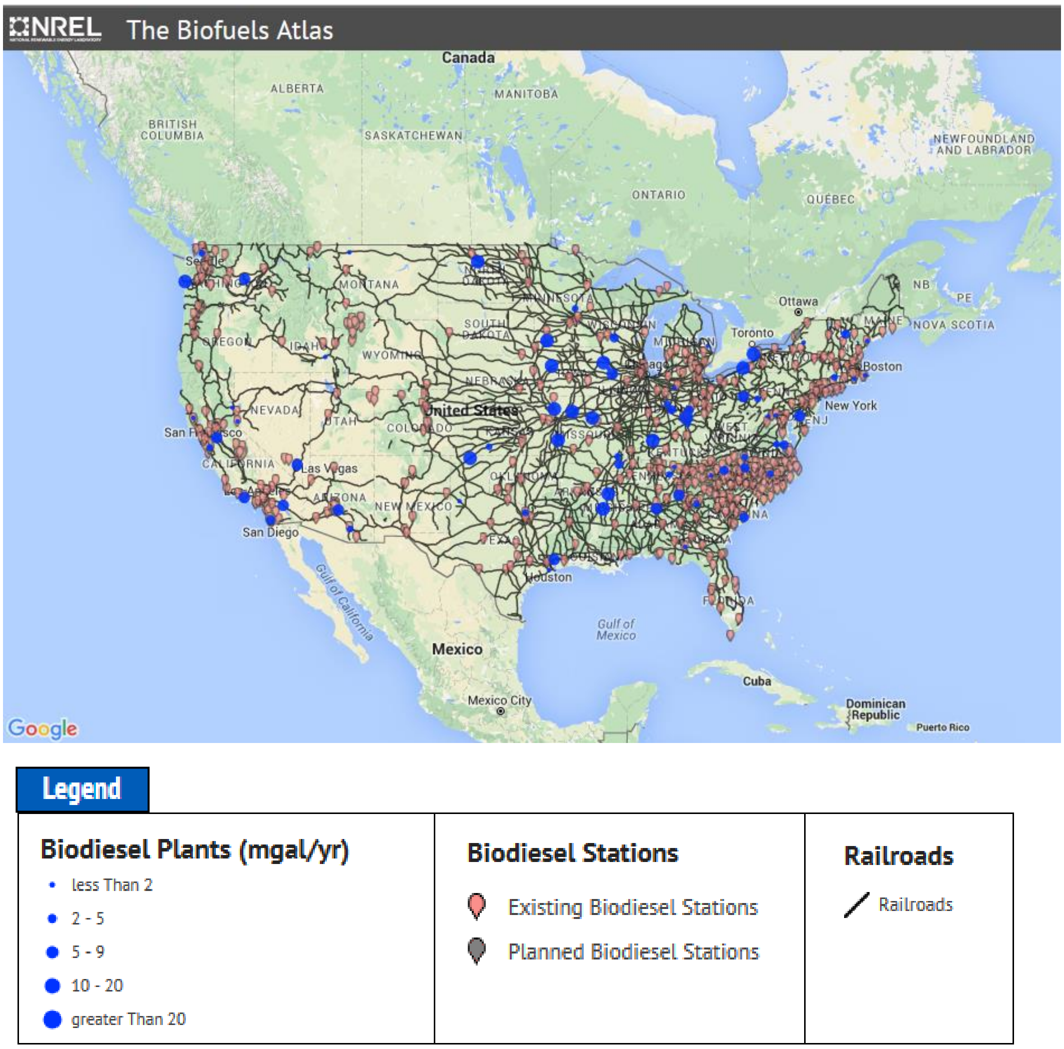


Figure A3-11. The Biodiesel Refineries & Stations in the US (NREL, 2015)

Biofuels transport is currently relying primarily on rail. Therefore, as a result of the reliance on rail transport, nowadays biofuel refineries are developed along existing rail routes. Moreover, “unit trains,” that entire trains of tanker cars dedicated to a single cargo of biodiesel are used for distribution. This method become cost effective large volumes of biofuels distribution from refineries to major population centers. Figure A3-11 shows the locations of biodiesel refineries and pump stations in the United States. It justifies that the location of the biodiesel refinery in the United adjacent to the filling stations. Moreover, all of the factories and pump stations are connected by railway lines (see black line)

One of biodiesel important issue is the fuel quality. Biodiesel is transported through numerous chains before taken by the consumer. There are many points along that chains where the biodiesel can be degraded or deteriorated by some contaminations. Thereby, the government designed an independent council called National Biodiesel Accreditation Commission (NBAC) that conduct a fuel quality certification program. Such certification gives producers and distributors a nationally recognized "seal of approval" known as "BQ-9000". All entities that are part of this program will ensure and provide the infrastructures for biodiesel quality achievement, such as ASTM D 6751, as well as adherence to quality standards for testing, distribution, storage, sampling, blending and fuel management practices (Tickell, 2006).

Total scores of biodiesel infrastructure of the selected countries are summarized in Table A3-17 using evaluation indicators provided by Table A3-16.

Table A3-16 The Evaluation Indicators of the Biodiesel Industry Infrastructures

No.	Infrastructure Criteria (IC)			Infrastructure Score (IS)	Maximum Score
1	Feedstock Transport	a	Train	25	100
		b	Airfreight	25	
		c	Truck	25	
		d	Barge	25	
2	FAME Transport	a	Train	25	100
		b	Airfreight	25	
		c	Truck	25	
		d	Barge	25	
3	Biodiesel Blending Transport	a	Train	25	100
		b	Airfreight	25	
		c	Truck	25	
		d	Barge	25	
4	Number of Biorefiner	a	0 - 20	25	100
		b	20 - 40	50	
		c	40 - 60	75	
		d	> 60	100	
5	Biodiesel Plant Distance to the Feedstocks	a	Nearby	50	50
		b	Faraway	0	
6	Biodiesel Plant Distance to the Blending Station	a	Nearby	50	50
		b	Faraway	0	
MAXIMUM INFRASTRUCTURE SCORE					**500**

Table A3-17 The Total Score for the Biodiesel Infrastructures

IC		Argentina		Brazil		China		Germany		Indonesia		US	
		PI	IS	PI	IS	PI	IS	PI	IS	PI	IS	PI	IS
1	a		25		25		25		25		25		25
	b												
	c		25		25		25		25		25		25
	d								25				
2	a		25		25		25		25		25		25
	b												
	c		25		25		25		25		25		25
	d								25		25		
3	a		25		25		25		25		25		25
	b												
	c		25		25		25		25		25		25
	d		25		25				25		25		25
4	a												
	b		50						50		50		
	c						75						
	d				100								100
5	a		50		50		50				50		50
	b								0				
6	a		50						50		50		50
	b						0						
TOTAL			325		325		275		325		350		375

Notes	
IC	Infrastructure Criteria
PI	Possessed Infrastructure
IS	Infrastructure Score

Hence, the GE Matrix score of the biodiesel infrastructure can be concluded as follows (see Table A3-18).

Table A3-18. The GE Matrix Rating for the Biodiesel Infrastructure/Facility

Total Score of Facility Assessment	Rating	GE Matrix Score
Argentina	HIGH	1.0
Brazil	HIGH	1.0
China	MEDIUM	0.5
German	HIGH	1.0
Indonesia	HIGH	1.0
United States	HIGH	1.0

c. Production Capacity

The Production Capacity is one of the primary determinants of the company's overall business power. It is critical because economies of scale in feedstock purchasing depending on these criteria. Thus, in conjunction with the supply and the market demand, capacity also decisive competitive cost advantage.

Previously, before evaluating this criterion, the author sets the assessments rating as perceived in the Table A3-19. Then, the Biodiesel Production Capacity data and its evaluation are displayed by Table A3-20.

Table A3-19. The Biodiesel Production Capacity Assessment Rating

Capacity (Million Liters)	Rating	Score
0 – 3000	LOW	0.0
3000 – 6000	MEDIUM	0.5
> 6000	HIGH	1.0

Table A3-20. The Biodiesel Production Capacity of Selected Countries during 2011-2013

Country Name	2011 Million Liters	2012 Million Liters	2013 Million Liters	Average	Assessment	
					Rating	Score
Argentina [I]	3,800	4,200	4,550	4,183	MEDIUM	0.5
Brazil [II]	6,742	7,400	7,900	7,347	HIGH	1.0
China [III]	3,400	3,600	4,000	3,667	MEDIUM	0.5
German [IV]	4512	4455	3520	4162	MEDIUM	1.0
Indonesia [V]	4,281	4,881	5,670	4,944	MEDIUM	0.5
United States [VI]	10219.5	10904.59	8099.9	9,741	HIGH	1.0

[I] (USDA-Argentina, 2014), (Idígoras, 2011)
[II] (USDA-Brazil, 2014), (Beckman, 2015)
[III] (USDA-China, 2014)
[IV] (UFOP, 2011) (UFOP, 2012) (UFOP, 2013)
[V] (USDA-Indonesia, 2014)
[VI] (US-EIA, 2015), (Beckman, 2015)

d. Regulation/Policy

The Regulation/Policy examination is an assessment of the regulatory environment to conduct a biodiesel business. The details of numerical ranking can be defined as follows (see Table A3-21).

Table A3-21 The Rating of Regulation/Policy on the Biodiesel Industry Assessment.

Regulation/Policy	Rating	Score
Weak Regulation/Policy	LOW	0.0
Enough Regulation/Policy and Partially Good Impact or Bad Impact	MEDIUM	0.5
Strong Regulation/Policy & Good Impact	HIGH	1.0

1) Argentina

Argentina's Law No. 26,093 mandated the use of biofuels beginning in January 2010. This law force biodiesel and bioethanol set initial blending at five percent (USDA-Argentina, 2014). There are three kinds of producers under this law:

a. The domestic market producers: get many tax incentives;
b. Self-consumption producers: supported by tax incentives;
c. The export-oriented producers: no tax incentives.

Argentina sets their biofuel policy for nondomestic consumers, about 60 percent of Argentina's total biodiesel production used to export (GBEP, 2013). A regulatory framework to encourage the production and biofuels utilization has released since 2007. The diversification of the energy supply is aimed by this framework. The structure expected to gain environmental conservation and promote the development of rural areas. Mainly, it was designed for the benefit of SME (Small and Medium Enterprises). At the moment, Argentina has no special program for advanced biofuel massive production. The initiation of these biofuel research has started by a few private sectors and the Universities (USDA-Argentina, 2014). Furthermore, in November 2013, the government has boosted the mandatory of biodiesel blend to 10% from the current 8%. It was to help offset a depreciation in exports resulting from EU anti-dumping policies (Lane, 2014). Finally, (USDA-Argentina, 2014) reported that started from February 2014 the mandate of the biodiesel blend is officially assigned to be ten percent. The government arranges the official prices for distributors' monthly and also put tax incentive standard for export. Agile development of the biodiesel industry has triggered by the various export tax on biodiesel and soybean oil. It takes a significant opportunity for the biodiesel sectors and adjusts variables in such a way that most players have some positive return.

As reported by (USDA-Argentina, 2015), the GoA disclosed a reduction of the biodiesel export tax on May 2015 from 15.21 % (effective tax 13.20 %) to 10.86 % (effective tax 9.80 %). The latest report by (Biofuel Digest, 2015), in

November 2015, the GoA is preparing the biodiesel export taxes into 3.31 percent. This policy is proven effectively encouraging blending and increasing biodiesel export.

2) Brazil

The Brazil Federal Government (BFG) has launched the National Biodiesel Production and Use Program for strengthening energy security by 2004. Even the self-reliance in oil production has achieved; Brazil still needs high costs import to meet 40 billion liters/year of the diesel oil domestic demand. The oil figure is getting worst by Brazilian oil characteristics, which is seen as rather poor and producing air pollution, especially due to its higher sulfur content (Adolphe & Fritsche, 2007), (Rodrigues & Accarini, 2008).

During the process of consolidation of the development program and considering the social and environmental benefits of biodiesel, the BFG was forced to design and use policy tools. That tools have to define the best ratio of blending, price caps, improvements in the production process, and utilization of the residues. (Padula, Santos, Ferreira, & Borenstein, 2012) reported that Brazil has defined prerequisites of biodiesel industry as follows: 1) Reduced energy imports, 2) Develop job opportunities in the poor regions, 3) Minimize environmental impact due to biodiesel production and utilization.

(La Rovere, 2011) identified the main problems of Brazil biodiesel production. It mainly linked to the catalytic method to detach glycerin and set the production process energy balance. Therefore, biodiesel quality measuring concepts are required, primarily for stability evaluation and the number of cetanes. On November 2004, the BFG has released the first biodiesel mandate to the market. The National Council for Energy Policy (CNPE) set the biodiesel for commercial use and blended 2% of biodiesel into the regular diesel oil (B2).

Federal Law #11,097/2005 defined minimum blending requirements of 2 % by 2008 and 5 % to be accomplished by 2013 (USDA, 2015). The Brazil Association of the Automotive Vehicles Manufacturers (ANFAVEA) has performed the diesel engines' guarantees even the 2% biodiesel used for their machines (La Rovere, 2011). Lately, CNPE ordered 3% of biodiesel mandates started from July 1st, 2008, and from July 1st, 2009 it become of 4% (CNPE, 2009). Moreover, the BFG also gives lower taxes for biodiesel produced by small farmers in the North and Northeast regions. Supporting by a special scheme called the “Social Fuel Seal” (Selo Combustível Social), the biodiesel producers that buy raw materials from small farmers in that regions get a tax incentive and opportunity of the soft loan from the Brazilian Bank for Social and Economic Development (Padula, 2012) (USDA-Brazil, 2014) (La Rovere, 2011).

This policy then became counterproductive. In the first side, it allowing a fair competition of small-scale production with soybeans agribusiness. Unfortunately, in the other side, the expansion of large-scale soybean plantations is increasingly threatening the Amazon forest. Accordingly, nowadays the biodiesel program of soybean is reconsidered and the alternative feedstock being researched. Provisional Measure Number 647 in May 29th, 2014, put the new regulation of Biodiesel Blend at 6 % (B6) as of July 1st, 2014, and 7 % (B7) as of November 1st, 2014 (USDA-Brazil, 2015).

Governmental policies and regulations on the Brazil biodiesel industry are proven directly related to the demand, production and trade. On the social side, Brazil has also partially achieved their goal to encourage family-based farming in this business. Even some remarks are raised to the fore, i.e. the threat of Amazon forest degradation and the cost-efficiency of biodiesel production. As long as there are tax incentives and subsidies that spoil the market, the production of biodiesel in Brazil became not feasible. However, some researchers have reported the positive impacts of Brazil biodiesel policies to structure, maintain and expand the biodiesel chain in Brazil. Any bottleneck of implementations has been seen on the study of alternative oilseeds (diversification of the feedstock) and family-farm sharing concept. It was remaining key issues in the field of political, technological and managerial stuff (Adolphe, 2007) (Northoff, 2008) (Sorda, 2010) (Padula, 2012).

There are several strategic key factors in this industry proposed by (Padula, 2012), i.e.: Investments and loans for family-farming assistance, financing and infrastructure improvement of the product distribution, technical assistance for farming and research for diversification of the feedstock.

3) China

China sets long run of bioenergy strategic plan and divides it into five years’ medium term. The 12th medium term will end up in December 2015 which targeting 4 million tons of ethanol and 1 million tons of biodiesel. The biodiesel target has already achieved but not for ethanol (USDA-China, 2015). The

Renewable Energy Law, which came into effect in January 2006 proof that the China is also serious in terms of renewable energy. The law has also set out the definitions of biofuels and confirms China's commitment to encouraging the use of biomass fuels (GSI, 2008).

Extraordinary of China economic growth needs big, reliable and sustain energy supply as a consequence. This issue become Chinese Government's top priorities. Moreover, volatile oil price and followed by environmental awareness pushed Beijing to consider biofuel industry as an option. China also built and pushed an open market for grain that used as biofuel feedstocks (for ethanol). This is intended to increase income and employment opportunities for rural communities. According to (Voegele, 2015), China runs 53 plants of biodiesel. The total capacity of that plants is approximately 4 billion liters. Most of them relied on the waste cooking oil feedstock. During 2010-2015, China has eradicated reuse of waste frying oil for human consumption. This action then escalated 18% of the biodiesel production. The slower production growth has only seen by 2013-2014 due to an enhancement of biodiesel import. Such policy lowered the profit margin for domestic producers and affected slower production growth.

Nonetheless, there are several problem exists (GSI, 2008), i.e. a shortage of sales channels, feedstock, and restricted government support. Many biodiesel players are closing their plants or exit the business completely. One of the biggest biodiesel player called the Gushan Group has also retreated after experiencing several years of heavy financial losses. Such cases happened caused by restricted law enforcement and lack of official mandate of biodiesel utilization. Moreover, the biodiesel cannot be sold to state-owned gas stations. (USDA-China, 2014) reported that a trial of biodiesel program for transportation fuel started in Hainan in 2010 by state-owned oil company CNOOC. Unfortunately, the trial program was only applied to two counties due to inconsistent feedstock supplies (mostly waste cooking oil).

Utmost Chinese biodiesel for fuel transport sold by private gas stations (small-scale operators) in the suburbs. Roughly 30 % of biodiesel is used by the transport sector, 50 % used by the industrial sector and 20 % used for farming machinery and angling boats (Voegele, 2015). In the implementation level, the concept of "new socialist countryside" that launched by the government causes a slight problem. There is evidence of land acquisitions conducted by local government and investors that establish large-scale biofuel developments. It will cause mass displacement of small landholders there. Thus, the objectives to empower small farmers less achieved. The competition of grain to use as a food or fuel is also alleviate high food prices (GSI, 2008).

4) German

There is a mandatory target of the European member states by 2020 to use 10 percent renewables in the transport sector (Renewable Energy Directive: RED). Each member has positive reaction responding this mandate. The European countries absorb that policy into their national regulations. In Germany, this law is translated into three pillars, i.e. 1) Tax Exemptions, 2) Mandatory Blending Target, 3) R&D Funding (Rauch, 2012). The Mineral Oil Duty Act has been revised by Germany on January 2004. After that amendment, all biofuels and heating oils obtained from biomass, blended or in pure form will get full tax relief until 2009 (Federal Government of Germany, 2004). According to this policy, pure biodiesel has grown significantly in Germany.

Furthermore, since August 1, 2006, the German launched a partial tax incentive on vegetable oil for fuel. This action also followed by the Biofuel-Quota Act on the 1st of January 2007. It mandates the mineral oil industry to put the biofuel blending target. This policy mainly reconstructed previous tax exemptions and reduced the fiscal burden of the government. Based on this rule, direct government tax incentive cannot be applied to the biofuels industry because that was already mandatory blended. Therefore, German did market intervention since they force the oil industry to sell biodiesel in the particular minimum share of an amount. Besides the petroleum industry, the mandate has also targeted to the biofuel producers and investors (Federal Government of Germany, 2011). All biofuels whether blended or B100 that are used to meet the quota are still taxed, except for second generation biofuels (BtL, lignocellulosic ethanol).

In January 2011, The Biofuels Sustainability Ordinance (BSO) released by German authority that force every produced biofuel registered to the BSO sustainability scheme. It must at also meet the mandatory of sustainability criteria from the RED where biofuels have to be 35% less carbon intensive than petroleum in 2011, 50% in 2017, and 60% in 2018. In the implementation level, this BSO is controlled by "the Bundesanstalt fur Landwirtschaft und Ernahrung" or The Federal Agency for Agriculture and Nutrition.

Started from 2015, the oil producers have to reduce the GHG emissions of their commodities by 3.5%, 4% in 2017 and 6% in 2020. There is no other way, to pursue this reduction; an alternative energy fuel has to be used. The German biodiesel policy led to some cases that will be discussed in the following review. 20% of German water withdrawals in 2010 reported used for a renewable resource (Ayres, 2014). It was usually being applied for irrigation, livestock and aquaculture purposes. That policies significantly influence agricultural production, land use and trade. (Banse, et al., 2011) published that Germany's agricultural sector partially supply the remaining EU's increased consumption for biofuel feedstock. Germany, together with the Benelux, and France becomes the major biodiesel producers within the EU. In 2014, Germany was including to the largest biodiesel consumers in the EU. There are benefits from the tax revenues of at least 0.6 billion Euros after German switch from tax relieve policy to the quota policy. The policy shifting has proven to give the positive impact on the government budgets (USDA-Europe, 2014).

5) Indonesia

The Government of Indonesia (GoI) sets an energy security concept which part of national security. Energy security is seen as the ability to respond dynamic changes in the global energy and ability to meet national energy needs independently (Ariati, 2008). Besides that, GoI has mandated national energy utilization. It was declared by the Presidential Decree No 5/2006 that targets energy mix of oil, gas, coal and renewable energy by 2025. The Indonesian Ministerial of Energy has also declared the Regulation No. 32/2008 that is associated to that Presidential Decree. Regulation 32 confirms a continuous set of targeted biofuel mandates during 2008-2025. Unfortunately, Indonesia ambitious targets for the biodiesel were missed due to the problems of logistics and infrastructure. Since August 2014, Indonesian Ministry of Energy and Natural Resources (MENR) mandates the FAME content in the diesel fuel (for transport) into 10 percent. Whereas the FAME content in the fuel industry is raised to a minimum of 20 percent (USDA-Indonesia, 2014).

The GoI has set a target of biodiesel consumption in 2014 of 4 million kiloliters. The 1.56 million kiloliters part of those target is used for subsidized diesel vehicle (transport sector) while the rest to be used by power plants and other non-subsidized sectors like mining and plantations. However, at the end of May 2014, only 447,000 liters that have been used in the transport sector (Rusdiana, 2014). The MENR reported that even at the end of 2014, the GoI was still missing the target of 820 kiloliters.

This missing target is mostly because of the supply chain problems throughout Indonesia, especially in the eastern part of the country, remote area. In the eastern part of Indonesia, biodiesel is not steadily available in the market or somehow the retailer is far away. Besides that, the GoI cannot provide adequate controls to ensure the biodiesel quality standards during its transport. Other significant factor is pricing. The consumers usually neglect the biodiesel benefit such as a renewable energy, lower GHG emission and favorable effect on engine lifetime. Indonesian people are very price sensitive type. When the biodiesel cannot be sold at the lower price than petrodiesel, then do not hope that people will buy this product (Goto, et al., 2010).

6) The United States (US)

The US is one of the countries that very concern of Biofuel over the past decades. Even, financial incentives to biofuels had already given when the Carter Administration supported the 1978 Energy Tax Act, reacted by the oil price shocks of the 1970s (Lifset, 2014). Afterwards, the regulations become very structured, well documented and progressive, such as the Energy Policy Act of 1992, the American Jobs Creation Act of 2004 that introduced the Volumetric Ethanol Excise Tax Credit (VEETC) and the Energy Policy Act of 2005 which gave more power to congress to regulate biofuel industry. In 2004, a tax credit of 51 cents per gallon of ethanol was introduced. The tax credit enlarged by the 2005 Energy Policy Act, it was extended to add biodiesel and enhanced by (US-Congress, 2007). The Biodiesel tax credit was given of US$1.00 per gallon (agricultural feedstock) while "waste grease" biodiesel accepts a credit of 50 cents per gallon. Some states also offer tax exemptions for biofuel producers.

Several plans are currently being realized to support bioenergy, i.e. the EPA-Energy Policy Act of 2005, the EISA - Energy Independence and Security Act (2007), the Farm Bill and the Biomass Research (2008). The U.S. Energy Policy

Act (2007) mandates to set the Biofuel 22% of transportation fuel mix by the year 2022 (Natalie, et al., 2013).

Unfortunately, these stimulation has failed to increase biofuels production or provide economic assistance to farmers. In fact, the fuel marketers are already required to purchase large volumes of biofuels under the national Renewable Fuel Standard (RFS), the tax credits do not drive to immense levels of production. U.S. Government Accountability Office (2009) reported: “VEETC does not stimulate the use of additional biofuel under current market conditions” (GAO-09-446, 2009) (UCS, 2010).

The advantages of the tax credits have belonged entirely to the oil companies that blend the fuels, instead of the biofuel producers and farmers (who grow the feedstocks). It is eliminating any economic benefits for rural communities. The Iowa State University (ISU) - Center for Agriculture and Rural Development (2010) published that “biofuel farmers will receive small or no additional advantage from tax credits.” Thus, only big industry gets incentives when current law already dictates them to purchase biofuels (Babcock, 2010).

In the operational level, all light-duty diesel engines are approved to operate on a blend of biodiesel up to five percent biodiesel (B5), and some are even approved up to 20 (B20). Nevertheless, as published by (Diesel Technology Forum, 2015), several states ask for biodiesel blend requirements or incentives that exceed some manufacturers' endorsement. Such condition influences filter clogging, poor engine performance and warranty issues for the users. By 2012, the state of Minnesota mandates 10 percent biodiesel (B10). In a certain period, diesel fuels sold in the state are obligatory at least B10, which is arranged to increase until 20 percent biodiesel (B20) on May 1, 2018. However, in Illinois, a tax incentive established in 2003 gives complete fuel tax exemption for any blend of biodiesel higher than 10 percent. Hence, the State Biodiesel Requirements are inconsistent. It is violating the advanced technology of clean diesel engines that come with precise fuel injection systems and require a consistent fuel blend.

Regulation/policy data of each country that preceding mentioned are summarized in Table A3-22.

Table A3-22. The Summary of Regulation/Policy Data

Country Name	Regulation/Policy Assessment	Rating	Score
Argentina	Strong Regulation/Policy and Good Impact	HIGH	1.0
Brazil	Strong Regulation/Policy and Good Impact	HIGH	1.0
China	Weak Regulation/Policy	LOW	0.0
German	Strong Regulation/Policy and Good Impact	HIGH	1.0
Indonesia	Enough Regulation/Policy and Partially Good Impact or Bad Impact	MEDIUM	0.5
United States	Strong Regulation/Policy and Good Impact	HIGH	1.0

e. Potential of the next generation biodiesel in the future

Instead of reviewed the current strength, this section will evaluate the potential of selected countries in the future related to their research on advanced biodiesel in term of feedstock availability, GHG reduction, production cost and biofuel yield per ha (see Table A3-23).

Table A3-23 The Potency of Selected Countries in the Research of Advanced Biodiesel and its Feedstock (Bart, 2010).

Feedstock	Production Areas	GHG Reduction	Production Cost	Biofuel yield per ha
RSO, SBO, SNO	US, German, Argentina, Brazil	**	**	*
PMO	Indonesia	**	**	***
Jatropha	Indonesia	***	***	***
Algae	US, German, Indonesia, China	***	****	****

Prior the evaluation is conducted, the author sets a rating of assessment criteria modified from (Bart, Palmeri, & Cavallaro, 2010), as highlighted by the Table A3-24.

Assumption: **one asterisk is equal to 10 points**

Max points: 3 asterisks x 10 x 12 box = 360 points,

Hence people could split the rating in the 1/3 division of 360 or per 120 span of points.

Table A3-24. Ratings and Scores of the Assessment Criteria

The Accumulation Points	Rating	GE Matrix Score
1 – 120	LOW	0.0
120 – 240	MEDIUM	0.5
240 – 360	HIGH	1.0

Accumulation of points that each selected country collected are presented in the Table A3-25.

Table A3-25. GE Matrix Score of Selected Countries for Advanced Biodiesel and its Feedstock.

Country Name	Total Points	Rating	GE Matrix Score
Argentina	5* = 50	LOW	0.0
Brazil	5* = 50	LOW	0.0
China	11* = 110	LOW	0.0
German	16* = 160	MEDIUM	0.5
Indonesia	28* = 280	HIGH	1.0
United States	16* = 160	MEDIUM	0.5

Appendix 4: GE Matrix Score and Position for Selected Countries

a) Argentina

1) Industrial Attractiveness (IA)

Table A4-1. Industrial Attractiveness Index of Argentina

Factors	Weight	Rating	Product
Market Penetration	25.0	0.5	12.5
Agriculture Value Added to the Percentage of GDP	15.0	0.5	7.5
Domestic consumption	20.0	0.0	0.0
Number of Export Destinations	15.0	1.0	15.0
Biodiesel Trade Balance	25.0	1.0	25.0
	100	**Industrial Attractiveness (I.A.) Index**	**60.0**

2) Competitive Strength (CS)

Table A4-2. Competitive Strength Index of Argentina

Factors	Weight	Rating	Product
Standardisation/Accreditation	25	1.0	25.0
The Infrastructure of Biodiesel Industry	20	1.0	20.0
Production Capacity	15	0.5	7.5
Regulation/Policy	25	1.0	25.0
Potential of the next generation biodiesel	15	0.0	0.0
	100	**Comp Strength (C.S.) Index**	**77.5**

3) Position

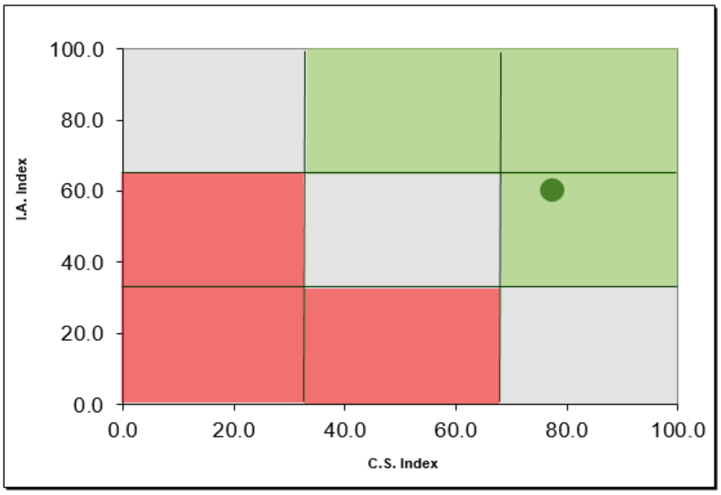


Figure A4-1. GE Matrix Position of Argentina

b) Brazil

1) Industrial Attractiveness (IA)

Table A4-3. Industrial Attractiveness Index of Brazil

Factors	Weight	Rating	Product
Market Penetration	25.0	1.0	25.0
Agriculture Value Added to the Percentage of GDP	15.0	0.5	7.5
Domestic consumption	20.0	0.5	10.0
Number of Export Destinations	15.0	0.5	7.5
Biodiesel Trade Balance	25.0	0.0	0.0
	100	**Industrial Attractiveness (I.A.) Index**	**50.0**

2) Competitive Strength (CS)

Table A4-4. Competitive Strength Index of Brazil

Factors	Weight	Rating	Product
Standardisation/Accreditation	25	1.0	25.0
The Infrastructure of Biodiesel Industry	20	1.0	20.0
Production Capacity	15	1.0	15.0
Regulation/Policy	25	1.0	25.0
Potential of the next generation biodiesel	15	0.0	0.0
	100	**Comp Strength (C.S.) Index**	**85.0**

3) Position

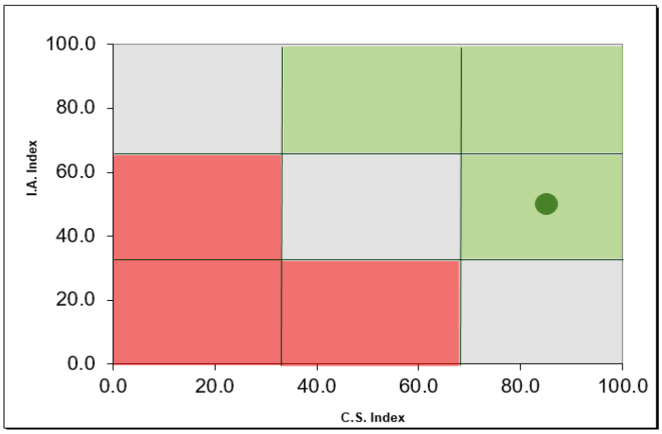


Figure A4-2. GE Matrix Position of Brazil

c) China

1) Industrial Attractiveness (IA)

Table A4-5. Industrial Attractiveness Index of China

Factors	Weight	Rating	Product
Market Penetration	25.0	0.0	0.0
Agriculture Value Added to the Percentage of GDP	15.0	0.5	7.5
Domestic consumption	20.0	0.0	0.0
Number of Export Destinations	15.0	0.0	0.0
Biodiesel Trade Balance	25.0	0.0	0.0
	100	**Industrial Attractiveness (I.A.) Index**	**7.5**

2) Competitive Strength (CS)

Table A4-6. Competitive Strength Index of China

Factors	Weight	Rating	Product
Standardisation/Accreditation	25	0.5	12.5
The Infrastructure of Biodiesel Industry	20	0.5	10.0
Production Capacity	15	0.5	7.5
Regulation/Policy	25	0.0	0.0
Potential of the next generation biodiesel	15	0.0	0.0
	100	**Comp Strength (C.S.) Index**	**30.0**

3) Position

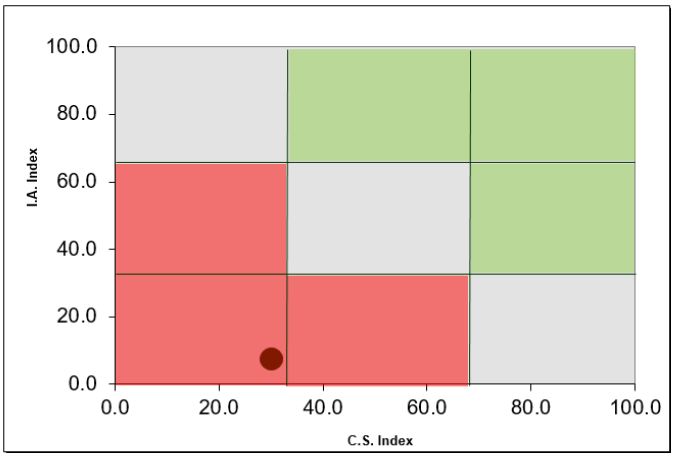


Figure A4-3. GE Matrix Position of China

d) Germany

1) Industrial Attractiveness (IA)

Table A4-7. Industrial Attractiveness Index of Germany

Factors	Weight	Rating	Product
Market Penetration	25.0	1.0	25.0
Agriculture Value Added to the Percentage of GDP	15.0	0.0	0.0
Domestic consumption	20.0	1.0	20.0
Number of Export Destinations	15.0	1.0	15.0
Biodiesel Trade Balance	25.0	0.5	12.5
	100	**Industrial Attractiveness (I.A.) Index**	**72.5**

3) Competitive Strength (CS)

Table A4-8. Competitive Strength Index of Germany

Factors	Weight	Rating	Product
Standardisation/Accreditation	25	1.0	25.0
The Infrastructure of Biodiesel Industry	20	1.0	20.0
Production Capacity	15	1.0	15.0
Regulation/Policy	25	1.0	25.0
Potential of the next generation biodiesel	15	0.5	7.5
	100	**Comp Strength (C.S.) Index**	**92.5**

3) Position

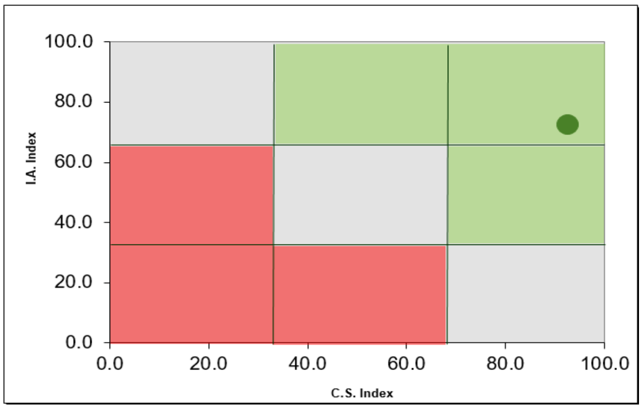


Figure A4-4. GE Matrix Position of Germany

e) Indonesia

1) Industrial Attractiveness (IA)

Table A4-9. Industrial Attractiveness Index of Indonesia

Factors	Weight	Rating	Product
Market Penetration	25.0	0.5	12.5
Agriculture Value Added to the Percentage of GDP	15.0	1.0	15.0
Domestic consumption	20.0	0.0	0.0
Number of Export Destinations	15.0	1.0	15.0
Biodiesel Trade Balance	25.0	1.0	25.0
	100	**Industrial Attractiveness (I.A.) Index**	**67.5**

4) Competitive Strength (CS)

Table A4-10. Competitive Strength Index of Indonesia

Factors	Weight	Rating	Product
Standardisation/Accreditation	25	1.0	25.0
The Infrastructure of Biodiesel Industry	20	1.0	20.0
Production Capacity	15	0.5	7.5
Regulation/Policy	25	0.5	12.5
Potential of the next generation biodiesel	15	1.0	15.0
	100	**Comp Strength (C.S.) Index**	**80.0**

3) Position

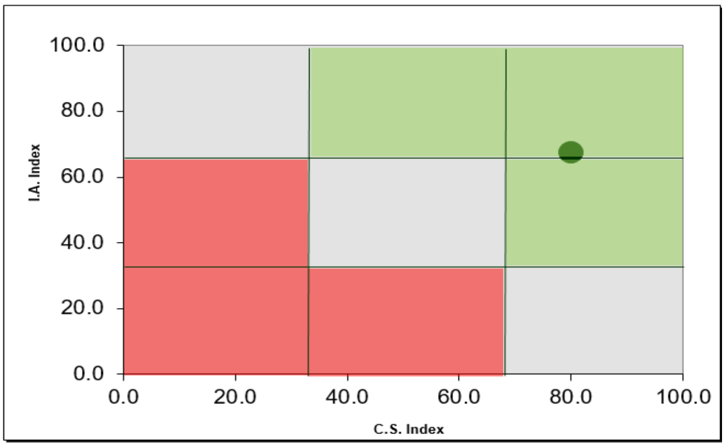


Figure A4-5. GE Matrix Position of Indonesia

f) The United States (US)

2) Industrial Attractiveness (IA)

Table A4-11. Industrial Attractiveness Index of the US

Factors	Weight	Rating	Product
Market Penetration	25.0	1.0	25.0
Agriculture Value Added to the Percentage of GDP	15.0	0.0	0.0
Domestic consumption	20.0	1.0	20.0
Number of Export Destinations	15.0	1.0	15.0
Biodiesel Trade Balance	25.0	0.0	0.0
	100	**Industrial Attractiveness (I.A.) Index**	**60.0**

5) Competitive Strength (CS)

Table A4-12. Competitive Strength Index of the US

Factors	Weight	Rating	Product
Standardisation/Accreditation	25	1.0	25.0
The Infrastructure of Biodiesel Industry	20	1.0	20.0
Production Capacity	15	1.0	15.0
Regulation/Policy	25	1.0	25.0
Potential of the next generation biodiesel	15	0.5	7.5
	100	**Comp Strength (C.S.) Index**	**92.5**

3) Position

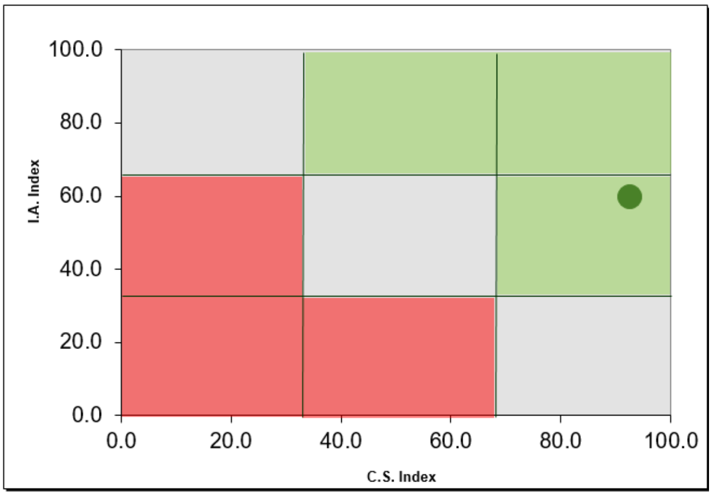


Figure A4-6. GE Matrix Position of the US

Summary of GE Matrix Score and United Position

Table A4-13. Summary of GE Matrix/McKinsey Index for All Selected Countries

Country Name	IA Index	CS Index
Argentina	60.0	77.5
Brazil	50	85.0
China	7.5	30.0
Germany	72.5	92.5
Indonesia	67.5	80.0
United States	60	92.5

Appendix 5: The Average of Biodiesel Consumptions per Fuel Terminals / Distribution Centres in 2014

Region I

No.	Location	Total Volume (Liter)
1	Medan	212048000
2	Dumai	112276000
3	Siak	63975000
4	Kabil	37667667
5	Tg Uban	18833833
6	Tembilahan	37667667
7	Kisaran	21237667
8	Siantar	21237667
9	Lhokseumawe	27793000
10	Sibolga	10618833
11	Meulaboh	27793000
12	Krueng Raya	13896500
13	Sabang	13896500
14	Sitoli	10618833
15	Kijang	18833833

Region II

No	Location	Total Volume (Liter)
1	Kertapati	31209333
2	Pangkalan Balam	21524000
3	Tg pandan	21524000
4	Panjang	79312000
5	Jambi	49761000
6	Baturaja	31209333
7	Lahat	31209333
8	Lubuk Linggau	33986800
9	P. Baai	33986800

Region III

No	Location	Total Volume (Liter)
1	Tg Gerem	101960400
2	Jakarta Group	240223000
3	Cikampek	129026000
4	Ujung berung	57583333
5	Tasikmalaya	57583333
6	Balongan	129026000
7	Padalarang	57583333

Region IV

No	Location	Total Volume (Liter)
1	Tegal	24000000
2	Pengapon	43863500
3	Rewulu	44603500
4	Boyolali	44603500
5	Maos	24000000
6	Cilacap	24000000
7	Cepu	43863500

Region V

No	Location	Total Volume (Liter)
1	Camplong	12719000
2	Malang	12719000
3	Madiun	12719000
4	Surabaya Group	69756400
5	Tg Wangi	42965400
6	Manggis	63964800
7	Sanggaran	28643600
8	Tuban	34878200
9	TWU-Bojonegoro	34878200
10	Ampenan	42643200
11	Badas	17439100
12	Bima	17439100
13	Reo	5422375
14	Maumere	5422375
15	Ende	5422375
16	Waingapu	5422375
17	Tenau	10844750
18	Atapupu	5422375
19	Kalabahi	5422375

Region VI

No	Location	Total Volume (Liter)
1	Pontianak	66950000
2	Banjarmasin	85570000
3	Samarinda	50643000
4	Balikpapan	34856000
5	Sampit	20098000
6	Pangkalan Bun	10177000

Region VII

No	Location	Total Volume (Liter)
1	TBBM Banggai	10842300
2	TBBM Bau-bau	10842300
3	TBBM Kendari	10842300
4	TBBM Kolaka	10842300
5	TBBM Kolonedale	10842300
6	TBBM Luwuk	5837250
7	TBBM Moutong	5837250
8	TBBM Palopo	10842300
9	TBBM Poso	5837250
10	TBBM Raha	10842300
11	TBBM Pare-pare	18275700
12	TBBM Bitung	15295000
13	TBBM Makassar	42643300
14	TBBM Donggala	5837250
15	TBBM Gorontalo	24472000
16	TBBM Toli-toli	15295000
17	TBBM Tahuna	6118000

Region VIII

No	Location	Total Volume (Liter)
1	TBBM Jayapura	6394080
2	TBBM Sorong	6394080
3	TBBM Biak	4110480
4	TBBM Kaimana	4110480
5	TBBM Manokwari	4110480
6	TBBM Nabire	4110480
7	TBBM Serui	4110480
8	TBBM Fak-Fak	4110480
9	TBBM Merauke	4110480
10	TBBM Wayame	4110480
11	TBBM Ternate	4110480
12	TBBM Tobelo	4110480
13	TBBM Tual	4110480
14	TBBM Dobo	4110480
15	TBBM Bula	4110480
16	TBBM Labuha	4110480
17	TBBM Namlea	4110480
18	TBBM Saumlaki	4110480
19	TBBM Sanana	4110480
20	TBBM Masohi	4110480
21	Jobber Timika	4567200

Appendix 6: Detailed Design of EvoSCM-B2.0 Prototype

a) Software Design

One of the well-known methods in a software development process is focused on the problem before solution. The reason is that there are many systems have failed because the requirements were not adequately determined. The hardware and software functioned correctly, but it was not all that needed. Many developers' failures were in capturing and understanding the problem not in implementing the solution. The problem could be easy to check, at least approximately. After the problem has been investigated and discovered, the next task is to show the problem requirement in a diagram, which is called problem frames. In the problem diagrams, the requirement is always the problem domains that needs to show how it's related to those areas, and what roles the domains play in the problem. The author uses the Jackson's notation (Jackson, 2001) to design the tracking system software. First analysis and problem examination using a context diagram.

The requirement, fact, and assumption are part of the basic terminology in software development that must be taking into account before we build a machine. Our goal is to construct a system with specified characteristics of the system. There are two essential components of the system, i.e. environment and machine. Environment is part of the real world that relevant for the problem, meanwhile machine is something that we are going to build (Heisel, 2010).

The requirement is an optative statement that describes how the environment should behave when the machine is in action. Such requirements need to be defined before the machine built. Requirements might also be requested in more specific by the clients who want to have some certain conditions for their system. The fact is the x properties in the environment, and the assumption is the condition that is needed to accomplish the requirement. The fact and assumption should be considered in the design of the software. Facts and assumptions give the actual condition of the environment of the system.

In this research, two parts of the software system are designed. Each part has its own requirement, fact and assumption, abbreviated with R,F and A, respectively. The first part is called Mobile Station and the second is Central Station.

Mobile Station

List of the requirements on the Mobile Station:

(R01) Operator can monitor his position through GPS device (monitorMS) and the position will appear on the Mini Display (displayMSpositionData).
(R02) Operator can monitor (monitorMS) the status of biodiesel and appear on the Mini Display (displayMSsensingData).
(R03) Alarm is triggered (alarmSwitchOn) and Operator get warned (operator- Warning) if the acid level of biodiesel, that get from ADC converter, is increasing (digitalPHdata).
(R04) Operator can also switch the Alarm o_ (alarmSwitchOff).
(R05) The position data of the truck is sent(sendPositionData) to the BTS Tower through Transmitter Unit (transmitPositionData).
(R06) The sensing data of biodiesel acid level is sent to BTS Tower (sendSensingData) through Transmitter Unit (transmitSensingData) at every 5 minutes (sendSensingData).

The facts of the Mobile Station are:

(F01) Increasing the acid value of biodiesel is equal to degrability of biodiesel.
(F02) GPS is a global navigation satellite system that provides position and location at all times and anywhere on the Earth.
(F03) An LCD Display 2.5" (63mm) is used to monitor the status of biodiesel in the container.

The assumptions of Mobile Station are:

(A01) Digital road map of distribution path is available on the truck.
(A02) No blank spot at every distribution path.
(A03) Mobile Station has enough power supply to operate the system.
(A04) Operator can be a driver of the truck.
(A05) Operator has GPS unit in his car.
(A06) All the data will be sending to the BTS Tower at every 5 minutes.

Central Station

List of the requirements of the Central Station:

(R01) Supervisor can monitor (monitorCS) the status of biodiesel and it will appear on the Display (displaySensingData).

(R02) Supervisor can monitor (monitorCS) the current position of the truck and it will appear on the Display (displayPositionData).
(R03) The Alarm will be raising (switchOn) in case of the status of biodiesel is degrading and Supervisor get warned (supervisorWarning).
(R04) The Alarm will be raising (switchOn) in case of the truck is out of the distribution track and Supervisor get warned (supervisorWarning).
(R05) The Alarm can be switched o_ (alarmSwitchOff) only by Supervisor.
(R06) The status of biodiesel is stored in the Database (setSensingData).
(R07) The position of the truck is stored in the Database (setPositionData).
(R08) Client can browse (request) the status of biodiesel on the internet.
(R09) Client can browse (request) the position of the truck on the internet.
(R10) Client can request an SMS about the position of the truck (requestSMSpositionData) by sending a request message to the SMS Gateway.
(R11) Client can request an SMS about the status of biodiesel (requestSMSsensingData) by sending a request message to the SMS Gateway.
(R12) Web page can update its data (getUpdate) from Database.
(R13) Web page can provide the data (setUpdate) to be able accessed by the Client.
(R14) BTS Tower receives the position of the truck (receivePositionData), henceforth Receiver Unit receives this data to be stored in the Database.
(R15) BTS Tower receives the status of biodiesel (receiveSensingData), henceforth Receiver Unit receives this data to be stored in the Database.

The facts of Central Station are given as follows:
(F01) Central Station acts as the central tracking system of biodiesel distribution.
(F02) Central Station acts as the quality control of biodiesel distribution.
(F03) Supervisor acts as an operator at the Central Station.
(F04) The position of the truck can be accessed from the web.
(F05) GSM is the standard mobile communication systems.

The assumptions of Central Station are given as follows:
(A01) Central Station has a power unit.
(A02) Every data that comes from BTS Tower is always saved to Database.
(A03) Client could be a normal user, owner, or director.
(A04) Only registered Client that has hotline number can request the SMS from SMS Gateway.
(A05) The data of position and biodiesel status is stored in the database at every time period (user determined).

Context Diagram

A context diagram is rather like the fundamental of a problem. It shows where the problem is located and what parts of the world it concerns. Context diagram represents the machine domain and the problem domains. It shows the interfaces between the domains, that how the machine is connected to problem domains and how problem domains are connected to each other. It is important to focus on a problem first before going straight to the design of a solution. The context diagram shows a very rough sketch and can be as a starting point to focus before embarking on developing a solution. Based on the predetermined of requirements, facts and assumptions, the context diagram of each station can be drawn (see Figure A6-1 and A6-2). The design of biodiesel tracking system on this research is referred to Jackson's rules and its five basic rules (Heisel, 2010).

In the context diagram all the problem domains are presented, such as the machine domain, designed domain and given domain. The problem domains are presented by the rectangles. The interfaces, which are the lines connected between two domains, are also drawn. The interfaces act as events and states and values as being shared between the connected domains (*shared phenomena*).

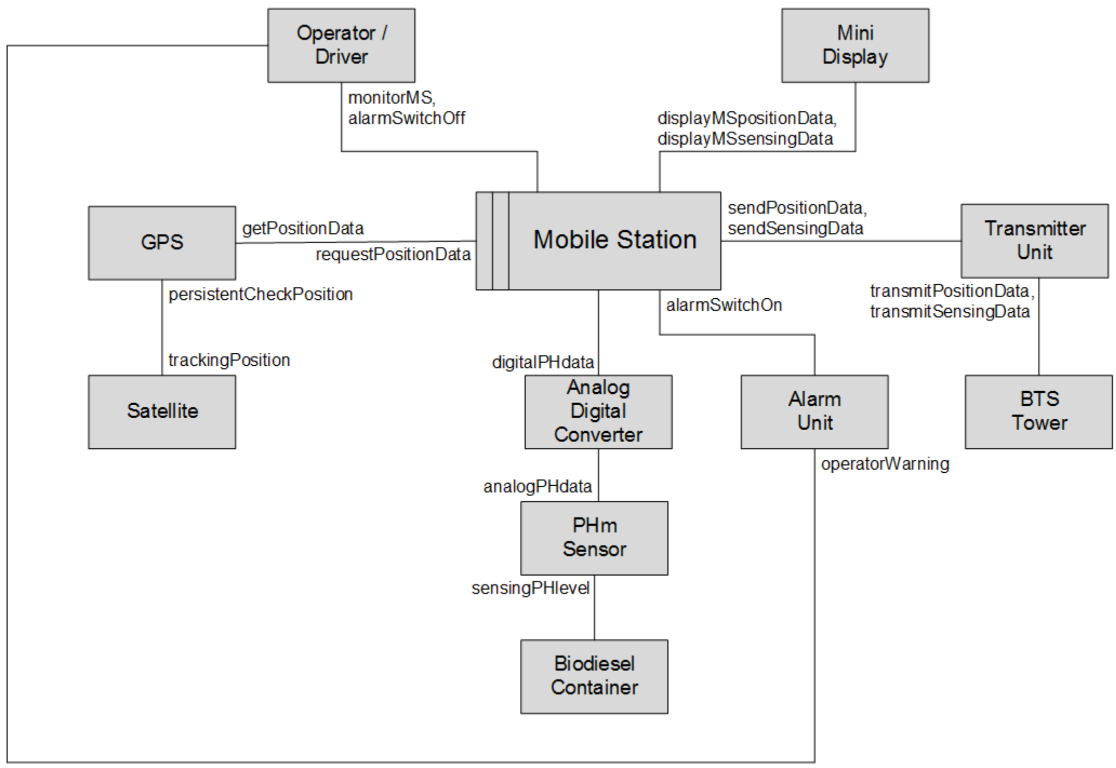


Figure A6-1. Context Diagram of the Mobile Station

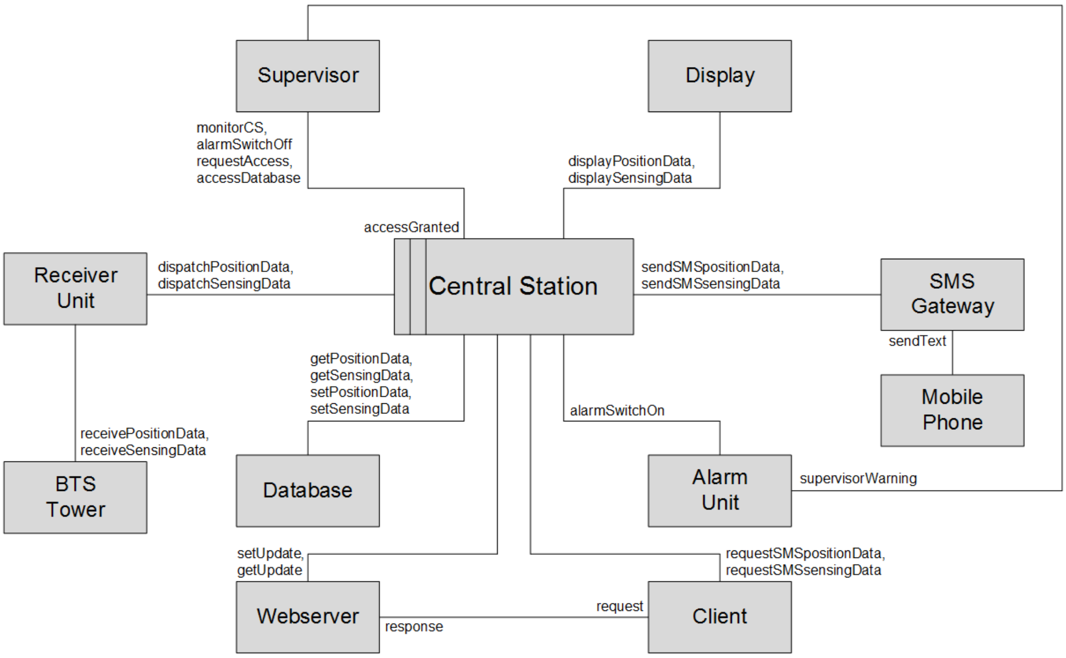


Figure A6-2. Context Diagram of the Central Station

Detailed Architecture

Composite structure diagram from UML is used to give a detailed understanding of the software architecture. Composite Structure Diagram is the new artefacts added to UML 2.0. It shows the internal structure (including parts and connectors) of a structured classifier or collaboration. Such diagram conceives the internal formation of a class or collaboration. (OMG-Team, 2011) defines that composite structure diagram is a kind of component diagram essentially used in modelling a system at micro point-of-view. In ordert o deliver that purpose, the author set the detailed architecture of mmobile and central station using a compostie structure diagram (see the Figure A6-3 and A6-4).

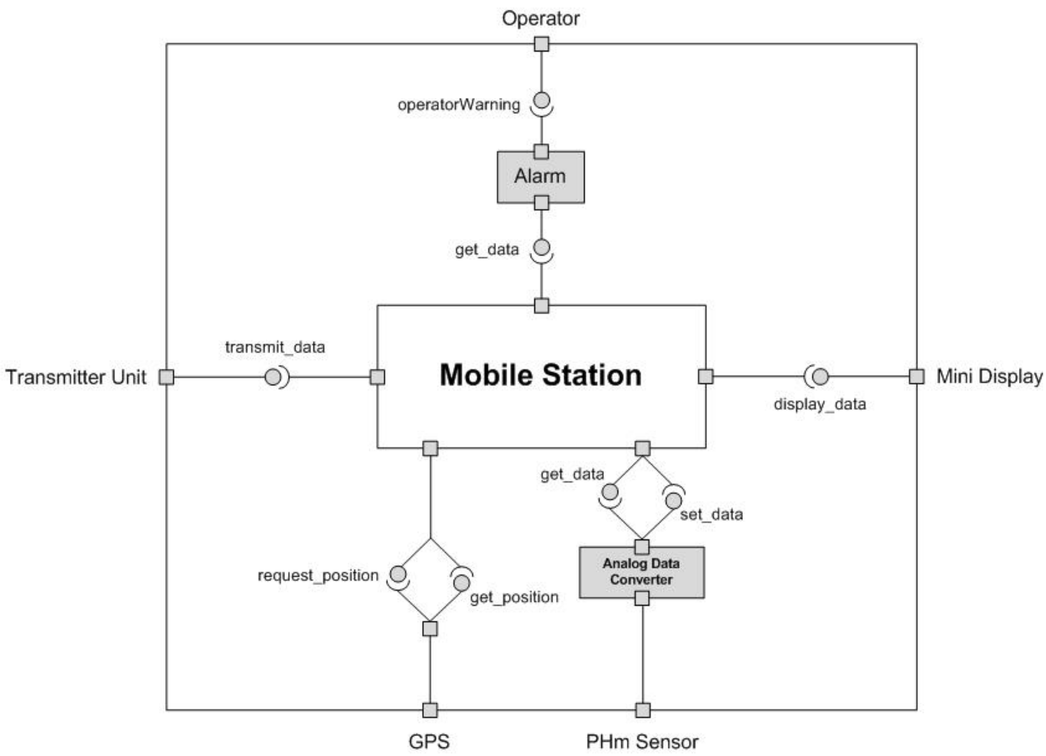


Figure A6-3. The Detailed Architecture of Mobile Station

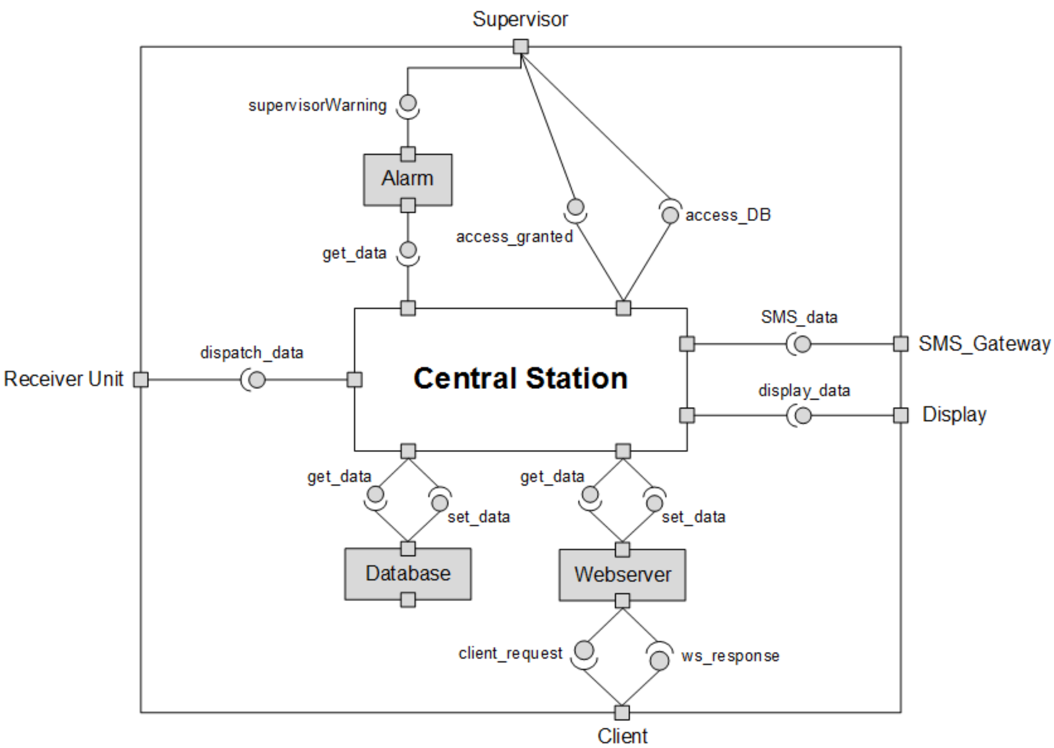


Figure A6-4. The Detailed Architecture of Central Station

b) Hardware Design

Global design of the proposed system is illustrated by Figure A6-5.

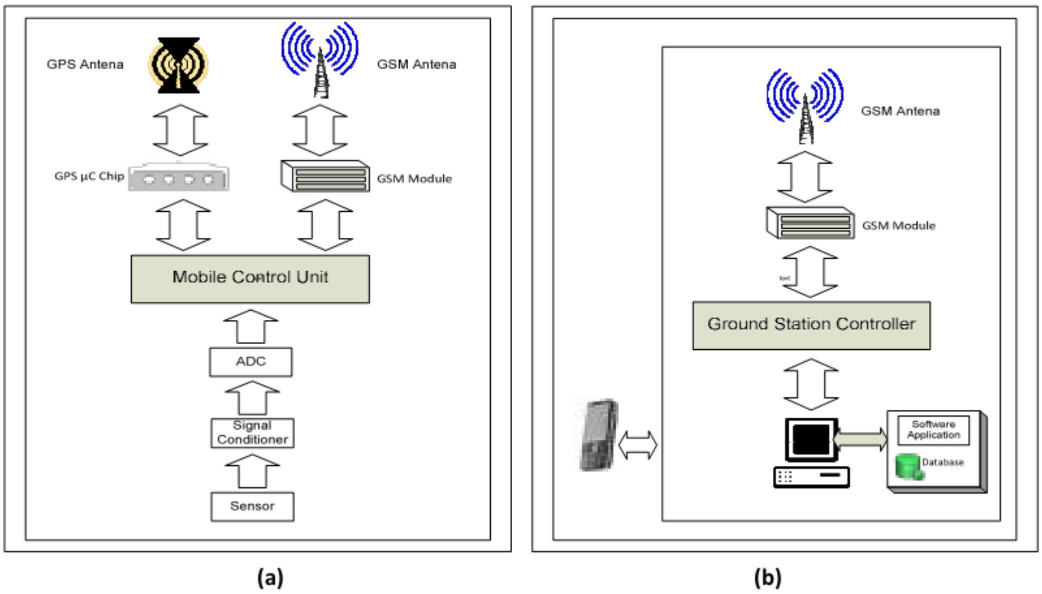


Figure A6-5. Gobal Design of EvoSCM-B2.0: (a) Mobile Station (b) Central Station

Furthermore, the author design the mainboard of mobile control unit and its electronic circuits supporters. The circuit diagram of the plan can be learned from Figure A6-6, A6-7 and A6-8.

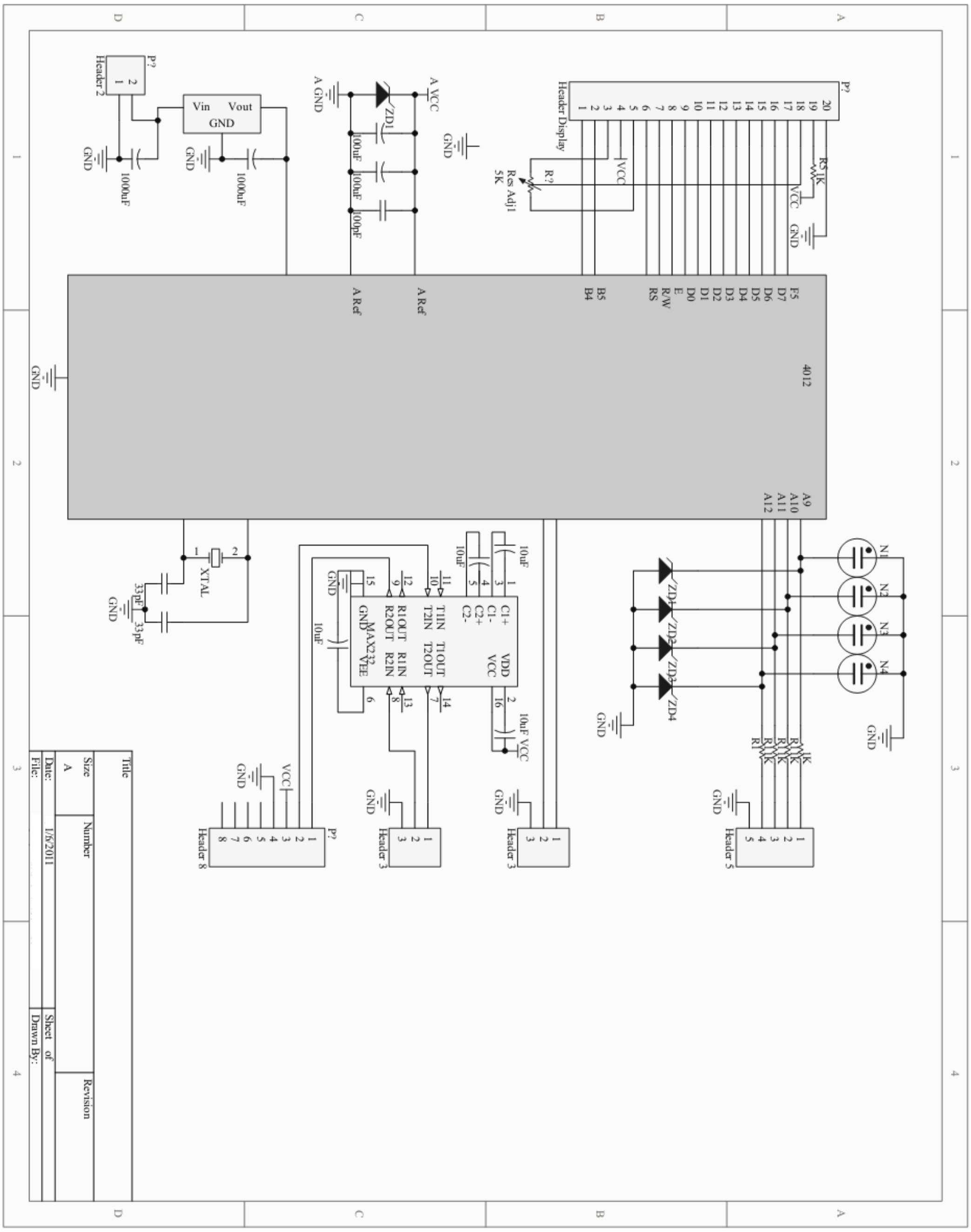


Figure A6-6. Electronic Circuit Design for the Main Board of the Mobile Control Unit

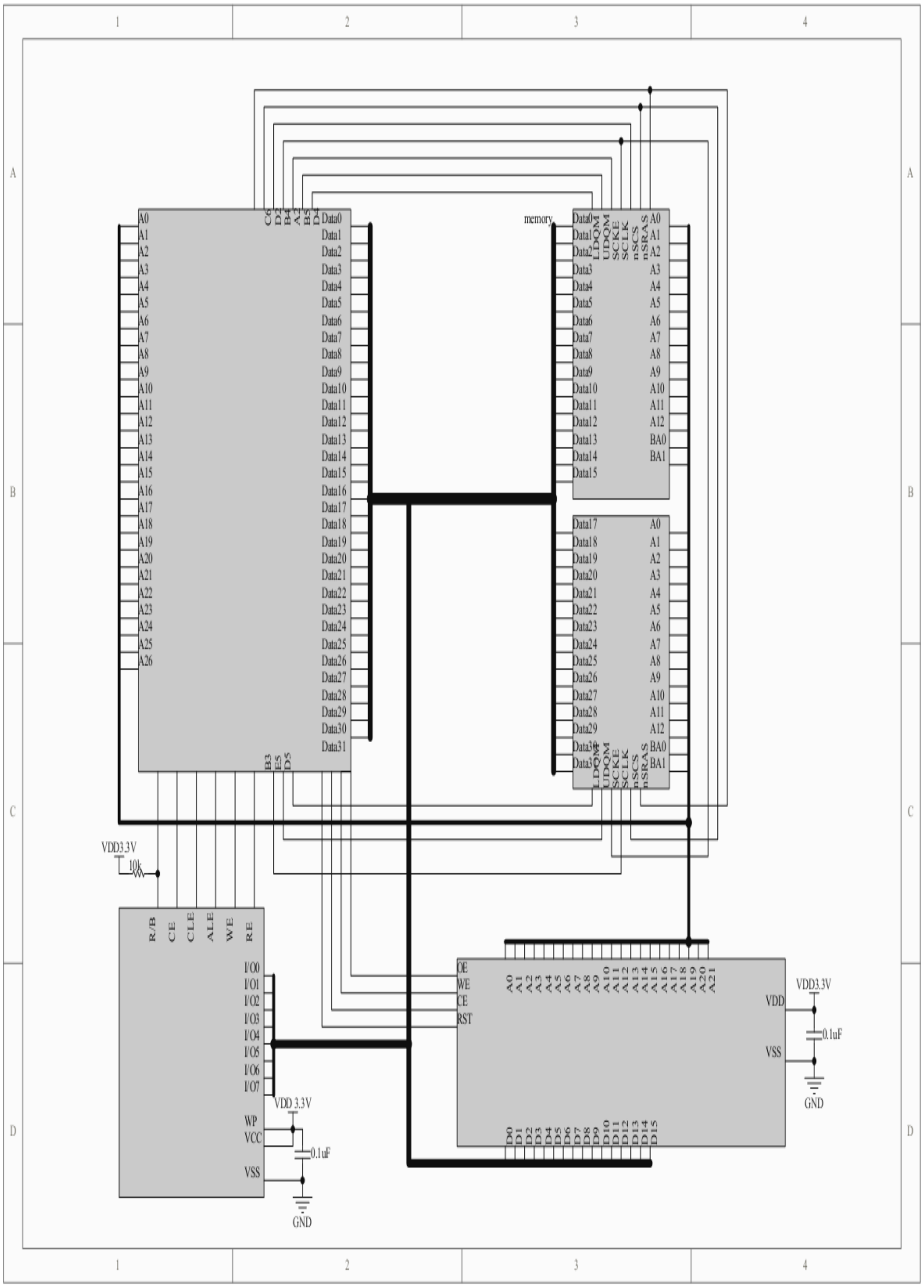


Figure A6-7. Electronic Circuit Design for the 1st Supporting Board of the Mobile Control Unit

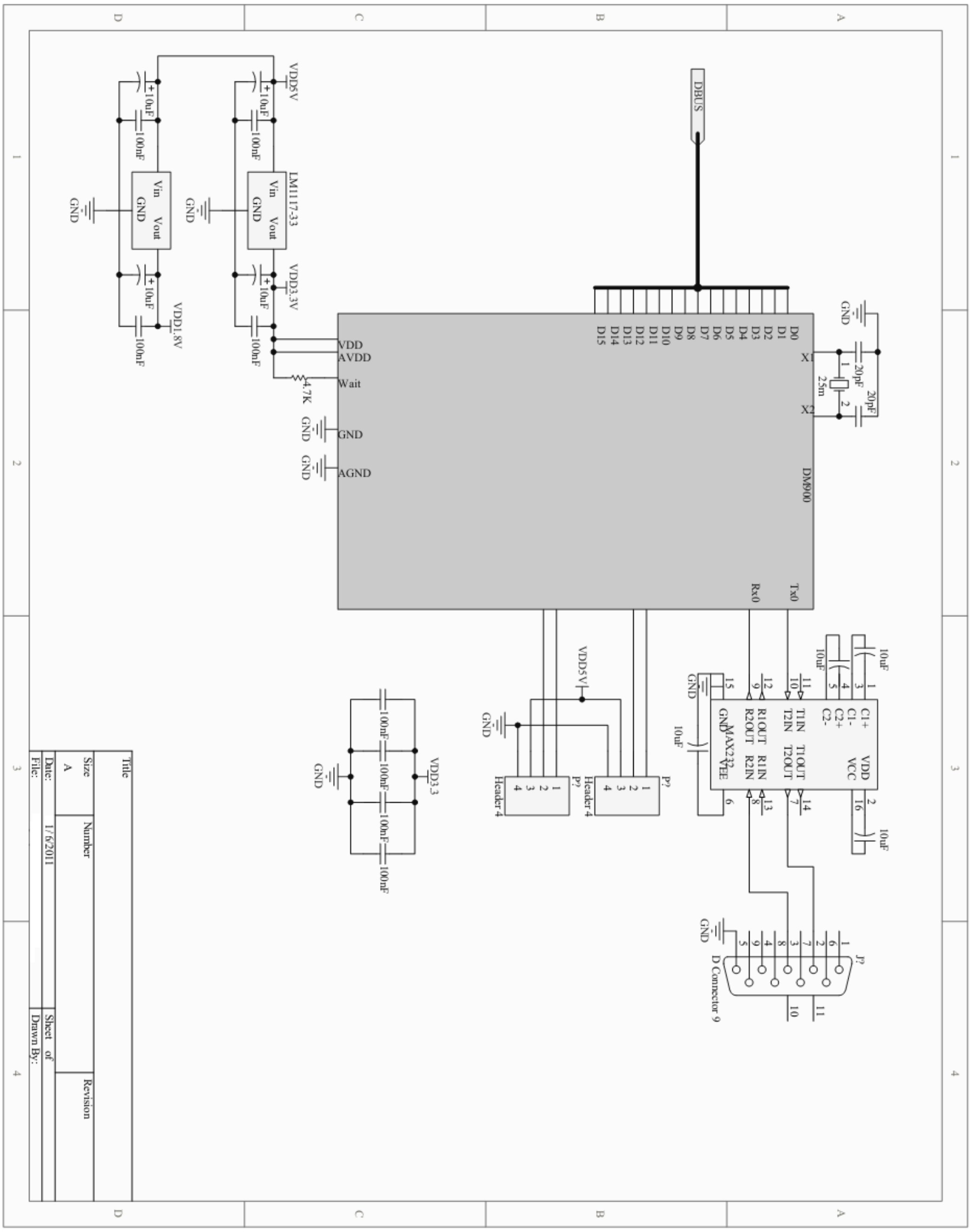
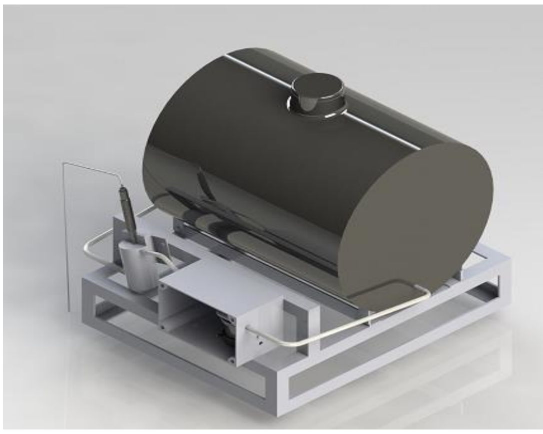


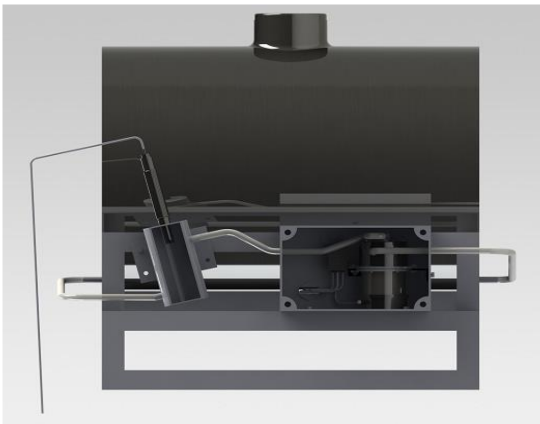
Figure A6-8. Electronic Circuit Design for the 2nd Supporting Board of the Mobile Control Unit

c) Container Prototype Design

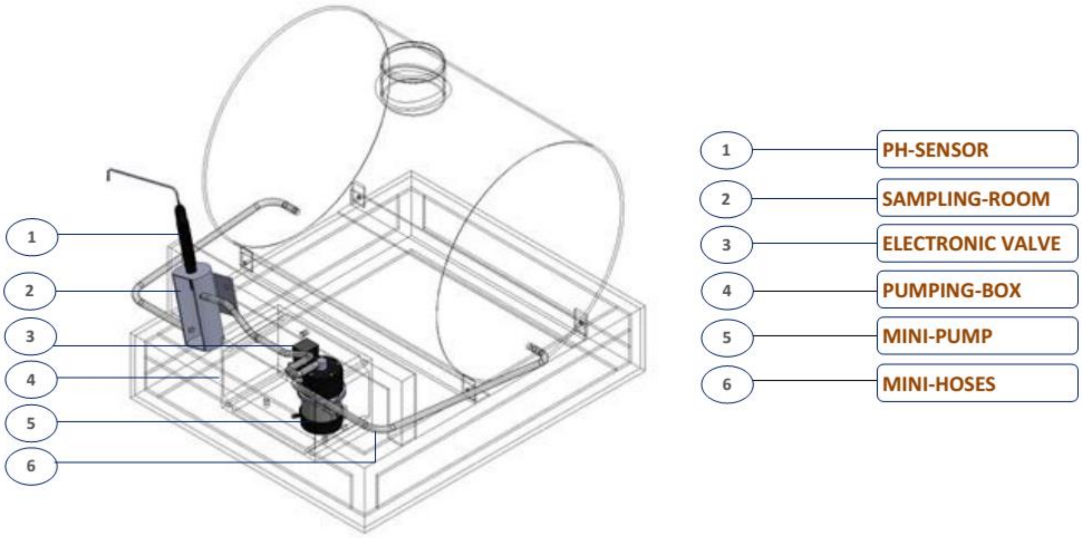
In order to test the data acquisition through the distribution channel, a prototype of tank-container also designed (Figure A6-9). The tank-container carries the distributed product which is transported. A sampling area, pump and sensors equip such tank. The microcontroller manages the sampling procedure, data retrieval and transmission on the mobile-station. GSM-module, GPS-module and other electronic-devices support this unit.



(a)



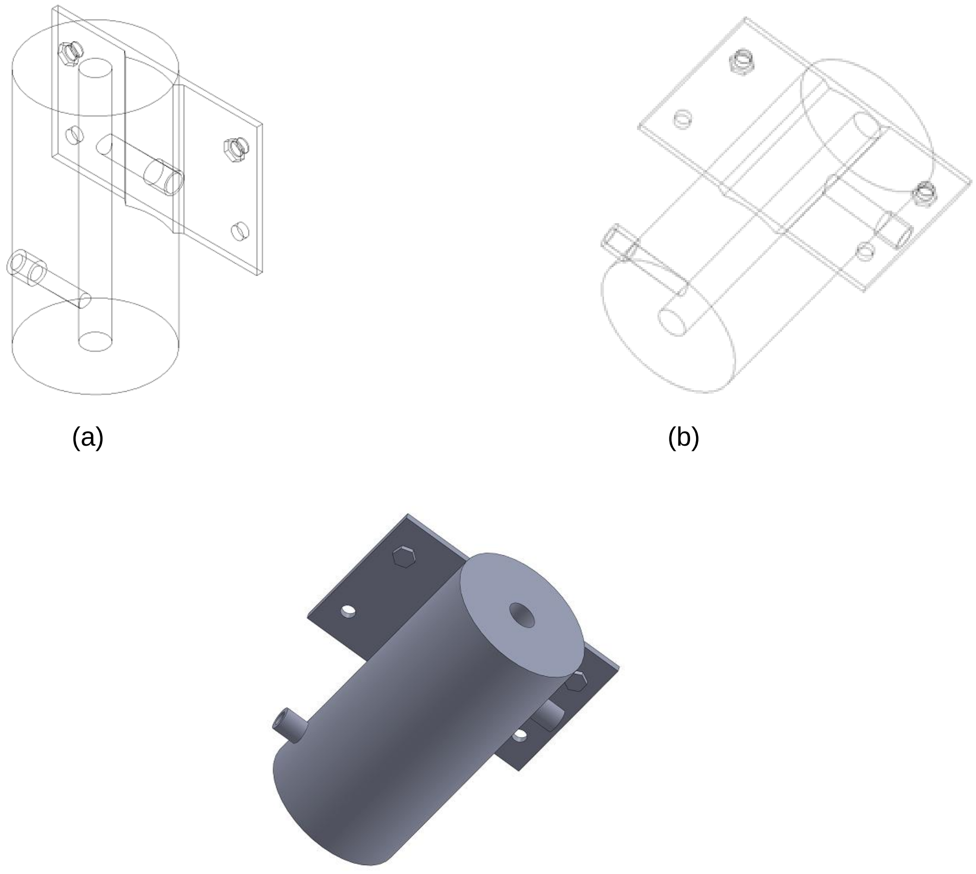
(b)



(c)

Figure A6-9. Prototype of the Tank-Container
(a) Side-View (b) Front-View (c) The 3D-Frame and the Device Legend

Biodiesel tank in the rear of the truck is modified in such a manner that the sample of biodiesel can be taken periodically and then returned back to the tank. Based on the field experiences, the author found that the liquid sensor will be difficult to give feedback during the process of transport if it is implanted directly to the tank. Due to a running state of the vehicle, biodiesel tank is always unstable that gives the arbitrary value of the sensor reading. This knowledge has made the author propose a 'sampling chamber' or 'sampling-room' for data retrieval.



(a) (b) (c)

Figure A6-10. The Sampling Chamber:
(a) 3D-Frame upright position (b) 3D-Frame position (c) 3D-Solid

Sampling room constructed very narrow and fit with the size of the sensor dipped into the hole of sampling room. The very tight cabin avoids the sensor from an arbitrary value of reading (Figure A6-10). Stream-in and out of the biodiesel into the sampling room is controlled by a pump and electronic valve. The electronic valve regulates the actuator behavior based on the electronic signal.

Appendix 7: The Mobile and Central Station Communication Protocols

Protocol	Function
LC LPOS	▪ Order mobile station to report the latest position and condition of biodiesel
	▪ Replied by mobile station in the sending of last position and biodiesel condition.
	Example : LC LPOS
	Reply message: Lat : S0658.0573 Long : E10733.2023 Speed : 0.22Alt : 702.2 PH : 09,12T:20/10/11 07:24:24
	It means: ▪ Position: 06°58.0573' South Latitude, 107°33.2023' East Longitude ▪ Velocity: 0.22 knot ▪ PH : 9.12 ▪ Time: UTC 10/10/2011 - 07:24:24
LC RPOS xx yyyy	▪ Order mobile station to report the latest position periodically along yyyy seconds and xx times
	▪ When xx = 99 then the report will be sent unlimited.
	▪ To stop unlimited sending, repeat LC RPOS protocol using limited repetition, for example LC RPOS 01 0060 .
	Example: LC RPOS 05 0060
	▪ This order will command mobile station to report the latest position and condition of biodiesel periodically in 60 seconds in amount of 5 times
	▪ Replied Message: Report OK
	▪ It means: Order has been accepted by mobile station and furthermore that order will be done.
LC MSG………..*	Order mobile station to display message on the mini-display
	Example: LC MSGhallo*
	Result: hallo (appear in the mini display of mobile-station)
LC SET1 xxxxx yyyyy zzzzz	Order mobile station to adjust the sampling period of biodiesel and pH measurement
	xxxxx : pumping period (second)
	yyyyy : stable period between pumping period (second)
	zzzzz : measurement period (second)
	Measurement period ≥ (pumping period + stable period)

Protocol	Function
checkxx	▪ Order central station to send last data of mobile station that used mobile ID xx (Command is ordered by mobile-phone) ▪ Last position and condition will be appeared on the mobile-phone
	Example: check01 (for ID mobile number 01)
	Result on the monitor:
	REPORT
	Name :Kijang
	ID : D888
	Date :20/10/2011 08:05
	Long : 107.5532
	Lat :-6.967701666
	Alt :698.2
	NAT :09.14
	Speed :0.09
	Note: this order can only be sent by the mobile-phone number that is registered as ADMIN in the central station.
msgxx yyyy*	Order central station to send yyyy message from mobile-phone into mobile station that used mobile ID xx
	Example: msg01 hallo from the Boss*
	Result: hallo from the Boss
	Note: this order can only be sent by the mobile-phone number that is registered as ADMIN in the central station.

Appendix 8: Detailed-chronological order of Integrated and Sustainable Biodiesel Development Concept

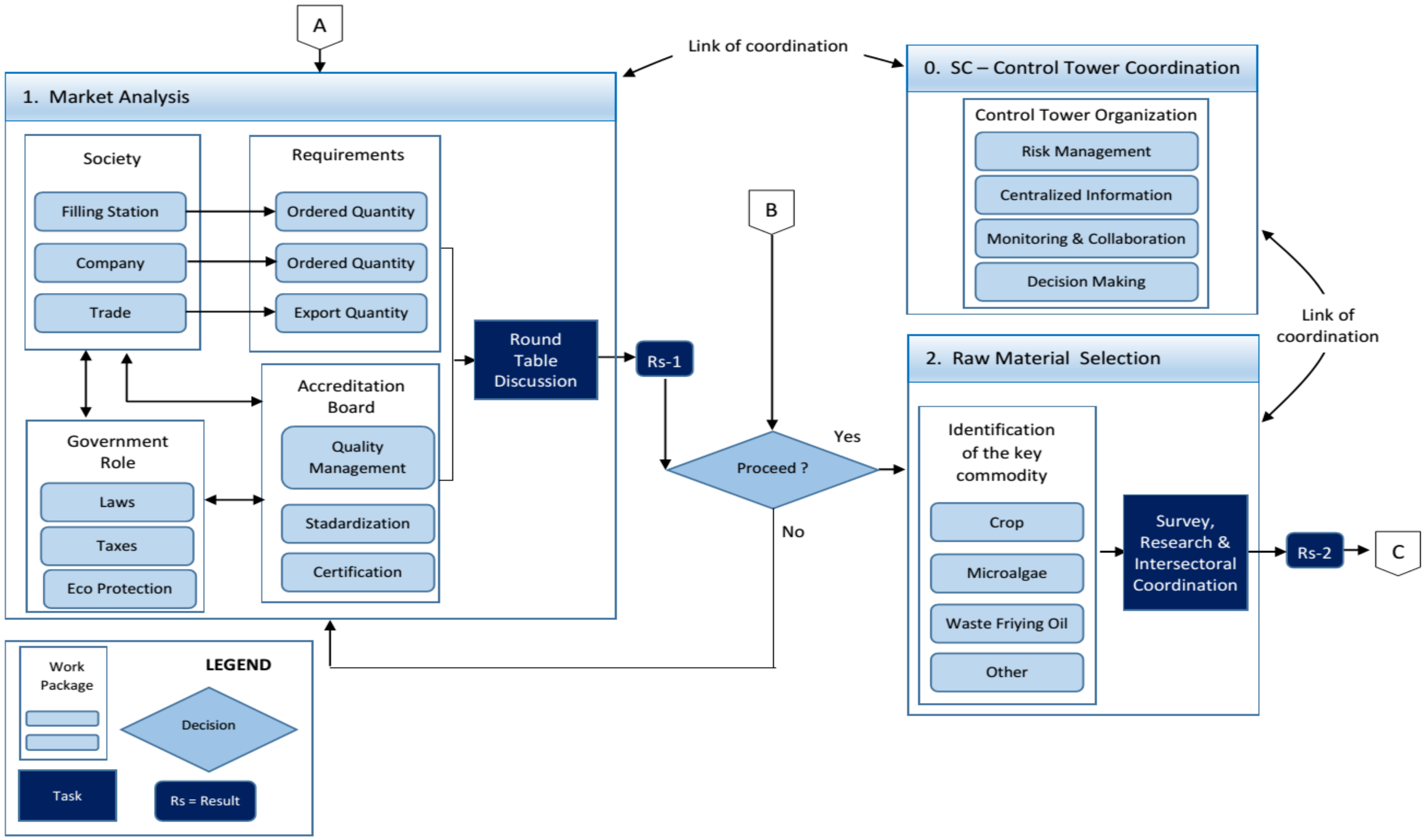


Figure A8-1. Sustainable Biodiesel Development - Stage 1-2: Market Analysis and Raw Material Selection

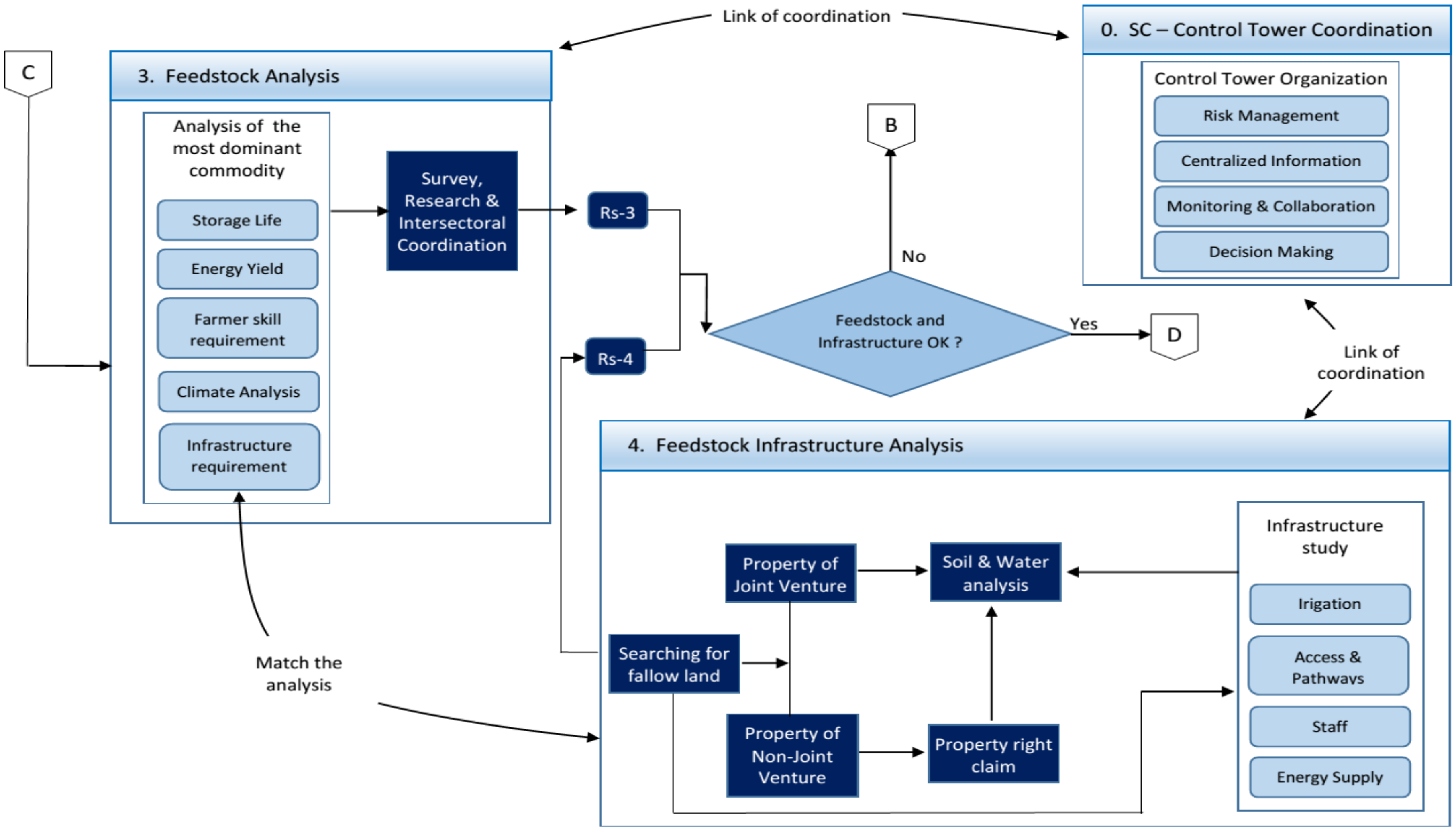


Figure A8-2. Sustainable Biodiesel Development - Stage 3-4: Feedstock & Feedstock Infrastructure Analysis

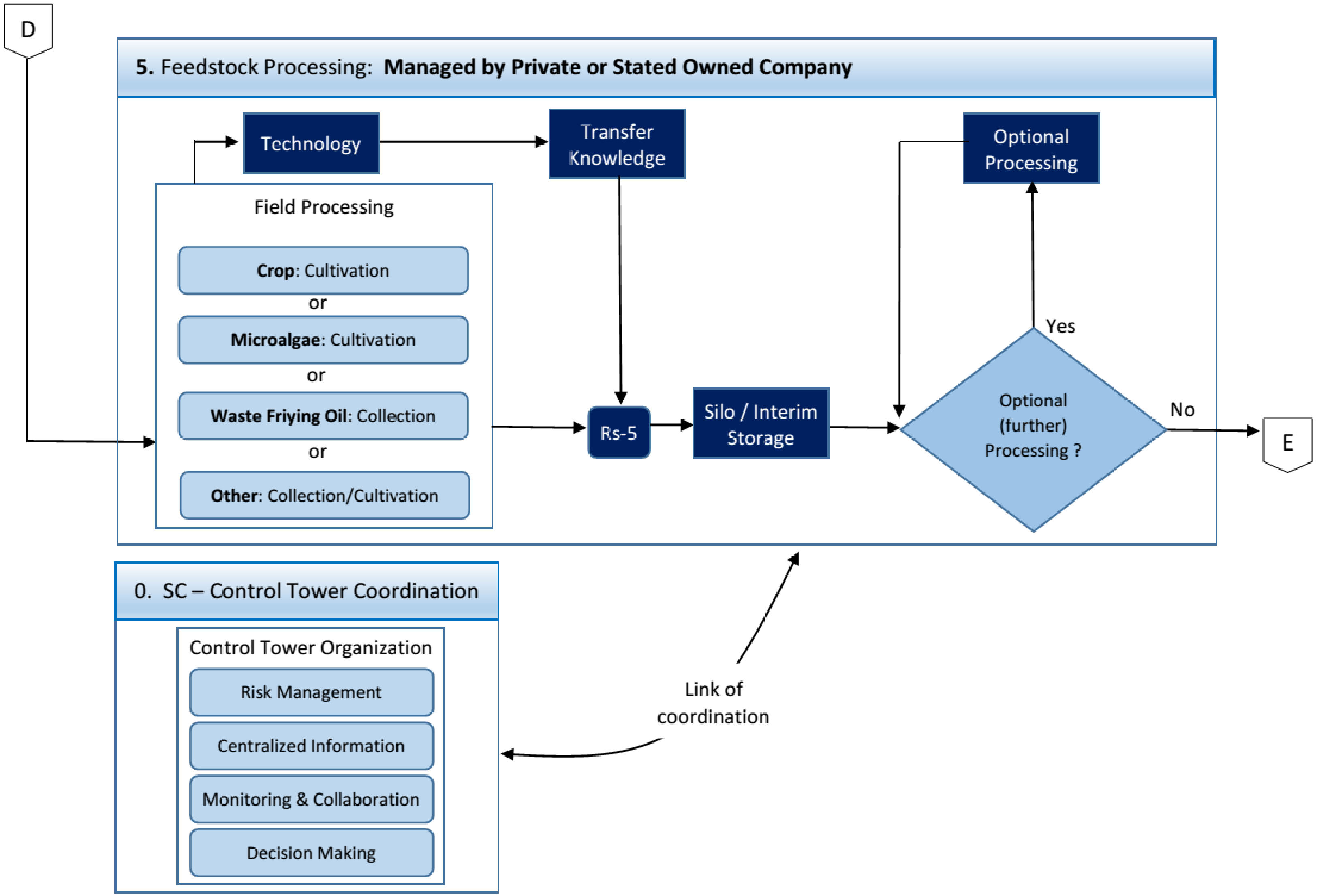


Figure A8-3. Sustainable Biodiesel Development – Stage 5: Feedstock Processing

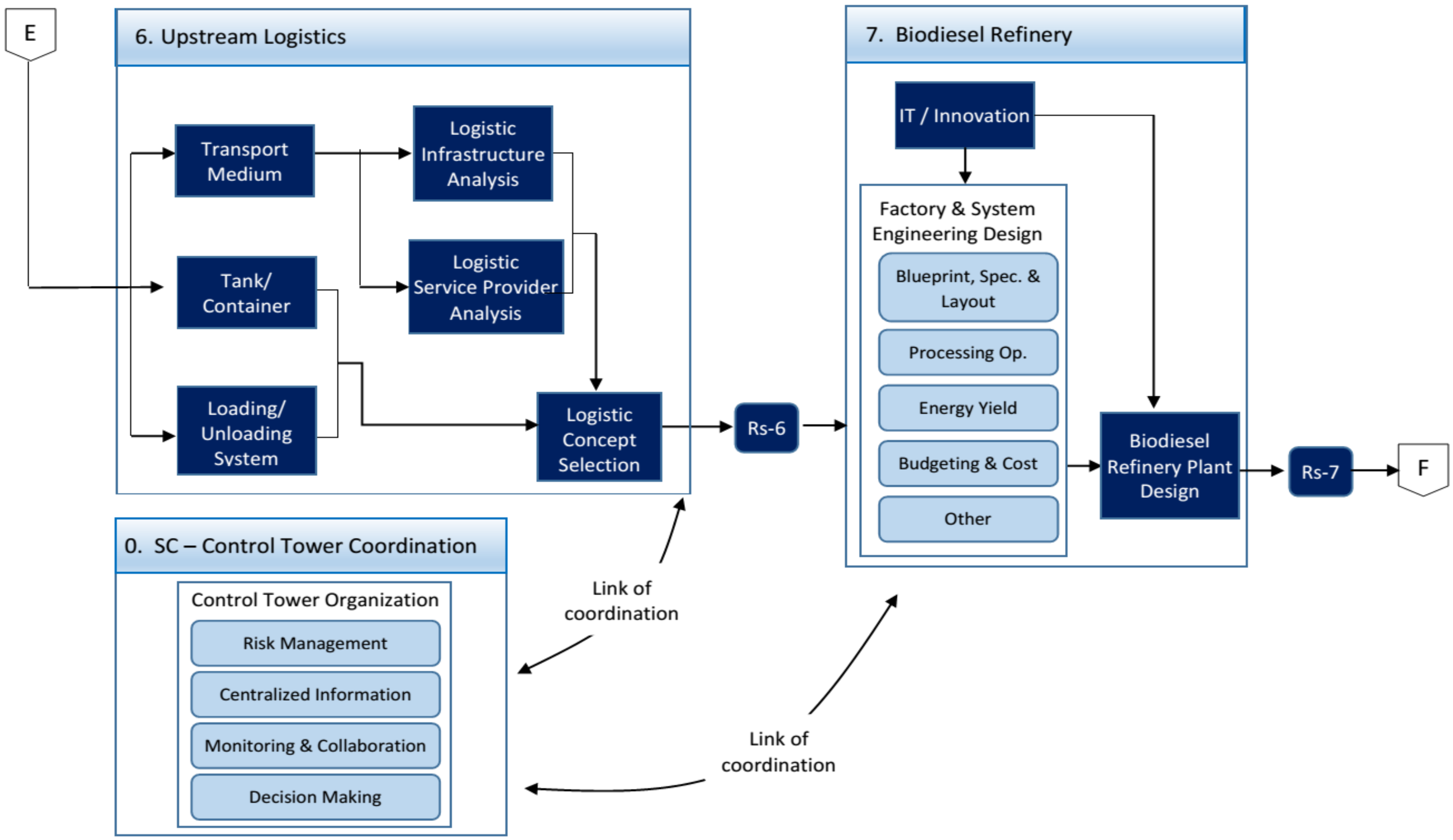


Figure A8-4. Sustainable Biodiesel Development – Stage 6-7: Upstream Logistic & Biodiesel Refinery Plan

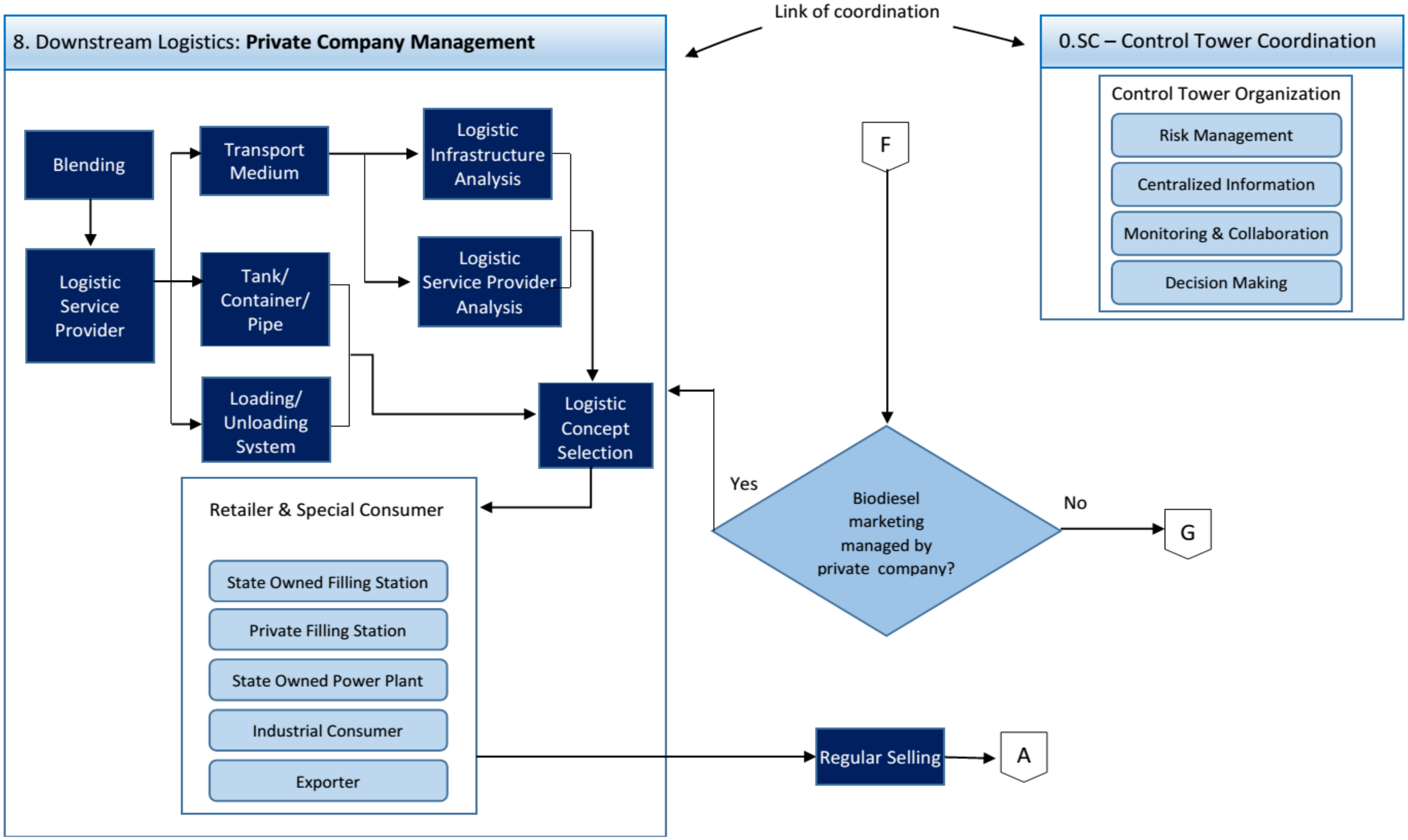


Figure A8-5. Sustainable Biodiesel Development - Stage 8: Downstream Logistics for Private Company Management

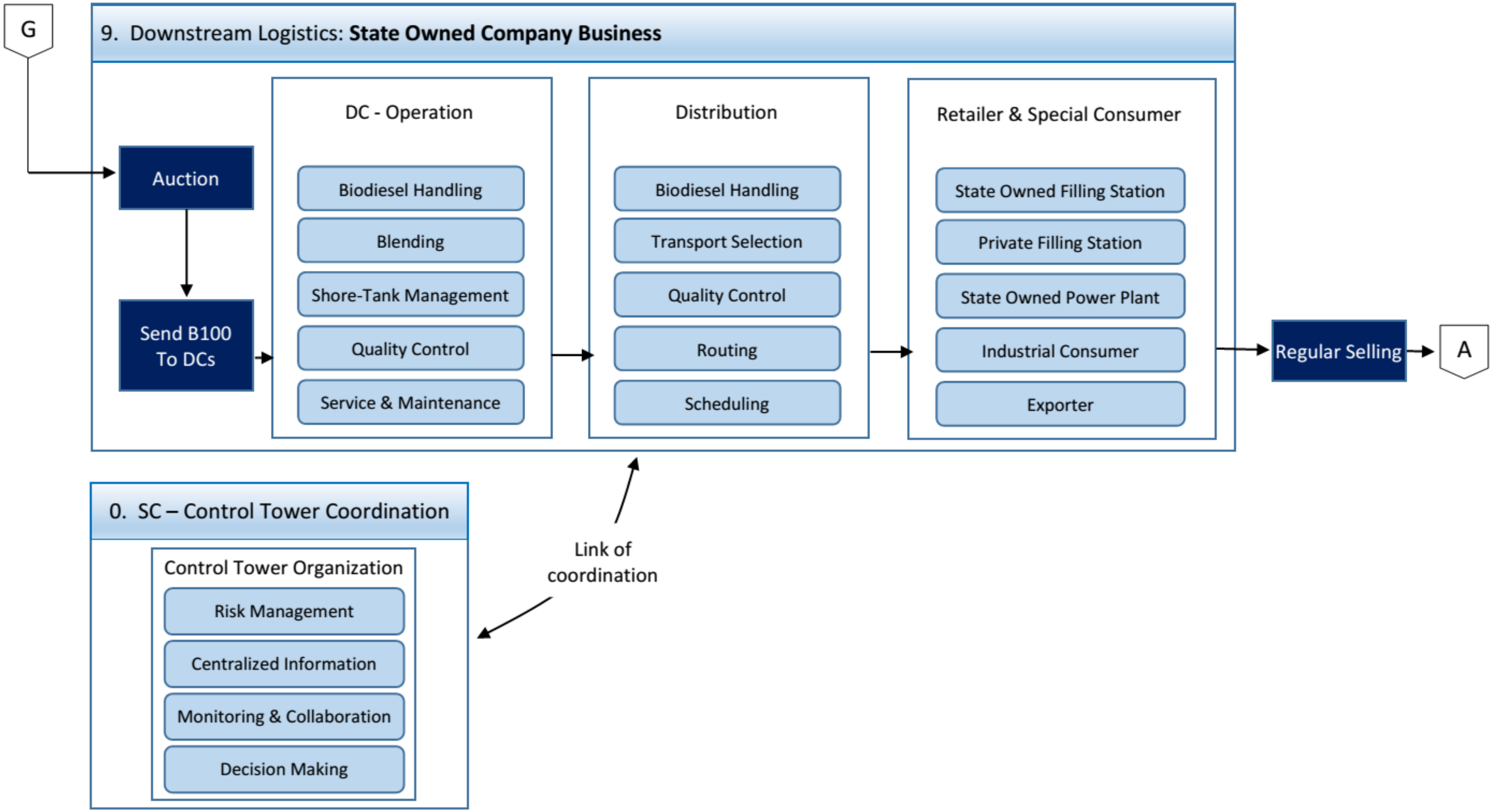


Figure A8-6. Sustainable Biodiesel Development - Stage 8: Upstream Logistics for State Owned Company