- Supervising the Academy of the Arabic Language and the National Committee of UNESCO

Considering the responsibility to lead national scientific research, MHE is responsible for collaboration with other public organization, privates, or other stakeholders to lead national strategies on sustainable development and to meet the national needs. As the most respectable entity of the high level research, National Research Center (NRC) under MHE with the collaboration with all relevant ministries have played key roles.

Present Jurisdiction/Responsibility for Jatropha Biofuel Supply Chain and Related Activities

As the responsible ministry to lead national strategies, MHE has been playing key role to develop the capacity of environmentally sound technologies and relevant human resources. At the 3rd meeting of Supreme Council of Science and Technology[10] on 22 January 2009, the council decided to give its priority to four (4) and 2nd priority to three (3) fields in the scientific research in Egypt due to its economic importance as well as its economic and social return. Following are the list of the prioritized fields:

1st priority

1) New and renewable energy: realization of Egyptian self-sufficiency with such energy,
2) Water resources: solution for lack of water resources to solve the growing population and agriculture expansion,
3) Life sciences including the medical and biological sciences,
4) Food and agriculture,

2nd priority

5) Space technology,
6) Information and communication technology,
7) Humanitarian and social sciences.

As a growing demand for alternative fuel sources in Egypt, chemical research division of the NRC has been studying the suitability and feasibility of Jatropha BDF with Egyptian Jatropha seeds with the collaboration with MALR for long time. At this moment, it has been trying more environmentally friendly refining process rather than conventional trans-etherification producing substantial amount of by products such as effluents and glycerides. NRC has been periodically published its achievement in international scientific journals. Based on the discussion with the representative researchers, the division will

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10 Chaired by the Prime Minister, Dr. Ahmed Nazif, attended by Ministers of MHE, MWRI, Military Production, MEE, International Cooperation, Economic Development, Communications, MALR, the Scientist Osama El-Baz, Head of the Scientific Research Academy and Head of the National Research Center.

continuously work on the improvement of the refining processing by NRC budget. The division has also used international grants and privates support for such technical improvement so far.

In addition to the NRC activities, Cairo University and Tsukuba University of Japan have started a five (5) year joint research program (2009-2014) supported by MHE and JICA. The objective of the program is effective use of water resources for agriculture, which is 2) and 4) of the prioritized fields of scientific development in Egypt mentioned previously. The study group focuses on high level water use in agriculture including effective irrigation measures, solution for accumulation of salinity, and agricultural wastewater use for edible and inedible crop cultivation. One of the study groups is focusing on the feasibility of the oil crop cultivation with agricultural wastewater applications. The efforts have just started during this JICA study, but the representative of the Cairo University and MHE is keen to extend its program to meet its study needs and other public and privates needs in commercially viable Jatropha biofuel supply chain development.

Intention for the Further Contribution

As the leading ministry to guide national strategy and support the national needs, MHE has shown keen interests to play the central role of the research and development in Jatropha biofuel industry development. Since the coordination for the relevant stakeholders and implementation of advanced research are the primary functions of the MHE, it has interests in coordination of key stakeholders, especially public sectors, and technical improvement throughout necessary institute in Egyptian.

6.10 Ministry of Water Resource and Irrigation

General Responsibility

http://www.mwri.gov.eg/En/index.htm

Ministry of Water Resource and Irrigation (MWRI) is responsible for any water resource management in Egypt. As water is one of the most important resources in Egypt, MWRI has played vital roles in Egypt to adequately settle the demands from all stakeholders and distribute the limited water resources.

Based on the MWRI's web page, its objectives are as follow:

- Formulate the water policies necessary for securing coverage of all the water requirements in agriculture, industry, drinking, navigation and power sectors as well as other consuming requirements.
- Maintain all the available water resources, rationalize its use, maximize its revenues and increase its efficiency by using state-of-the-art technologies in managing water of the Nile River, the

underground reservoir, rainfall, torrents and drainage water that is usable according to specific standards.

- Control distribution of irrigation water; establish, operate and maintain grand barrages and reservoirs and industrial works along the Nile River along with its branches, rayahat, canals, and irrigation and drainage networks.
- Improve and develop irrigation methods for the optimization of the available water resources
- Maintain water quality and protect water from pollution.
- Increase Egypt's share from the Nile water by cooperation and coordination with the Nile basin countries to establish joint projects to polarize and make use of the lost water.

In order to develop the long-term strategy for waster use in Egypt, MWRI has develop National Water Resources Plan-2017 (NWRP) with the collaboration of all relevant authorities. NWRP gives the present status of the nationwide water usage, problems and issues, and the proposal for solutions. The NWRP includes relevant policy decisions and measures that will be implemented. All stakeholders are involved in NWRP implementation, and careful planning and coordination were conducted. An implementation framework is developed to assign clear responsibilities for the implementation of the varied plans. It also includes the budgetary requirements for the implementation, including investments and recurrent costs.

Present Jurisdiction/Responsibility for Jatropha Biofuel Supply Chain and Related Activities

Though wastewater is a part of national water resources, MWRI has not gotten involved in any activities for Jatropha related activities. Since HCWW is responsible for management of wastewater is re in Egypt, MWRI has closely worked with MOH and HCWW to indirectly manage the wastewater resources.

Intention for the Further Contribution

MWIR's intention for the Jatropha related activities is not clear. As HCWW is responsible for the management of the wastewater in Egypt, MWIR may not directly get involved in the Jatropha related activities. However, considering the strategic distribution of water resources in Egypt, MWIR is the responsible ministry. Thus, MWIR may play significant role to develop a government's policies on large scale wastewater usage for Jatropha or other energy crop cultivation.

6.11 Important Authorities to be Involved in the Further Stage

Based on the discussion with previously mentioned authorities, Jatropha biofuel industry development widely involves many line ministries that are not currently involved but are likely to claim their involvement due to their jurisdiction and responsibility for some part of the biofuel industry activities. Because the biofuel industry development involves not only an industrial sector development but also large scale regional development, large scale land use, a large quantity of wastewater resource management and more, a powerful supervision is necessary to beyond the relevant government authorities. For such purpose, prime minister's office or a supreme level committee would be necessary to direct the political decision directly.

Prime minister's office has been aggressively working on Egyptian sustainable development with advanced strategies. Food, water and energy security strategies have been the three essential fields of concern. As the highest coordination committee on energy strategy, Supreme Council of Energy (SCE) has been playing central role to make the energy related policies for present and future concerns. SCE is chaired by Dr. Ahmed Nazif, Prime Minister, and comprised of the ministers of Defense, Finance, Petroleum, Electricity and Energy, Economic Development, Foreign Affairs, Environment, Investment, Trade and Industry, and Housing.

As population grew and living standards improved, growing demand for the energy became the serious concerns for Egyptian sustainable development. As the series of discussion under SCE, it has been seriously considering new and renewable energy use for the future strategy. Some government policies on wind and solar power have already been implemented to maximize the capacity development of renewable energy with the collaboration with privates. Since the growing demand for the fuels is another serious matter to be concern, SCE has been seeking for alternative fuels from new and renewable resources.

One of the taskforces concerning energy security measures under the SCE set six (6) potential measures to be specially focused for the long-term strategy as shown below. As the technical achievement of the focused measures vary, they are not the exclusive candidates. Its addressed measures would be changed in case of other reliable source availability or technically and economically non-competitive measures in the future.

- Improvement of energy efficiency (consumer side),
- Leverage of electricity sectors including infrastructure and management (supply side),
- Natural gas shifting,
- Adequate energy subsidies,
- Renewable energy (wind, solar, water) use for electricity,
- Alternative fuels including biofuels and GTL (gas to liquid).

Present Jurisdiction/Responsibility for Jatropha Biofuel Supply Chain and Related Activities

SCE has been discussing the feasibility of biofuel feed production by applying wastewater in desert area as the source of alternative fuel. At 8th and 10th meeting of SCE, minister of MOE and MOP had specifically reported the potentiality of biofuels and Jatropha biofuel feed production with the application of treated wastewater (news archive, cabinet web).

Another example of a presidential decree could be considered as a part of government's keen interest to accelerate the wastewater use for oil crop production recently.

- Presidential decree no. 387 of 2009 re-allocating area of 831 acres at Aswan for the establishment of sewage treatment plants and the farms therein, 16/12/2009

The detail information and present status of the presidential decrees on Aswan wastewater plant and farms are not clear. However, based on the discussion with HCWW officials for its affiliate Aswan company in December 2009, the Aswan company has been interested in Jatropha production with treated wastewater.

A part form energy related strategy, Jatropha and other oil crop production with treated wastewater has been continuously discussed in the central level. Discussion on Strategic Plan on Land Usages, on 3rd December 2007 is one of the examples. The meeting was chaired by The Prime Minister and attended by Ministers of MWRI, MOE, MOH, and Ministry of Tourism as well as Cairo Governor and Chairman of Lands Usages Center. The objective of the meeting was to discuss the future plan on land usages in the triangle locates in northern Ismailia desert road and locates between El-Oboor and 10th of Ramadan.

A report prepared by MOH suggested the development of such area should consider the shortage of enough water needed for "Traditional agriculture." For the solution for such water shortage, MOH recommend "Establishment of agricultural zone on 50,000 feddan in the above mentioned triangle to be irrigated by the sanitation treated water and planted using untraditional ways in the form of wooden and oil forest where oil will be used in energy and fuel process and not for the human usages."

The prime minster suggested concerned ministries (MALR, MOH and MOE) to set comprehensive plan to re-use the sanitation water for wooden and oil forests in nearby regions with limited fertility and water sources. He also called for the importance of studying the possibility of using agriculture wastes especially wastes of rice, sugarcane and cotton to extract some energy sources achieved by a scientific way.

6.12 International Agencies

6.1.1 Deutsche Gesellschaft für Technische Zusammenarbeit

General Responsibility

http://www.gtz.de/en/weltweit/maghreb-naher-osten/671.htm

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) has supported Egyptian development on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) since 1956.

Based on the formal agreement between the German and Egyptian governments, GTZ focuses on the following priority areas:

- Climate and environment
- Water resources and water management
- Participatory development programme in urban areas (Mubarak-Kohl Initiative)
- Promotion of women's rights in Egypt (Mubarak-Kohl Initiative)
- Vocational and technical training and employment programme (Mubarak-Kohl Initiative)

Due the germen government's policy, a memorandum of understanding between Egypt and Germany in the field of environment and clean energy was signed on 12 June, 2006. Primary objectives of the MOU are as follow:

- Contribution to a part of global efforts to improve the environment and global climate through the implementation of the Kyoto Protocol, particularly the aspect of trade in emissions of carbon dioxide
- Bilateral cooperation between Egypt and Germany in the field of electricity and energy, both in the field of traditional energy and increase the efficiency of conventional engines or in renewable energy such as hydropower, wind energy
- Creation of a Center for Renewable Energy in Egypt to serve the Middle East and North Africa
- Various sectors of the environmental protection regarding air pollution or adjust the positions of industry and benefit from German technology

As the incorporation of the Egypt-EU cooperation such as EU's southern and eastern neighboring policies and other relevant high level communications, GTZ has played key roles on the ground especially in the mentioned area of support.

Present Activities Related to Jatropha Biofuel Supply Chain Development

GTZ's activities on Jatropha biofuel supply chain development are not known. However, GTZ has been supporting HCWW's strategy on its economically viable operation. As a part of the income source, HCWW has working on the profitable use of wastewater and GTZ's assistance may have been addressed to develop such strategies. Some of the HCWW's documents clearly show the GTZ's support on HCWW's afforestation program with treated wastewater (ex. Figure. 6.4). In addition to support on the water resource management, GTZ has been deeply involved in the energy strategy in Egypt. Though the potentiality of the biofuel from the oil crops are relatively small effects compared to wind and solar power, Egyptian government has shown keen interests on Jatropha biofuel. Thus, GTZ may have supported such efforts from energy side as well.

Intention for the Further Contribution

In case of the serious request from the Egyptian government, GTZ is likely to support Jatropha biofuel industry development since German technologies are relatively competitive and reliable in Jatropha breeding researches as well as biofuel production.

6.1.2 The U.S. Agency for International Development

http://egypt.usaid.gov/Default.aspx?PageID=0

General Responsibility

The U.S. Government through the U.S. Agency for International Development (USAID) has significantly contributed to the quality of life of all Egyptians since 1975. Nationwide programs in health, education, trade facilitation, small and micro-enterprise, tourism, and infrastructure development have benefited Egyptians across the nation.

Ultimate goal of the USAID-Egypt is the development of a globally competitive economy that benefits Egyptians equitably. "Its programs aim to create private sector jobs and sustain human and natural resources by focusing on:

- Economic Growth (including environment, antiquities, and agriculture)
- Infrastructure (including water and wastewater, electric power, and telecommunications)
- Education (including basic and higher education)
- Health (including family planning and infectious disease surveillance and response)
- Democracy and Governance (including administration of justice and citizen participation)"

Present Activities Related to Jatropha Biofuel Supply Chain Development

Based on the discussion with EEAA officials, USAID granted the pilot Jatropha afforestation project in Luxor. The grant project has already completed and showed the technical and economical feasibility of the treated wastewater application for Jatropha cultivation. Though the study should be carefully reassessed by international experts on Jatropha plantation development, the promotion project has greatly contributed to the government's effort on effective wastewater management with economical view points.

Intention for the Further Contribution

As same as other international aid agencies, in case of the serious request from the Egyptian government, USAID is likely to support Jatropha biofuel industry development with relevant advanced technologies.

6.13 Private's Activities in Jatropha Supply Chain

Present Activities Related to Jatropha Biofuel Supply Chain Development

Although numbers of the international and Egyptian investors have shown keen interests in Jatropha investment for last several years, none of actual plantation has been developed by privates except Amiral group's advanced efforts in Suez. One of the Amiral's energy companies, Amiral energy, has been working on the Jatropha cultivation with close collaboration with Suez governorate. Due to the privates' business efforts to develop the profitable business model, details of its achievement is not disclosed. Based on the discussion with the Amiral's representative, it has reached certain level to move the industrial level plantation supposedly over 1,000 feddan plantation.

Intention for the Further Contribution

Amiral is seeking for a reliable partner to develop the large scale Jatropha plantations in Upper Egypt. Due to the confidentiality of the private businesses, its actual action plans are not know. However, as the pioneer and only experienced private working on the Jatropha plantation on the field, Amiral would be the highly potential candidate of the large scale plantation either public and privates' joint program or privates' investment projects.

7. Potential Use of Jatropha Biofuel in Egypt and Biofuel Standardization

7.1 Biofuel Standardization

7.1.1 Liquid biofuels that can be produced from Jatropha

Potentially, four kinds of liquid biofuel can be produced in Egypt from Jatropha. They are; PPO (Pure Plant Oil), BDF (Bio-Diesel Fuel), HVO (Hydrotreated Vegetable Oil) and Bio-Jet Fuel. PPO can be used either as a feedstock to produce BDF, HVO and Bio-jet Fuel or as a substitute of petroleum derived diesel fuel to run some sorts of old type diesel engines or modified diesel engines. Accordingly, PPO, BDF and HVO can be said as fuels for "Agricultural/Fishery Machines" and "Power Generators" as well as for "Road Vehicles". Bio-Jet Fuel is a fuel for "Aircraft".

7.1.2 Properties/production technology

1) PPO (Pure Plant Oil)

PPO is used relatively widely in some European countries, particularly, in Germany, Netherland and Iceland. In 2007, approximately 800,000ton of PPO was used in the entire EU regions.

PPO is sometimes called by other name, i.e. SVO (Straight Vegetable Oil), and can be produced from oil crops such as jatropha, rapeseed, palm, sunflower, etc. Its production technology is rather simple. First, growing oil crops and harvesting oil seeds, then crushing them to produce raw vegetable oil and filtering the final product to remove impurities. The neat oil thus produced can be used either as a diesel engine fuel or as a feedstock for producing BDF, HVO and Bio-Jet Fuel.

As to the use for diesel fuel, any warm diesel engine could be run satisfactorily on heated PPO. But, a difficult problem is to get engine started and continue to run it until it reaches operating temperature. To solve this problem, the most of existing diesel engines must be modified mechanically so that they could be run on PPO.

By its very nature, PPO has different properties than petroleum derived diesel fuel. As is shown in Figure.7.1, vegetable oil is consisted of so called "triglyceride ester". Chemically, triglyceride ester contains various types of three fatty acid chains. Fatty acid distribution differs depending upon the kinds of vegetable oil. Figure. 7.2 shows typical fatty acid distributions of four kinds of vegetable oils.

CH_2OCOR
$CHOCOR$
CH_2OCOR

Figure. 7.1 Triglyceride

Type of Fatty acid	Rapeseed Oil	Palm Oil	Sunflower Oil	Jatropha Oil
C16 C=C 0 (Palmitic)	2-7	39-47	5-8	15
C16 C=C 1 (Palmitoleic)	<0.5	< 0.5	<0.3	0.8
C18 C=C 0 (Stearic)	1-3	4-6	3-7	7
C18 C=C 1(Oleic)	51-80	36-44	14-40	43
C18 C=C 2 (Linoleic)	15-30	9-12	48-74	35
C18 C=C 3 (Linolenic)	2-16	<0.5	<0.3	
C20 C=C 0 (Eicosanic)	0.2-1.2	<1.0	0.1-0.5	0.2

Figure. 7.2 Typical Fatty Acid Distribution (wt%) of Vegetable Oil

From Figure. 7.2, we could know two basic facts. Firstly, the similarity of the property of rapeseed oil to that of jatropha oil. Secondly, the difference of property between palm oil and jatropha and rapeseed oil. As can be observed from Figure. 7.2, both rapeseed oil and jatropha oil contain heavier fatty acid chains with more C=C double bonds comparing to palm oil. The difference of fatty acid distribution of PPO is just the reasons why palm oil tends to be easily solidified at the higher temperature than jatropha and rapeseed oil. This difference of fatty acid distribution could also tell the reasons why jatropha and rapeseed oil are more easily oxidized when they are stored and exposed to air comparing to palm oil. At any rate, properties of PPOs are fully dependent upon the kinds of oil crops used.

The reasons of using PPO in such countries as Germany are due to; First, existence of PPO favored fuel taxation system. Second, existence of sufficient number of enterprises who could provide the customers with engine modification and warranty service. Third, existence of satisfactory PPO re-fuelling network system throughout the country.

PPO is regarded as CO2 neutral fuel. This means that PPO, like all other biofuels, do not emit CO2 much comparing to petroleum-derived diesel fuel even counting CO2 emission by well to wheel method. This may be the biggest advantage of using PPO as a substitute to conventional diesel oil .

2) BDF (Biodiesel Fuel)

BDF has been produced and used commonly in the EU since around 1990s. In the EU regions, in 2007, 6.1 Mtoe of BDF was consumed. Thus, BDF is an already commercially proven biofuel. BDF consisted of mainly fatty acid methyl ester, so it is frequently referred to as FAME. FAME is produced through transesterification of triglyceride. The reaction equation for BDF production is shown below in Figure. 7.3.

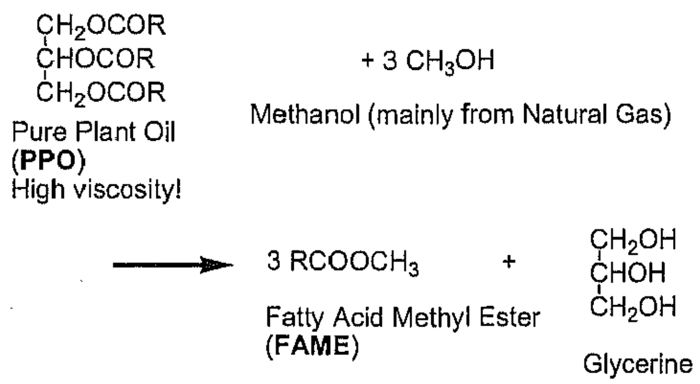


Figure. 7.3 Reaction equation of transesterification

As can be seen in Figure. 7.3, the triglyceride esters of vegetable oil are changed into methanol monoesters that have single fatty acid chains, which cause the lower viscosity comparing to that of PPO. Table. 7.1 shows comparison of properties of various oils including BDF. This table shows how PPO (in this case rapeseed oil) has high kinematic viscosity comparing to BDF, though BDF itself has a little bit higher viscosity than conventional diesel oil. Regarding the other properties, BDF is a little bit inferior to conventional diesel oil in terms of specific gravity, pour points and heating value, though flash point is the property BDF is superior to petroleum derived diesel oil. Generally speaking, FAME is GHG emission free fuel and is considered as environmentally safe, non-toxic and biodegradable fuel, which makes people believe that FAME is as a favorable substitute to petroleum-derived diesel oil.

Table. 7.1 Comparison of properties of BDF with other kind of oil

	Diesel Oil	Rapeseed Oil PPO	BDF(FAME)
Specific Gravity@15°C	0.84	0.92	0.88
Kinematic Viscocity cSt			
@30°C	3.5	50.8	5.6
@50°C	2.4	25.9	
Pour Point (°C)	-22.5	-17.5	-5.5
Flash Point (°C)	80	320	135-145
Heating Value (kcal/kg)	10,600	9,300	9,000

Surely, BDF is a superior from GHG emission point of view. However, it has some drawbacks. The following list shows the major problems that might be caused by the use of FAME.

✓Instability (stabilization additive needed)
✓Corrosion of metals
✓Swelling of plastics and rubbers
✓Compatibility with engine
✓Exhaust emissions (NOx increase)
✓Exhaust after-treatment devices
✓Fuel logistics (separate distribution)
✓Quality control costs
✓Low energy density

"Instability" is related to the property of FAME of easily oxidized tendency by exposure to air. If this occurs undesirable ingredient of free fatty acid is produced and as a consequence quality of FAME is seriously deteriorated. As to another item, "Exhaust after-treatment devices" means that if FAME is used with car equipped with exhaust emission control device, the catalyst of the device would be damaged, which would be resulted in dysfunction of device as emission control device. "Fuel logistics (separate distribution)" implies that if FAME is to be introduced to the market, a separate distribution pipelines, pump as well as storage tanks will be required so that FAME could be handled separately from conventional diesel oil. Thus, introduction of FAME to the market often requires extra investment cost for distribution infrastructure and subsequent oil quality control cost would be increased.

Because of these drawbacks, even though FAME is an abundantly used biofuel in the EU regions, many people predict that in the mid to long time future the second generation or third generation biodiesel including HVO will inevitably substitute FAME.

3) HVO (Hydrotreated Vegetable Oil)

Hydrotreating of vegetable oils is a highly sophisticated way of producing bio-based diesel oil. HVO is very high quality diesel oil, even more than petroleum derived diesel oil. HVO is a common name referred in the EU, though sometimes called as "Renewable Diesel Fuel". Because of its rather recent emergence in the world, HVO is sometimes called by different names in the different regions. For example, it is referred to as "Bio-Hydrofined Diesel or BHD" in Japan and "Non-Esterified Renewable Diesel or NERD" in the US.

Chemically, hydrotreated vegetable oil (HVO) is mixture of paraffinic hydrocarbons and is free of sulfur compounds and aromatics. Cold properties of HVO can be adjusted to meet the local requirements by adjusting the severity of the process or by additional catalytic processing. Cetane number is very high, and other properties are very similar to the diesel fuels produced by using Fischer-Tropsh(FT) synthesis technology (GTL and BTL).

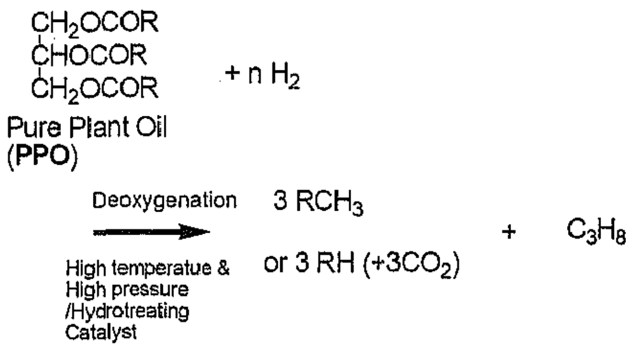


Figure. 7.4 Reaction Equation of Hydtotreating

Since HVO is basically hydrocarbons, it can meet conventional diesel fuel requirements specified in either EU diesel oil standard of EN 590 or US diesel oil standard of ASTM D 975. The FAME ester specifications of EN 14214 of EU or ASTM D 6751 do not apply for HVO.

Table. 7.2 shown below compares typical properties of HVO, EN 590:2004, GTL and FAME produced from rape seed oil. As can be observed from this table the properties of HVO are almost identical with those of GTL and can sufficiently meet with the requirements of EN 590 specifications. Great advantages of HVO over the petroleum-derived diesel oil is it has contains very low total and poly-aromatics with high Cetane number. Non-oxygen contents are an advantage over FAME. Meanwhile, FAME contains around 10 wt% of Oxygen, which may cause storage instability problem. Properties of high viscosity together, higher end concentration of distillation temperature range and low heating value are also regarded as disadvantages of FAME.

Table. 7.2 Comparison of Typical Properties of HVO, Petroleum Diesel, GTL and FAME

	HVO	EN 590 (summer grade)	GTL	FAME (from rape seed oil)
Density at 15 °C (kg/m^3)	775 ... 785	≈ 835	770 ... 785	≈ 885
Viscosity at 40 °C (mm^2/s)	2.5 ... 3.5	≈ 3.5	3.2 ... 4.5	≈ 4.5
Cetane number	≈ 80 ... 99	≈ 53	≈ 73 ... 81	≈ 51
Distillation range (°C)	≈ 180 ... 320	≈ 180 ... 360	≈ 190 ... 330	≈ 350 ... 370
Cloud point (°C)	-5 ... -25	≈ -5	-0 ... -25	≈ -5
Heating value, lower (MJ/kg)	≈ 44.0	≈ 42.7	≈ 43.0	≈ 37.5
Heating value, lower (MJ/l)	≈ 34.4	≈ 35.7	≈ 34.0	≈ 33.2
Total aromatics (wt-%)	0	≈ 30	0	0
Polyaromatics (wt-%)[1]	*0*	*≈ 4*	*0*	*0*
Oxygen content (wt-%)	0	0	0	≈ 11
Sulfur content (mg/kg)	< 10	< 10	< 10	< 10
Lubricity HFRR at 60 °C (µm)	< 460[2]	< 460[2]	< 460[2]	< 460
Storage stability	*Good*	*Good*	*Good*	*Very challenging*

(1) European definition including di- and tri+ -aromatics
(2) With lubricity additive

Another concern of FAME is higher NOX emission than conventional diesel oil. Again, with this respect, HVO performs very well. As is shown in Figure. 7.5, HVO (NExBTL in this chart) demonstrated substantial amounts of NOX emission reduction comparing to the conventional diesel oil.

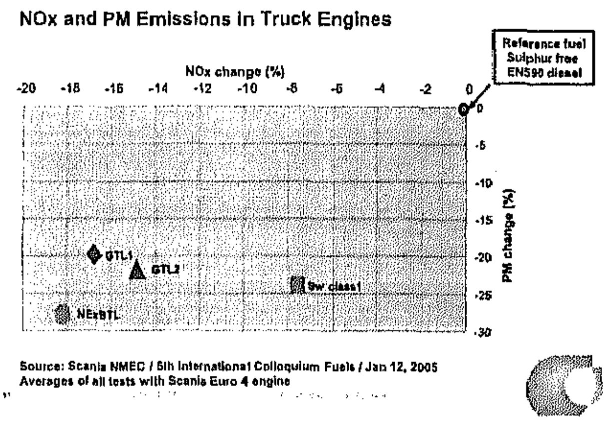


Figure. 7.5 NOX and PM Emission Performance of HVO

The quality of FAME is dependent fully upon the properties of the feedstock used. HVO, however, can be produced from many kinds of vegetable oils without compromising the fuel quality. Rapeseed, sunflower, soy bean as well as palm oil can be usable. However, as these feedstocks compete with food production, alternative non-food oil such as jatropha as well as algae oil are considered as favorable future feedstock.

Table. 7.3 compares three bio-diesel oil production technologies in terms of their advantages and disadvantages.

Table. 7.3 Pro and Con of Different Bio-based Diesel Production Technology

Large scale production	Process	Product	Feedstocks: Volume availability and price	Product quality	Production plant investments
≈ 1995 ...	Esterification	Biodiesel Ester FAME	-	-	+
2007 ...	Hydrotreating	Renewable diesel C_nH_{2n+2} HVO	+	+ + +	-
≈ 2015 ...	Gasification + Fischer-Tropsch	Renewable diesel C_nH_{2n+2} FT-BTL	+ + +	+ + +	- - -

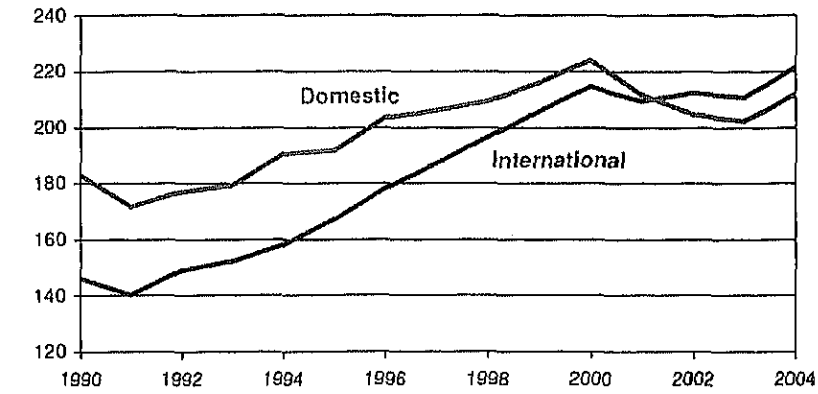
C_nH_{2n+2} is a general formula for paraffinic hydrocarbons. + sign indicates benefit, - sign indicates disadvantage

Regarding HVO production plant, so far, only Neste Oil Co. have constructed commercial scale HVO production facilities, though several HVO-units are under planning stage by oil companies around the world. The Neste's first commercial scale plant was constructed in 2007 at the Neste's Porvoo Oil Refinery Site in Finland. Its production capacity is 170,000 ton/year. Neste also has constructed the second plant of the same capacity again in Finland in 2009. Neste oil is now building two another world scale HVO production plants, one in Singapore and the other in Rotterdam. Each plants are capable of producing 800,000ton/year of HVO, and they will be completed in 2010 and 2011 respectively.

4) Bio-Jet Fuel

Bio-jet fuel is defined as a biomass-derived jet fuel that is compatible with existing aviation infrastructure and technologies. Bio-jet fuel is sometimes referred to as "Bio-SPK (Bio-Derived Synthetic Paraffinic Kerosene)", "HRJ (Hydrotreated Renewable Jer)" or "drop-in fuel" and will be used to replace conventional petroleum-based jet fuelst.

Bio-Jet Fuel and efficiency gains are the aviation industry's two greening promises, used to justify never ending aviation expansion in the face of growing public concern over climate change. According to the IPCC, aviation contributes 2% of the world CO2 emission. This may appears that aviation is a relatively small contributor to climate change. However, as can be observed from the Figure. 7.6 and Figure. 7.7, aviation's continued CO2 emission growth from the past to the future will never be allowed as a GHG emitter.



Source: UNFCCC (excludes the Russian Federation)

Figure. 7.6 CO2 Emission of Aviation (1990-2004)

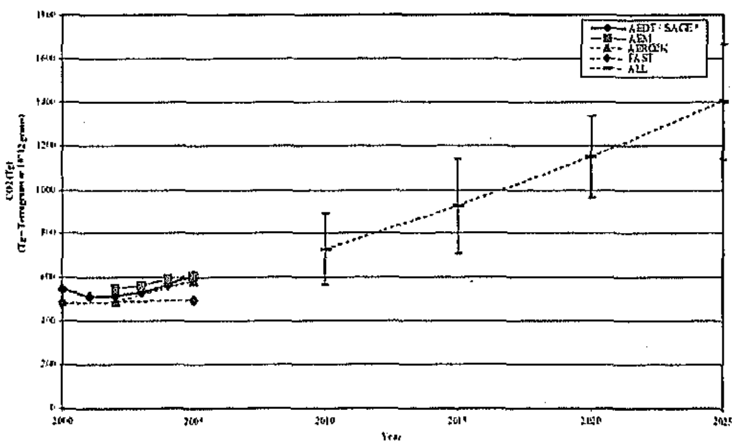


Figure. 7.7 Forecast of Total Aviation CO2 Emission (2005-2025)

Recognizing this in mind, airlines, aircraft manufacturers, OEM companies, government agencies as well as oil and biotech companies and venture capitalist have started to invest large sum of money into research and development of Bio-Jet Fuel. Key advantages of using Bio-Jet Fuel for aircraft are threefold. Firstly, Environmental benefits: sustainably produced Bio-Jet Fuel result in a substantial reduction in CO2 emissions across their lifecycle. Secondly, Diversified supply: Bio-Jet Fuel offers a viable alternative to fossil fuels and can substitute petroleum-derived jet fuel, with a more diverse geographical fuel supply through non-food crop sources. Thirdly, Economic and social benefits: sustainable Bio-Jet Fuel provides a solution to the price fluctuations related to fuel cost volatility facing aviation. Bio-Jet fuel can provide economic benefit to parts of the world, especially developing nations that have unviable land for food crops that is suitable for growing non-food oil crops.

As is shown in the Table. 7.4 below aircraft companies have already started test flight by using Bio-Jet Fuel. Because safety is the aviation industry's top priority, testing on potential new Bio-Jet fuel must be particularly rigorous. Troughs testing in laboratories, in equipment on the ground, and in the air, an exhaustive testing process even under the extreme conditions were carried out. As a result, their successful test flights in the last one to two years have clearly demonstrated that Bio-Jet Fuel is a technically viable fuel. Figure. 7.8 shows the test result of engine ground run by Air New Zealand. Interestingly, this result implies Jatropha-based Bio-SPK may perform even better than conventional jet fuel due to its higher energy density.

Table. 7.4 Bio-Jet Fuel Test Flight Summary by Boeing

Airline	Air New Zealand	Continental Airlines	Japan Airlines
Aircraft	Boeing 747-400	Boeing 737-800	Boeing 747-300
Engine	Rolls-Royce RB211-524G2-T	CFM International CFM56-7B	Pratt & Whitney JT9D-7R4G2
Plant Feedstock	50% jatropha	47.5% jatropha, 2.5% algae	42% camelina, 8% jatropha and algae
Fuel Provider for Test Flight	UOP	UOP	Nikki Universal/UOP
Flight Date	30 December 2008	7 January 2009	30 January 2009
Highlights of Engine Tests/ Ground Run Results	Sea level static steady state performance to compare fuel flow with heat of combustion. Accels and decels to compare transient operability characteristics.	Sea level static steady state calibrations and accels and decels to obtain engine performance, transient operability and emissions data for various blend percentages	Sea level static steady state performance, accels and decels to obtain engine operability and emissions data on Neste Oil provided paraffins (for ground engine test only).
Flight Test Summary and Objectives	Climb to FL 350, Mach 0.84 accels and decels, engine windmill restarts, starter-assisted engine relights, simulated missed approach, suction feed test	Climb to FL390, Mach 0.78, accels and decels, engine windmill restarts, starter-assisted engine relights, simulated missed approach, suction feed test	Climb to FL390, Mach 0.80, accels and decels, engine windmill restart, suction feed test. It was the only hydro-mechanical engine fuel control used for this series of flight tests.

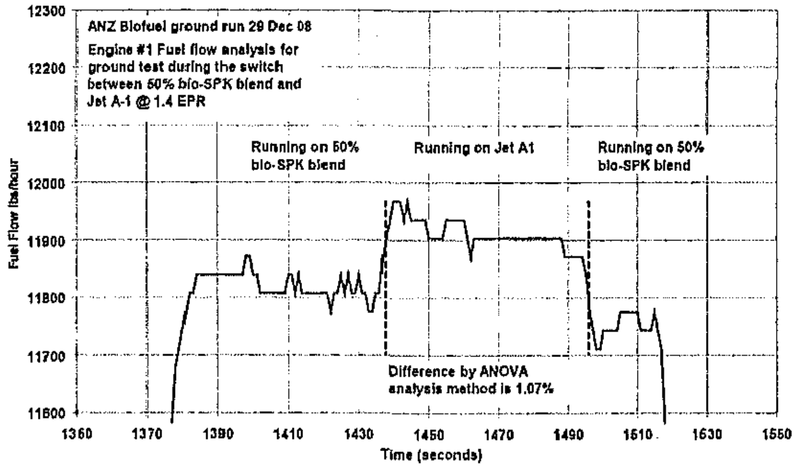


Figure. 7.8 Test Result of Engine Ground Run by ANG Boeing

Bio-Jet Fuel can be produced by applying the hydro processing technology, which is not very specific but rather commonly used in petroleum refineries around world. At present, no commercial scale bio-Jet Fuel production facilities are under operation, though not a few enterprises are considering to construct Bio-Jet Fuel production facilities. For example, Syntroleum, a US based company is said to have licensed its Bio-Synfining process to Dynamic Fuels, that is a 50/50 joint venture company between Syntroleum and

Tyson Foods. Dynamic Fuel is said to complete its first Bio-Jet Fuel production plant in 2010. Also, it is to be noted that UOP, a subsidiary of Honeywell Company, publicly announced that they are ready to offer licenses and basic engineering design packages to entities who are interested in producing Bio-Jet Fuel from PPO.

Figure. 7.9 below shows how UOP's "Renewable Jet Process" functions. First, bio-derived oils, i.e. PPO (triglyceride and free fatty acid), are cleaned to remove impurities using standard oil cleaning process. The oils are then converted to the shorter chain diesel range paraffins using UOP's Renewable Jet Process, which converts vegetable oils by removing oxygen molecules from the oils and converting any olefins to paraffins by reaction with hydrogen. The removal of the oxygen atoms raises the heat of combustion of the fuel and the removal of the olefins increases the thermal and stability of the fuel. A second reaction then isomerizes and cracks the diesel range paraffins, to paraffins with carbon numbers in the jet range. The end product is so called a Bio-SPK fuel that contains the same types of molecules that are typically found in conventional petroleum base jet fuel.

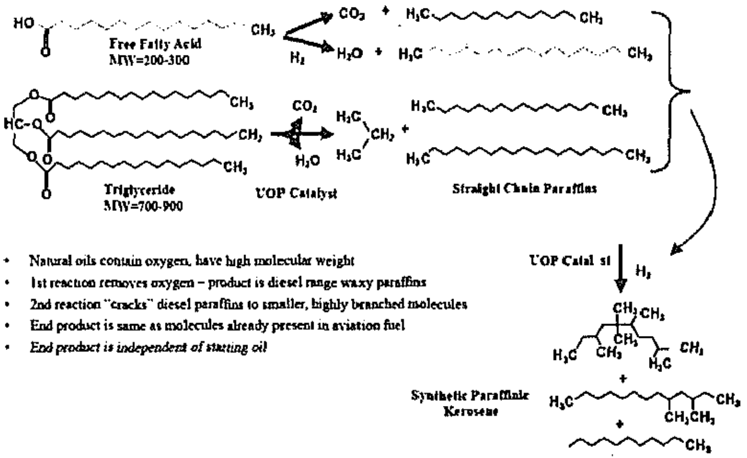


Figure. 7.9 Reaction Equation of Bio-Jet Fuel

Table.9.5 shown below compares properties of Bio-Jet Fuels produced from both Jatropha and Camelina to Jet A-1 fuel specification. Except density, all other properties completely satisfy the Jet A-1 specifications.

Table. 7.5 Properties of Jatropha and Camelina-based Bio-Jet fuel

Analysis of Renewable Jet Samples

Property	Jet A-1 Spec	Jatropha SPK	Camelina SPK
Flash point, °C	38 min	46	42
Freeze point, °C	-47	-57	-63.5
Net heat of combustion, MJ/kg)	42.8 min	44.3	44.1
JFTOT (2.5h at control temp, °C)	260 min	300	300
Filter pressure drop, mmHg	25 max	0	0
Tube deposits	<3	<1	<1
Distillation,			
10%	185 max	168.5	163
50%	report	186.0	183.5
End boiling point	340 max	248	242
Density, kg/m^3	775 - 840	749*	753*
Sulfur, ppm	-	<0.01	<0.01
Trace metals (each), ppm	-	<0.05	<0.05

* by definition SPK fuels have a lower density. However once blended with aromatics the final jet fuel meets the Jet A-1 density specification.

7.1.3 Standardization

Standards and specifications setting for quality assurance purpose are inevitable work to have biofuels to be used safely and efficiently in the society. Hereunder, we will describe the major standards and specifications adopted for PPO, BDF, HVO and Bio-Jet Fuel.

1) PPO (Pure Plant Oil)

As already mentioned earlier, PPO could be used as a substitute to diesel fuel. However, the countries where PPO is used as a diesel engine fuel in large amount are limited. Therefore, the countries which have PPO quality standard for diesel fuel use are also limited. Germany is supposed to be a sole country that have PPO quality standard for diesel fuel use. The Table. 7.6 shown below is German's PPO quality standard DIN V51605 adopted by DIN. When we use this standard we must be very cautious, since this standard is applicable only to rapeseed derived PPO. As we have already seen in previous section, properties of PPOs differ very much depending upon the fatty acid distribution of original oil crops.

Since no countries in the world have ever adopted Jatropha PPO quality standard for diesel oil use, if Egypt wishes to promote the use of Jatropha PPO as a diesel fuel, Egypt needs to develop its own Jatropha oil PPO Standard. Probably, good thing with Jatropha oil is its similarity to rapeseed oil.

Accordingly, German PPO standard for rapeseed oil could be used as a very good reference in making Jatropha oil PPO standard.

From practical point of view specifically important properties of PPO standard will be ;

- ✓ Kinetic viscosity
- ✓ Total contamination
- ✓ Acid value
- ✓ Oxidation stability
- ✓ Phosphorus content
- ✓ Water content

Table. 7.6 Rapeseed PPO Standard (DIN V 51605)

Property	Unit	Limit value		Test method[a]
		min.	max.	
Visual examination	—	Free of visible contamination, sediments and free water		—
Density at 15 °C[f]	kg/m³	*900,0*	*930,0*	DIN EN ISO 3675 or DIN EN ISO 12185
Flash point according to Pensky-Martens	°C	220	—	DIN EN ISO 2719
Kinematic viscosity at 40 °C	mm²/s	—	36,0	DIN EN ISO 3104
Net calorific value[b]	kJ/kg	36 000	—	DIN 51900-1, -2, -3
Ignition performance	—	39	—	See 5.5
Coke residue[c]	% *(m/m)*	—	0,40	DIN EN ISO 10370
Iodine value	g iodine/ 100 g	95	125	DIN EN 14111
Sulphur content	mg/kg		10	DIN EN ISO 20884 or DIN EN ISO 20846
Total contamination	mg/kg		24	DIN EN 12662
Acid value	mg KOH/g		2,0	DIN EN 14104
Oxidation stability[d] at 110 °C	h	6,0		DIN EN 14112
Phosphorous content	mg/kg		12[e]	DIN EN 14107
Sum of contents of magnesium and calcium	mg/kg		20	E DIN EN 14538
Ash content (oxide ash)	% *(m/m)*		*0,01*	*DIN EN ISO 6245*
Water content	% *(m/m)*		0,075	DIN EN ISO 12937

[a] See also 5 3
[b] Typical mean net calorific values serving as failure data on the market lie in the range of approximately 37 500 kJ/kg.
[c] The determination shall be carried out on the overall sample and not on the 10 % residue.
[d] Testing without the addition of any additives
[e] See also explanations in 5 6.2.
[f] For the density/temperature conversion, see 5 6.4.

2) BDF (Biodiesel Fuel)

Since BDF is mainly consisted of fatty acid methyl ester, its properties differ greatly from those of petroleum derived diesel oil, although both fuels can effectively be used as diesel engine fuel. One of the important differences between BDF and petroleum diesel oil is BDF contains oxygen atoms in its fatty acid methyl ester chain; meanwhile petroleum diesel oil does not in its hydrocarbon chain. It is just this difference which makes the quality standard of BDF differ so much from that of petroleum derived diesel oil. Table. 7.7 shows EU FAME standard, EU14214.

From Practicall point of view, particularly important properties of FAME Standard will be;

- ✓ FAME contents
- ✓ Kinetic viscosity
- ✓ Acid value
- ✓ Oxidation stability
- ✓ Phosphorus content
- ✓ Water content

Table. 7.7 EU FAME standard, EU14214

Property	Unit	Limits		Test method [a] (See Clause 2)
		minimum	maximum	
FAME content [b]	% (m/m)	96,5 [b]	-	EN 14103
Density at 15 °C [c]	kg/m³	860	900	EN ISO 3675 EN ISO 12185
Viscosity at 40 °C [d]	mm²/s	3,50	5,00	EN ISO 3104
Flash point	°C	101	-	EN ISO 2719 [e] EN ISO 3679 [f]
Sulfur content	mg/kg	-	10,0	EN ISO 20846 EN ISO 20884
Carbon residue (on 10 % distillation residue) [g]	% (m/m)	-	0,30	EN ISO 10370
Cetane number [h]	-	51,0	-	EN ISO 5165
Sulfated ash content	% (m/m)	-	0,02	ISO 3987
Water content	mg/kg	-	500	EN ISO 12937
Total contamination	mg/kg	-	24	EN 12662
Copper strip corrosion (3 h at 50 °C)	rating	class 1		EN ISO 2160
Oxidation stability, 110 °C	hours	6,0	-	prEN 15751 [i] EN 14112
Acid value	mg KOH/g	-	0,50	EN 14104
Iodine value	g iodine/100 g	-	120	EN 14111
Linolenic acid methyl ester	% (m/m)	-	12,0	EN 14103
Polyunsaturated (≥ 4 double bonds) methyl esters	% (m/m)	-	1	[j]
Methanol content	% (m/m)	-	0,20	EN 14110
Monoglyceride content	% (m/m)	-	0,80	EN 14105
Diglyceride content	% (m/m)	-	0,20	EN 14105
Triglyceride content [i]	% (m/m)	-	0,20	EN 14105
Free glycerol	% (m/m)	-	0,02	EN 14105 [i] EN 14106
Total glycerol	% (m/m)	-	0,25	EN 14105
Group I metals (Na+K) Group II metals (Ca+Mg)	mg/kg mg/kg	-	5,0 5,0	EN 14108 [k] EN 14109 EN 14538 EN 14538
Phosphorus content	mg/kg	-	4,0	EN 14107

[a] See 5.6.1

[b] The addition of non-FAME components other than additives is not allowed, see 5.2. When C17-methyl esters naturally appear in FAME this can result in a lower measured fatty acid methyl ester content. In this situation reference should be made for verification to a modified determination procedure [4], until a modified method is established within CEN

[c] Density may be measured by EN ISO 3675 over a range of temperatures from 20 °C to 60 °C. Temperature correction shall be made according to the formula given in Annex C. See also 5.6.2

[d] If CFPP is -20 °C or lower, the viscosity shall be measured at -20 °C. The measured value shall not exceed 48 mm²/s. In this case, EN ISO 3104 is applicable without the precision data owing to non-Newtonian behaviour in a two phase system

[e] Procedure A to be applied. Only a flash point test apparatus equipped with a suitable detection device (thermal or ionization detection) shall be used. See also 5.6.2.

[f] A 2 ml sample and apparatus equipped with a thermal detection device shall be used

[g] ASTM D 1160 shall be used to obtain the 10 % distillation residue. See also 5.3.4.

[h] See 5.6.3

[i] See 5.6.2

[j] A suitable test method is under development by CEN [3]

[k] See 5.6.2. See Annex A for precision data for sum of Na + K

EU's FAME standard EN14214 is not a sole standard adopted in the world. Different regions and courtiers adopted different quality standard depending upon the regional situations and conditions. Table. 7.8 compares FAME standard between Japan and USA. Interestingly, Japanese standard is much stricter than US standard.

Table. 7.8 Differences of FAME Standard between Japan and USA

	Japan for B5 FAME JIS K 2390	USA for B6-B20 FAAE ASTM D-6715-07b
Ester mass%	min.96.5	NA
Viscosity, mm^2/s	3.5-5.0	1.9-6.0
Sulfur content, mg/kg	max. 10	max. 15
Cetane number	min. 51	min. 47
Acid value, mg KOH/g	max. 0.50	max. 0.50
Iodine value, g-iodine/100 g	max. 120	NA
Linoleic acid ME, mass%	max. 12.0	NA
Methanol, mass%	max. 0.20	max. 0.20
Monoglyceride, mass%	max. 0.80	NA
Diglyceride, mass%	max. 0.20	NA
Triglyceride, mass%	max. 0.20	NA
Total glycerine, mass%	max. 0.25	max. 0.25
Na+K, mg/kg	max. 5.0	max. 5.0
Ca+Mg, mg/kg	max. 5.0	max. 5.0
Phosphorus	max. 10.0	max. 10.0

As to FAME, 100% FAME, which is called neat BDF, is not officially permitted to use. Instead, in most of the courtiers where BDF is used, governments very often decide maximum allowable contents of FAME in the petroleum derived diesel oil. In the case of the EU B5, that is 5% blend of FAME into conventional diesel oil, was the maximum contents allowed by the old EU Directive. But, in 2009 regulation was revised and now up to 7% FAME blending, namely B7 is allowed. In the case of Japan, B5 is allowed, meanwhile in the USA, up to 20% FAME blending, namely B20 fuel is allowed to use by the government regulation.

3) HVO (Hydrotreated Vegetable Oil)

There is no specific quality standard applicable for HVO in the world. This is because HVO has very high quality, even more than petroleum derived diesel oil. Therefore, it would not be necessary to make any other standard than the conventional diesel oil standard In fact, the EU Directive 2009/28/EC allows HVO to blend with conventional diesel oil at any ratio up to 100%.

4) Bio-Jet Fuel

Historically, aircraft turbine engines have been certified to operate on conventional petroleum-derived jet fuel meeting specifications ASTM D1655 or DEF STAN91-91. Over the almost 50 years since the introduction of turbine engines, this fuel has been a constant. However, the development of alternative aviation fuels, such as Bio-Jet Fuel, has necessitated the development of an industry qualification process to ensure these new fuels perform in an essentially identical manner as conventional jet fuels. On

September 2009, the American Society of Testing and Materials (ASTM) International approved the world's first semi-synthetic aviation fuel specification. This specification D7566, entitled "Standard Specification for Aviation Turbine Fuels Containing Synthesized Hydrocarbons", is accepted as a significant milestone towards the aviation industry's goal of the broad use of synthetic jet fuels in the commercial aviation world.

Table. 7.9 indicates how semi-synthetic aviation fuels produced by UOP by blending 50% of Jet A or Jet A-1 fuel with HRJ produced from PPO could almost satisfactorily meet with Jet A/Jet A-1 fuel specifications (that is ASTM D1655 requirements).

Table. 7.9 Jet A/Jet A-1 Specifications vs HRJ fuels Specifications

Property		Jet A / Jet A-1	ANZ	CAL	JAL	ASTM Test Method
Mixture of Jet A or Jet A-1 // SPK is in Volume % Blended with			50 Jet A-1	50 Jet A	50 Jet A	
		Part 1: Basic Requirements				
COMPOSITION						
Acidity, total mg KOH/g	Max	0.10	0.002	0.001	0.002	D3242
Aromatics: one of the following requirements shall be met						
1. Aromatics, volume %	Max	25	8.8	9.2	8.9	D1319
2. Aromatics, volume %	Max	26.5	N/A	N/A	N/A	D6379
Sulfur, mercaptan, [c] mass %	Max	0.003	0.0004	<0.0001	0.0003	D3227
Sulfur, total mass %	Max	0.30	<0.015	<0.0001	0.0403	D1266, D2622, D4294 or D5453
VOLATILITY						
Distillation:						
Distillation temperature, °C:						D2887 or D86
10 % recovered, temperature (T10)	Max	205	170.4	170.5	171.0	
50 % recovered, temperature (T50)		report	190.3	194.0	200.5	
90 % recovered, temperature (T90)		report	226.9	228.0	240.0	
Final boiling point, temperature	Max	300	246.8	248.5	258.0	
Distillation residue, %	Max	1.5	1.2	1.2	1.2	
Distillation loss, %	Max	1.5	0.4	0.2	0.2	
Flash point, °C	Min	38	45.0	45.0	44.5	D56 or D3828
Density at 15°C, kg/m³		775 to 840	779	780	789	D1298 or D4052
FLUIDITY						
Freezing point, °C	Max	−40 Jet A −47 Jet A-1	-62.5	-61.0	-55.5	D5972, D7153, D7154 or D2386
Viscosity −20°C, mm²/s	Max	8.0	3.606	3.817	4.305	D445
COMBUSTION						
Net heat of combustion, MJ/kg	Min	42.8	43.6	43.7	43.5	D4529, D3338 or D4809
One of the following requirements shall be met:						
(1) Smoke point, mm, or	Min	25	33			D1322
(2) Smoke point, mm, and	Min	18		27.7	28.6	D1322
Naphthalenes, volume, %	Max	3.0	N/A	0.2	1.2	D1840
CORROSION						
Copper strip, 2 h at 100°C	Max	No 1	1A	1A	1A	D130
THERMAL STABILITY						
JFTOT (2.5 h at control temperature)						
Temperature, °C	Min	260	300	300	300	D3241
Filter pressure drop, mm Hg	Max	25	3.0	0.0	0.2	
Tube deposits less than		3	1.0	1.0	1.0	
		No Peacock or Abnormal Color Deposits				
CONTAMINANTS						
Existent gum, mg/100 mL	Max	7	1.0	<1	<1	D381, IP 540
Microseparometer, Rating						D3948
Without electrical conductivity additive	Min	85				
With electrical conductivity additive	Min	70				
ADDITIVES		See 6.3				
Electrical conductivity, pS/m			123.0	<1	<1	D2624
		Part 2: Extended Requirements				
COMPOSITION						
Aromatics: one of the following requirements shall be met						
1. Aromatics, volume %	Min	8	8.8	9.2	8.9	D1319
2. Aromatics, volume %	Min	8.4	N/A	N/A	N/A	D6379
Distillation:						D2887 or D86
T50-T10, °C:	Min	15	19.9	23.5	29.5	
T90-T10, °C:	Min	40	56.5	57.5	69	
Lubricity, mm	Max	0.85	0.64	0.65	0.66	D5001

Jet A and Jet A-1 denote the following. Jet A is a kerosene type jet fuel that meets ASTM D1655 specification and is supplied at civil airports throughout the USA and in parts of Canada. While, Jet A-1 is also a kerosene type jet fuel that meet the same ASTM specifications but is supplied broadly outside of

North America. Both fuels are very similar but Jet A-1 has to meet more stringent requirements than Jet A. For example, max. freezing point for Jet A is -40℃ but it is -47℃ for Jet A-1.

As is mentioned earlier, Boeing together with some airline companies conducted several successful flight tests using Bio-Jet Fuel. Following the success of these flight trials, Bio-Jet Fuel is needed to be certified as a safe and appropriate aviation fuel for commercial use. The aviation industry is now working closely with fuel specification bodies, such as the American Society for Testing and Materials (ASTM) International and the UK's Defense Standard Agency. The approval process looks at a minimum of 11 key properties, including energy density, freezing point, appearance, volatility, fluidity and many other characteristics that would make it fit for aviation use. Currently, Certification for 50/50 blend of HRJ with JetA-1 fuel is expected to be issued in 2010, and certification for 100% HRJ fuel will be ready during 2013.

7.2 Practical Usage of Jatropha Biofuels

As described in the biofuel standardization in section 9.1, maturity of the biofuel production technologies vary, but such standardization secure the safety use of those biofuels for "Conventional" power sources. As long as a biofuel product meets those standards, usage of such fuel does not make significant difference compared to the conventional combustion. In order to meet the voluntary or mandatory needs for low co^2 emission fuels most of the described fuels are practically/commercially distributed in some countries where the governments set advanced policies on biofuel supply chain development and usage.

Since Jatropha biofuel is not commercially available on the market in any country at this moment, this section briefly describes the most likely applicable use of Jatropha biofuels based on similar property biofuel applications.

Road Vehicles, Locomotives and Ships

BDF would be the most common application of the Jatropha biofuel for diesel cars. Not only EU but also the United States have been continuously expanding the sales of the BDF through the conventional fuel stands. There are some known issues for BDF application as described previously, but such issues have been also proven to be avoided with lower concentration of BDF in the conventional diesel fuel. Even some BDFs have been applied with 100% base. However, the supply capacity is basically too small for the conventional diesel use. As a result, diesel fuel with low BDF mixture (2-5%) fuels have been typically consumed without significant issues.

Synthetic diesel fuels from vegetable oil known as HVO, BHD or NERD, are not widely available on the market at this moment. However, it has been recognized as 100% compatible fuel for any diesel fuel application reportedly so that it would be seamlessly distributed in the market once they are commercially available.

PPO has been commercially available in selected EU countries where rapeseed oil is competitively available such as Netherlands. Due to the higher viscosity of the PPO, it is not quite suitable for fast engines such as smaller passenger cars having the rotation speed above 2,000rpm. There are some company providing advanced technologies to modify the fuel system or physical modification such as cylinders and fuel injection to adapt PPO even for fast rotation engines. Though not all technologies are practically reliable, some technologies, especially physical modification, have been widely accepted by not only residential users but also commercial truck companies. Due to the limited availability of the PPO on the market, none of the major car and truck makers produce PPO adapted cars or trucks.

Power Generator

Though application of BDF for power generators is much suitable compared to road vehicles due to stable and slower rotation of power unites, it is not widely applied simply due to the economical reasons. Except the special cases, electric generation environment is generally competitive where BDF or PPO is available. Most of the case, heavy fuel oil (HFO) is cheaper than conventional diesel, BDF or PPO so that BDF and PPO are not the fuel option in general. In terms of the technical feasibility, BDF is mostly capable without any mixing limits reportedly. For the PPO application, typical modification similar to the modification of HFO engines for diesel units are required. Some major generator companies such as Wartsila (Finland) have produced PPO generators and officially supported the maintenance and operation.

In case of the following circumstances, BDF or PPO application would be applicable:

- High cost of electricity generation typically fuel combustion and small units
- High cost of transmission line development
- High cost of electricity transmission due to loss
- Availability of competitive BDF or PPO supply

It is typically applicable for rural electrification. A successful Jatropha PPO generation project can be seen in India.

Aircraft

Synthetic bio-jet fuels known as Bio-SPK or HRJ has been tested in the limited test environment. Based on the referred information in section 9.1, those bio jet fuels are almost identical and no modification is required for the jet engines. Since there are no bio-jet fuel standards available at this moment, BIO-SPK and HRJ can be only applicable under the conventional jet fuel standard, which limit the concentration of the bio-jet fuel. However, after the approval of the bio-jet fuel standards, such fuels might be applicable 100% mixture basis. However, as similar to the BDF, the demand is much higher than supply capacity low rate mixture fuels are likely to be available in the near future.

CHAPTER III
Cost Analysis of Egyptian Model

III. Cost Analysis of Egyptian Model

8. Basis of the Cost Analysis and Basic Assumptions

In order to analyze the financial feasibility of the Egyptian Jatropha biofuel supply chain development, updated information with conservative assumptions, which are not available at this moment, are collected. Based on the commercial BDF supply chain business models in EU, biofuel producers are technically and financially feasible unless they could access to the "Competitive biofuel feeds." In other words, if biofuel feed producers can supply LOW COST feeds, whole biofuel supply chain become feasible.

Because the biofuel feed price was not competitive enough to compete fossil fuels in early 2000's, some advanced EU centuries put subsidies to make the biofuel feed competitive in order to meet EU's biofuel policy and attract private investments into the biofuel sectors. As the result of the favorable investment condition, such countries have successfully developed the certain BDF supply capacities. Recently, some of such countries decided to cut such favorable subsidies due to the feasibility of such businesses and emergency needs for global recession.

Since heavily applied subsidies in many sectors in Egypt have been pointed by international aid agencies, government of Egypt has been actively working on the adequate distribution of the national budget. Under such circumstances, dependency of the government subsidies for Jatropha biofuel supply chain development in Egypt will not favorable environment for private investors as well as policy makers. Thus, we did not consider any governmental subsidies for this financial analysis.

In general, biofuel feed is not competitive enough as widely distributed conventional fuels without subsidies. It is challenging for Egyptian Jatropha biofuel model without such financial support. In order to make the Egyptian model feasible, we focused on RELIABLE jet fuel rather than diesel fuel for road vehicles and industrial needs due to the aviation sectors' mandate needs and their limited options to operate the aircrafts as described in section 2. Unlike road vehicles, jet fuel is the only option for aircraft operators with available technologies. Thus, we assumed that Jatropha bio jet fuel has exclusive competitiveness against conventional jet fuel to reduce green house gas, which is able to add values of GHG reduction, widely known as "Carbon credits."

Though the synthetic bio-jet fuel technologies are still ongoing process of commercialization, it is likely to reach commercially competitive level as similar technologies as other conventional hydro refining technologies for conventional fuels. As mentioned previously, biofuel production sectors is likely to become feasible if it is accessible to the "Competitive biofuel feed." Due to the difficulty of the stable and competitive Jatropha seed supply in Asia and African cases, none of commercial BDF producers is able to operate their facilities with Jatropha.

Therefore, in order to simplify the feasibility of the Egyptian Jatropha biofuel supply chain model, we analyze the financial feasibility of Jatropha plantation only. Though we only analyzed the Jatropha plantation model, we also consider the cost and feasibility of the biofuel producers and acceptable bio-jet fuel pricing to lead the realistic value of the Jatropha seeds. Followings are the basic assumptions for commercial scale plantation in 2020.

Table. 8.1 Basic Assumptions for Commercial Scale Plantation in 2020

Item	Value	Remarks
Initial year	2020	With technical improvement and policy development as well as the commercially viable price of crude oil price
Project Life	15 year	Considering internal rate of return (IRR) for 15years
Size of the Plantation	1,000 feddan (400ha)	Due to the MALR's experiences, 1,000 feddan would be the minimum scale of the plantation to cost effectively develop the plantation 1 ha = 2.5 feddan
Seed Productivity	0.92 t/feddan-y (2.3t/ha-y)	Present Luxor level, without high yield breading
Jatropha Trees	460 tree/feddan (1,150 tree/ha)	Luxor practices (3m x 3m)
Oil Recovery Rate (ORR)	20%	Percentage of recoverable/convertable weight of Jatropha oil: presently 20% at Luxor with mechanical oil extraction
Land Lease	100 LE/feddan-y (US$45/ha-y)	Symbolic price for reference purpose US$1 = 5.5 LE
Treated Wastewater	2.0 LE/m^3 (US$0.4/ m^3)	Assumed HCWW's operation cost (HCWW)
Cooperate Tax	0%	20y exemption, due to Law No. 8 of Investment Incentives, renewable energy or Upper Egypt development related project shall be applicable
Jatropha vegetable Oil Price in 2020	3,438 LE/t (US$625/t)	Price of biofuel feeds for refinery = Value of extracted vegetable oil price including Jatropha oil + CO_2 premium (see, section 3.2)
Jatropha Seed Sales	550 LE/t (US$100/t)	80%* of Jatropha vegetable oil price x ORR(20%) * 100 - 80% = 20% profits is typically feasible for oil extraction business
Initial cost of Plantation	2,780 LE/feddan (US$1,264/t)	Estimated cost of existing project including Pump House, Pump and Filter (500 m3 / h to head of 65m , rotation 1500 R/m x 2), Outlet Line from Pump (200mm x 2), Main Outlet Line (500mm x 1), Inlet Line

Item	Value	Remarks
		from Balance Pond/Water Treatment Station, Ground Preparation for Plantation, Seedling, Man Power for Plantation Development, Drip Irrigation Piling, Miscellaneous
O&M cost of Plantation	991 LE/Feddan-y (US$405/ha-y)	Actual cost by MALR including Workers-permanent, Workers-seasonal, Utility-power, Utility - potable water, Transportation for workers, Miscellaneous/Replace

9. Internal Rate of Return

In order to analyze the financial feasibility of the Jatropha plantation project, we calculated the internal rate of return (IRR), a commonly used cash flow analysis to clarify whether a project is profitable enough compared to a conservative interest benchmarks such as long-term public interest rates. Theoretically, it is worth to invest if the IRR is higher than such benchmarks. In general, the bench mark is higher in developing countries and lower in developed countries. However, the bench marks are commonly set between 10 and 20 depending on the countries' situation. In Egypt case, based on the discussion with private business representatives, benchmarks would be between 15 and 20% depending on the type of the project and location, etc. If the risk of a project is lower, the benchmark is also lower. For the Jatropha plantation, there are few good practices so that it would be considered as higher risk project. Since the IRR does not consider the cost of borrowing money and inflation to exclude the uncertainties, the actual profits are usually lower than IRR cash flows. Thus, we consider 20% as the bench mark of Egyptian Jatropha biofuel plantation project.

9.1 Cash Out

Initial Investment

Based on the latest afforestation projects by MALR/EA, expected costs for initial investment are calculated as follow:

Item	LE/feddan	US$/ha
Pump House	130	59
Pump and Filter (500 m3 / h to head of 65m , rotation 1500 R/m x 2)	300	136
Outlet Line from Pump (200mm x 2)	10	5
Main Outlet Line (500mm x 1)	100	45
Inlet Line from Balance Pond/Water Treatment Station	10	5
Ground Preparation for Plantation	500	227
Seedling	100	45
Man Power for Plantation Development	100	45
Drip Irrigation Piling	1,500	682
Miscellaneous	30	14
Base Cost	2,780	1,264

Source: MALR/EA

Operation and Management

Based on the latest afforestation projects by MALR/EA, expected costs for initial investment are calculated as follow:

Based on the latest afforestation projects by MALR/EA, expected costs for initial investment are calculated as follow:

Item	1,000LE/y	1,000US$/y
Workers - permanent	300	91
Workers - harvesting	400	73
Utility - power	80	15
Utility - potable water	4	1
Transportation for worker	107	19
Miscellaneous/Replace	100	45
Base Cost	991	180

Source: MALR/EA

Cost of Treated Wastewater

Based on the discussion with HCWW officials, the actual cost for the water treatment excluding investment costs would be 2.0 LE/m^3 with recent mechanical treatment. In the case of lagoon type treatment, it would be 25-50% less cost than the mechanical treatment. Even by HCWW officials, it is hardly to tell the price of the treated wastewater for sale at this moment. Therefore, we set 2.0 LE/m^3 as the reference price for the base case.

Cost of Land Lease

Based on the discussion with MALR officials, price of the farmland has increased unpredictable level. The range is 10 to 100 times higher than original price in the past. In some case the price is even several hundred times higher. As same as other countries, the price of the farm land is defined based on the profitability of the land. If the Nile is accessible, the price is very expensive and Jatropha is not profitable enough to use such land. It is actually prohibited to cultivate woods or Jatropha in such farmland with Nile river water to secure the food production. If the ground water is accessible, price is also expensive and not low enough for Jatropha cultivation.

Based on the MALR's opinion, a project serving national needs like Jatropha biofuel supply, the price of the land should be free. Historically in such case, government sets "Symbolic price" such as 100 LE/feddan. As same as wastewater price, it is hardly to determine the price of land at this moment. We set the land lease price as 100 LE/feddan-y for the base case.

Total Cost (1,000 LE)

Project Year	2020	2021	2022-34
Total Cost	**4,202**	**1,422**	**1,422**
Initial Investment	2,780	0	0
Plantation O&M	991	991	991
Treated Wastewater	331	331	331
Land Lease	100	100	100

9.2 Cash In

Seed Production

Based on the Luxor and other plantations' experience it takes at least 3 years to mature the commercially productive level, we assumed the average productivities of one Jatropha tree as follow.

Project Year	Year 1	Year 2	Year 3	Year 4-15
Seed Productivities (kg/tree)	0	1	2	2
Seed Productivities (ton/feddan)	0	0.46	0.92	0.92
Seed Productivities (ton/ha)	0	1.2	2.3	2.3

Seed Sales

Seed sales is the only cash in for this simplified analysis. Sales price of the Jatropha seed in 2020 would be 550 LE/t (US$100/t) so that the expected income would be as follow

Cash In

Project Year	2020	2021	2022	2023-34
Cash In (1,000 LE/y)	**0**	**253**	**506**	**506**
Seed Sales (1,000 LE/y)	0	253	506	506
Seed Sales (1,000 US$/y)	(0)	(115)	(230)	(230)

9.3 Cash Flow and IRR

Cash Flow/Balance

Since the cash-out is higher than cash-in, this project is clearly impossible as a private investment projects. It may not be sustainable level even if it is a public afforestation project. Due to the negative cash flow, IRR is not possible to calculate. If the economical benefits such as anti-desertification exceeds the economical loss, it would be beneficial as a public project. In order to make the project financially feasible, reduction of cash out, increase of cash in or both reduction of cash out and increase of cash in are required.

Table. 9.1 Cash Flow of the Base Case with Existing Condition

Project Year	Year 1	Year 2	Year 3	Year 4-15
Cash Flow/Balance	**-4,202**	**-1,169**	**-916**	**-916**
Cash Out	4,202	1,422	1,422	1,422
Cash In	0	253	506	506

10. Sensitive Analysis

In order to examine how the Jatropha plantation project becomes financially feasible, we have tested some assumed condition with conservative manners, which is likely to be achieved based on historical record of technical improvement or conventional business development.

10.1 Option 1: Basic condition

Balance will be negative for the whole project period

10.2 Option 2: Increase Seed Productivities with Existing High Yield Breed

Though the productivities of the Luxor case is relatively higher compared to the other Asia and African cases, it is not high enough for the high initial investment and operation and management cost (O&M). Based on the discussion with MALR officials, most of the Jatropha plantations in Egypt applied seeds or seedling from Luxor. The original source of Luxor seeds are a wild breed from India. Due to the excessive interests of Jatropha, many national or private research group have been working on high yield breed development. There are some higher productive seeds available on the markets so that we examine the IRR with higher yields. This scenario also improve the seed productivities by putting more Jatropha trees, which is widely used in Asian countries. In addition, OER is also increased due to the commonly experienced OERs in the countries where the higher breed is developed.

Followings are the modified assumptions for option 2.

Item	Value	Remarks
Seed Productivity	2.6 t/feddan-y (6.5t/ha-y)	Existing high yield breed level, the results of recent efforts on conventional high yield breading
Jatropha Trees	512 tree/feddan (1,280 tree/ha)	Asian practices for higher yield (3m x 2.5m)
ORR	25%	Typical ORR in Asia and African cases

With the above improved condition, cash flow turns positive after project year 5 due to the maturity of the Jatropha tree (Table. 10.1).

Table. 10.1 Cash Flow of the High Yield Breed Application - Option 2

Project Year	Year 1	Year 2	Year 3	Year 4	Year5	Year 6-15
Cash Flow/Balance	**-4,240**	**-1,108**	**-756**	**-52**	**300**	**300**
Cash Out	4,240	1,460	1,460	1,460	1,460	1,460
Cash In	0	352	704	1,408	1,760	1,760

Despite the positive cash flow after year 5, IRR reaches only negative meaning too little profits for the initial investments. Table. 10.2 shows the sensitivity of the seed sales (cash in) and cost (cash out). The reddish-hatching area represents the IRR above 20%, which may be the bottom line for the privates' consideration. The central column represents the IRR of the option 2 (-6.8%), which is far from the consideration of privates' investment projects. The left column next to the central column (#DIV/0!) represents the case of 10% reduction (90% of the expected cash in) of cash in. On the other hand, right column represents the 10% increase of the cash in (-1.4%). As same manner as seed sales, one above column represents 10% increase of the initial and O&M costs (#DIV/0!) while one below column represents the 10% reduction of the costs (-0.9%). Each sensitivity examined from 50% reduction (50% of the expected number) to 50% increase (150% of the expected number).

Based on the sensitivity analysis table below, cost is rather higher sensitivity than seed sales, which is favorable business model for project owner. Since the seed sales is likely to fluctuate by the external factors such as seasonal pricing or international energy prices, it is a favorable business model to develop a moderate or minimal sensitivity for the seed sales. On the other hand, the cost is relatively smaller possibility of fluctuation so that it is easier to stabilize the cash out and IRR.

Table. 10.2 Sensitive Analysis of the Seed Sales Price and Cost for Option 2

		Seed Sales	688 LE/t									
	-6.8%	50%	60%	70%	80%	90%	100%	110%	120%	130%	140%	150%
	150%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#NUM!	-6.8%
	140%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#NUM!	-6.8%	-2.7%
	130%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#NUM!	-6.8%	-2.5%	1.0%
	120%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-6.8%	-2.2%	1.5%	4.6%
	110%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-6.8%	-1.8%	2.1%	5.4%	8.3%
Cost	100%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-6.8%	-1.4%	2.8%	6.3%	9.4%	12.2%
Initial Investment 12780.000LE	90%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-6.8%	-0.9%	3.6%	7.4%	10.7%	13.6%	16.4%
Annual Cost 1460.000LE	80%	#DIV/0!	#DIV/0!	#DIV/0!	-6.8%	-0.2%	4.6%	8.6%	12.2%	15.4%	18.3%	21.0%
	70%	#DIV/0!	#DIV/0!	-6.8%	0.5%	5.8%	10.2%	14.0%	17.5%	20.7%	23.6%	26.4%
	60%	#DIV/0!	-6.8%	1.5%	7.4%	12.2%	16.4%	20.1%	23.6%	26.9%	30.0%	33.0%
	50%	-6.8%	2.8%	9.4%	14.7%	19.4%	23.6%	27.5%	31.2%	34.7%	38.0%	41.2%

10.3 Option 3: Further Improved Seed Productivities (New Breed)

The option 2 clearly shows the cash in level is not good enough to make the project feasible. We assumed the technological approach to further improve the existing high yield breed with conventional breeding technique or modern genetic science technique later on. In order to apply further high yield breeds, it is necessary to make some extensive efforts to create a new breed in Egypt. Based on conventional agro industries' records, most of the productivities have reached at least several times higher than original productivities. Especially profitable business cases, the productivities reach 5 to 7 times higher than the original breed recently. In order to analyze the feasibility in conservative manner, we set 3 times higher productivities

Followings are the modified assumptions for option 3.

Item	Value	Remarks
Seed Productivity	4.1 t/feddan-y (10.2t/ha-y)	High yield breeding, 300% higher yield of Luxor yield and 160% higher than existing high yield breeds

With the above improved condition, cash flow turns positive after project year 4 due to the maturity of the Jatropha tree (Table. 10.3).

Table. 10.3 Cash Flow of the High Yield Breed Application - Option 3

Project Year	Year 1	Year 2	Year 3	Year 4	Year5	Year 6-15
Cash Flow/Balance	**-4,240**	**-1,108**	**-404**	**652**	**1,356**	**1,356**
Cash Out	4,240	1,460	1,460	1,460	1,460	1,460
Cash In	*0*	*352*	*1,056*	*2,112*	*2,816*	*2,816*

IRR improved greatly and reached 13.7%, but it is still not high enough level as a private investments. In case of 20% successful cost reduction, the IRR exceeded the bench mark of 20%. In the case of 20% cost reduction, the fluctuation of the seed sales within 10% maybe considerable number for privates though the IRR became 18% (2% below the bench marck).

Table. 10.4 Sensitive Analysis of the Seed Sales Price and Cost for Option 3

						Seed Sales		688 LE/t				
	13.7%	50%	60%	70%	80%	90%	100%	110%	120%	130%	140%	150%
	150%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#NUM!	-3.5%	1.2%	4.9%	8.2%	11.1%	13.7%
	140%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-5.5%	-0.1%	4.2%	7.7%	10.9%	13.7%	16.4%
	130%	#DIV/0!	#DIV/0!	#DIV/0!	-8.2%	-1.6%	3.3%	7.2%	10.7%	13.7%	16.6%	19.2%
	120%	#DIV/0!	#DIV/0!	#NUM!	-3.5%	2.2%	6.6%	10.4%	13.7%	16.8%	19.6%	22.2%
	110%	#DIV/0!	#DIV/0!	-6.1%	0.8%	5.9%	10.1%	13.7%	17.0%	20.1%	22.9%	25.6%
Cost	100%	#DIV/0!	#NUM!	-1.0%	4.9%	9.7%	13.7%	17.4%	20.7%	23.7%	26.6%	29.3%
Initial Investment2780.000LE	90%	#DIV/0!	-3.5%	3.7%	9.2%	13.7%	17.7%	21.4%	24.7%	27.8%	30.8%	33.6%
AnnualCost1460.000LE	80%	-7.2%	2.2%	8.6%	13.7%	18.2%	22.2%	25.9%	29.3%	32.6%	35.7%	38.6%
	70%	-0.1%	7.7%	13.7%	18.8%	23.3%	27.4%	31.2%	34.8%	38.2%	41.5%	44.6%
	60%	6.6%	13.7%	19.6%	24.7%	29.3%	33.6%	37.7%	41.5%	45.1%	48.6%	52.0%
	50%	13.7%	20.7%	26.6%	32.0%	36.9%	41.5%	45.9%	50.0%	54.0%	57.8%	61.6%

10.4 Option 4: New Breed with Cost Reduction

The option 3 shows some possibility in cost reduction so that we assumed to consider the possible cost reduction. At this moment, all afforestation project except Suez were developed and operated by public agencies. In the most cases, privates make extensive efforts to reduce the cost and make the profit higher.

With the consultation with experienced engineers and experts in afforestation with treated wastewater, we conservatively assumed 10% cost reduction in initial investment and some part of O&M cost as follow.

Followings are the modified assumptions for option 4.

Item	LE/feddan	US$/ha
Initial Investment (Base Cost)	**2,502**	**1,137**

Item	1,000LE/y	1,000US$/y
Workers - permanent	240	44
Workers - harvesting	400	136
Utility - power	80	5
Utility - potable water	4	45
Transportation for worker	87	16
Miscellaneous/Replace	100	227
Base Cost	**911**	**166**

Table. 10.5 Cash Flow of the Cost Reduction - Option 4

Project Year	Year 1	Year 2	Year 3	Year 4	Year5	Year 6-15
Cash Flow/Balance	**-3,882**	**-1,028**	**-324**	**732**	**1,436**	**1,436**
Cash Out	3,882	1,380	1,380	1,380	1,380	1,380
Cash In	0	352	1,056	2,112	2,816	2,816

IRR improved slightly and reached 16.3%, but it is still not high enough level as a private investments. In case of further 10% successful cost reduction, the IRR exceeded the bench mark of 20%.

Table. 10.6 Sensitive Analysis of the Seed Sales Price and Cost for Option 4

							Seed Sales	688 LE/t				
	16.3%	50%	60%	70%	80%	90%	100%	110%	120%	130%	140%	150%
	150%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-6.1%	-0.4%	3.9%	7.6%	10.8%	13.6%	16.3%
	140%	#DIV/0!	#DIV/0!	#DIV/0!	#NUM!	-2.2%	2.8%	6.8%	10.3%	13.4%	16.3%	18.9%
	130%	#DIV/0!	#DIV/0!	#DIV/0!	-4.6%	1.4%	6.0%	9.8%	13.2%	16.3%	19.1%	21.8%
	120%	#DIV/0!	#DIV/0!	-7.9%	-0.4%	4.9%	9.2%	12.9%	16.3%	19.4%	22.2%	24.9%
	110%	#DIV/0!	-13.0%	-2.8%	3.6%	8.5%	12.6%	16.3%	19.6%	22.7%	25.6%	28.4%
Cost	100%	#DIV/0!	-6.1%	1.9%	7.6%	12.2%	16.3%	20.0%	23.3%	26.5%	29.4%	32.3%
Initial Investment 2780,000LE	90%	#NUM!	-0.4%	6.4%	11.8%	16.3%	20.3%	24.0%	27.5%	30.7%	33.8%	36.7%
Annual Cost 1380,000LE	80%	-3.7%	4.9%	11.1%	16.3%	20.8%	24.9%	28.7%	32.3%	35.6%	38.8%	41.9%
	70%	2.8%	10.3%	16.3%	21.4%	26.0%	30.3%	34.2%	37.9%	41.5%	44.9%	48.1%
	60%	9.2%	16.3%	22.2%	27.5%	32.3%	36.7%	40.9%	44.9%	48.7%	52.3%	55.9%
	50%	16.3%	23.3%	29.4%	35.0%	40.1%	44.9%	49.4%	53.8%	58.0%	62.0%	65.9%

10.5 Option 5: New Breed and Cost Reduction with Free Land Lease

In order to further explore the cost reduction, we assumed to cut the land lease cost. It is not a common case to exclude the cost of the land, it would be possible with the strong government's will for the achievement of a national needs.

Followings are the modified assumptions for option 5.

Item	Value	Remarks
Land Lease	0 LE/feddan-y (US$0/ha-y)	Political desision is needed.

Table. 10.7 Cash Flow of the Land Lease Free Case - Option 5

Project Year	Year 1	Year 2	Year 3	Year 4	Year5	Year 6-15
Cash Flow/Balance	**-3,782**	**-928**	**-224**	**832**	**1,536**	**1,536**
Cash Out	3,782	1,280	1,280	1,280	1,280	1,280
Cash In	0	352	1,056	2,112	2,816	2,816

IRR improved slightly and reached 18.5%, and it is quite close to the considerable level as a private investments. In practical, small difference can be negligible if an investor has access to a low cost financial scheme. Also, some frontier companies with advanced competitiveness in technologies or management would be capable of this IRR level. Typically, for public companies, this IRR would be the considerable level of investment.

Table. 10.8 Sensitive Analysis of the Seed Sales Price and Cost for Option 5

						Seed Sales		688 LE/t				
	18.5%	50%	60%	70%	80%	90%	100%	110%	120%	130%	140%	150%
	150%	#DIV/0!	#DIV/0!	#DIV/0!	#NUM!	-2.3%	2.6%	6.6%	10.0%	13.1%	15.9%	18.5%
	140%	#DIV/0!	#DIV/0!	#DIV/0!	-4.9%	1.0%	5.5%	9.3%	12.7%	15.7%	18.5%	21.1%
	130%	#DIV/0!	#DIV/0!	#NUM!	-1.0%	4.2%	8.5%	12.2%	15.5%	18.5%	21.3%	23.9%
	120%	#DIV/0!	#DIV/0!	-3.7%	2.6%	7.5%	11.6%	15.2%	18.5%	21.5%	24.3%	27.0%
	110%	#DIV/0!	-7.6%	0.5%	6.3%	10.9%	14.9%	18.5%	21.8%	24.8%	27.7%	30.5%
Cost	100%	#DIV/0!	-2.3%	4.7%	10.0%	14.5%	18.5%	22.1%	25.4%	28.6%	31.5%	34.4%
InitialInvestment2502,000LE	90%	-6.5%	2.6%	8.9%	14.0%	18.5%	22.5%	26.1%	29.6%	32.8%	35.9%	38.8%
AnnualCost1280,000LE	80%	-0.3%	7.5%	13.5%	18.5%	22.9%	27.0%	30.8%	34.4%	37.8%	41.0%	44.1%
	70%	5.5%	12.7%	18.5%	23.6%	28.1%	32.4%	36.3%	40.1%	43.7%	47.1%	50.4%
	60%	11.6%	18.5%	24.3%	29.6%	34.4%	38.8%	43.1%	47.1%	50.9%	54.6%	58.2%
	50%	18.5%	25.4%	31.5%	37.1%	42.2%	47.1%	51.7%	56.1%	60.3%	64.4%	68.4%

10.6 Option 6: New Breed and, Cost Reduction, Free Land Lease with Free Wastewater

In order to further explore the cost reduction, we assumed to cut the wastewater cost. Based on the discussion with HCWW representatives, it is not an acceptable option to provide wastewater for free due to HCWW and its affiliate companies' financial dependency and sustainable operation. One of the difficulties of the biofuel feed businesses is the time lag between the initial investment and positive cash flow due to the requirement of the maturity period for the biofuel feeds. For the most profitable energy business, oil palm, takes seven (7) years to reach the maturity, but the latter profits are able to cover the initial investments. Considering the "Incentives" for the private investors, limited time favorable treatment such as tax exemption greatly help their investment decisions. For the Egyptian Jatropha plantation development, developed plantation could be one of dependable source of domestic energy without limited operation time though the replanting of Jatropha and renovation of water system are required. In order to make the result simple, we set the wastewater cost for free.

Followings are the modified assumptions for option 6.

Item	Value	Remarks
Treated Wastewater	0.0 LE/m^3 (US$0.0/ m^3)	Political desision is needed.

Table. 10.9 Cash Flow of the Land Lease and Wastewater Free Case - Option 6

Project Year	Year 1	Year 2	Year 3	Year 4	Year5	Year 6-15
Cash Flow/Balance	**-3,413**	**-559**	**145**	**1,201**	**1,905**	**1,905**
Cash Out	3,413	911	911	911	911	911
Cash In	0	352	1,056	2,112	2,816	2,816

IRR finally reached 27.1%, and it could be the considerable level as a private investments. However, as described in the discussion with HCWW, it is not easy to find a solution for both Jatropha operators and HCWW. At this moment, SUTSWA program has been applying wastewater without any charge, but it is necessary for HCWW to find a source of operation costs rather than continuously depending on public budgets.

Table. 10.10 Sensitive Analysis of the Seed Sales Price and Cost for Option 6

		Seed Sales 688 LE/t										
	27.1%	50%	60%	70%	80%	90%	100%	110%	120%	130%	140%	150%
	150%	#DIV/0!	-7.4%	-0.2%	5.0%	9.3%	12.9%	16.2%	19.2%	22.0%	24.6%	27.1%
	140%	#DIV/0!	-3.9%	2.6%	7.5%	11.7%	15.3%	18.6%	21.6%	24.4%	27.1%	29.6%
	130%	#NUM!	-0.6%	5.4%	10.1%	14.2%	17.8%	21.2%	24.2%	27.1%	29.8%	32.4%
	120%	-5.3%	2.6%	8.3%	12.9%	17.0%	20.6%	24.0%	27.1%	30.1%	32.9%	35.5%
	110%	-1.3%	5.9%	11.3%	15.9%	20.0%	23.7%	27.1%	30.3%	33.4%	36.3%	39.0%
Cost	100%	2.6%	9.3%	14.6%	19.2%	23.3%	27.1%	30.6%	33.9%	37.1%	40.1%	43.0%
Initial Investment 2780,000LE	90%	6.5%	12.9%	18.2%	22.9%	27.1%	31.0%	34.7%	38.1%	41.4%	44.6%	47.6%
Annual Cost 911,000LE	80%	10.7%	17.0%	22.3%	27.1%	31.5%	35.5%	39.4%	43.0%	46.5%	49.9%	53.1%
	70%	15.3%	21.6%	27.1%	32.1%	36.7%	41.0%	45.0%	48.9%	52.6%	56.2%	59.7%
	60%	20.6%	27.1%	32.9%	38.1%	43.0%	47.6%	52.0%	56.2%	60.3%	64.2%	68.0%
	50%	27.1%	33.9%	40.1%	45.8%	51.2%	56.2%	61.1%	65.7%	70.2%	74.5%	78.7%

11. Summary of the Cost Analysis

The series of cost analyses clearly show the needs for productive improvement and substantial efforts in cost reduction measures. The improvement of seed productivities can be achieved conventional technologies including breading and harvesting as well as advanced scientific measures. However, it is not available on the mark and such "New breed" should be locally adapted to secure the stable yields. In general it takes time to develop such new breeds while cultivation technologies can be immediately applicable with the experiences in Asia and African countries where harvesting are conducted with rain fed condition.

On the other hand, the cost reduction is also necessary challenge to make the Egyptian Jatropha biofuel model feasible. As an energy security measure, it is required to develop extensive scale of Jatropha or other energy crop plantation, but present practices are not financially feasible to extend such scale. As described in the each option, there are varied solutions available at this moment but also high level political wills are required even with the application of the new breed.

Therefore, it is recommendable to address the key pointes raised in this cost analyses to make the business model feasible as soon as possible rather than just waiting for a good offer. There would be substantial efforts required. However, the Egyptian case is one of the most unique and close circumstances to reach an economically viable Jatropha biofuel model in the world. The following chapter describes the details of the challenges and recommendations.

CHAPTER IV
Challenges and Recommendations

IV. Challenges and Recommendations

Based on the experts' field investigation and updated information as of 2009, Egyptian Jatropha biofuel industry development clearly needs not only technical improvement but also political actions to make the industry feasible. Following are the primary key points to be addressed and recommendations for the immediate actions.

12. Challenges and Considerations

Followings are the seven (7) priorities to be addressed for the development of a competitive industry development in Egypt by the effective collaboration with the public and private.

12.1 Increase Productivity of Jatropha Seed

The cost analyses, section 10-13, clearly show the realistic impracticability of the Jatropha biofuel supply chain development with existing condition. Despite the higher productivities of Jatropha seed compared to the rain-fed Asian and African practices, such higher productivities are not high enough for costly expenditures of irrigation systems and their operation and maintenance costs. Since Jatropha is a very new agribusiness crop, the productivities of the Jatropha has not reached the commercially viable level. As same process as other agribusiness species, Jatropha needs basic breeding process apart from the wild species. In Egyptian practices, there are no improved breeds application at this moment so that fluctuation of seed productivities are relatively high, which is very high risk for the massive plantation development. The highest productivities are not high enough for the costs. Thus, the present productivity level would never realize an economically viable business model.

As the same procedure as other industrial crops, we firstly recommend to proceed with the productivity improvement program with the collaboration with advanced technical providers domestically and internationally. Followings are the list of strategies for the productivity improvement program.

Item	Remarks
1. High yield breeding program	● Concentration of limited financial and technical resources in Egypt including facilities and appropriate researchers ● Starting from conventional high yield breeding with the support of international experts ● Low fluctuation and high yield breed development, subject to above 4t-seed/feddan (10t-seed/ha) ● Improvement of oil content and quality with conventional breeding and genetic science
2. Improvement of cultivation and harvesting technique	● Technical transfer of cultivation technique from advanced countries

Item	Remarks
	● Further development of economical cultivation technique for Egyptian model including pruning and pollination
3. Profitable use of byproducts	● Technical transfer of competitive byproduct applications such as animal feed, fertilizer, biomass fuel, biogas production for seedcake and pruned branches

12.2 Cost Reduction of Irrigation System and O&M

Cost reduction is the other challenge to overcome. Although Egyptian drip irrigation systems are uniquely adapted to reduce the cost, Egypt is the ONLY county commercially applying such costly drip irrigation system for Jatropha or other woods production. In general, afforestation is less profitable than other farming so that irrigation farming is generally limited to profitable food cultivation. Though the drip irrigation system can greatly reduce the loss of the water and increase the applicability of farming in non conventional farm land such as sandy or hilly area, it needs extensive investments for piping and its civil works and maintenance. In addition, adequate filtering systems and proper management is required to avoid the clogging of pilings with contents of the treated wastewater.

As a result, it is even higher cost than irrigation farming with fresh water. However, the profitability of the Jatropha will not exceed the typical food cultivation. Therefore, successful cost reduction of the present irrigation practices is the key to make the Egyptian Jatropha biofuel industry feasible. Strategic key points and recommendations are as follow.

Item	Remarks
1. Strategic allocation of Jatropha plantation for existing wastewater plants	● Minimizing the cost of wastewater distribution ● Allocating favorable soil type ● Considering geographically minimal cost for irrigation and civil works
2. Cost reduction of drip irrigation system for large scale plantation	● Technical improvement to adapt large scale model ● Maximizing the scale merit such as low cost procurement ● Simplified system development ● Maintenance free system development for anti-clogging or other daily maintenance ● Long life product development for periodical replacement parts
3. Advanced R&D for applied surface irrigation for large scale plantation	● Simplified system development for los cost initial investment and O&M ● Technical development for water loss ● Cost-effective land preparation with smart utilization of geographical features ● Competitive technological development to effectively distribute wastewater in typically inapplicable soil type such as sand

Item	Remarks
4. Cost reduction of O&M costs	● Adequate technical training and efficient laborer management ● Cost effective harvesting ● Dehulling and drying technique improvement ● Improved biofuel feed storage technique for quality control and reduction of loss in handling
5. Cost effective logistic system development	● Minimizing the seed handling cost

12.3 Security of Wastewater Supply

It is clear that wastewater is one of the most critical limiting factors for Jatropha plantation development in Egypt. Not only security of the wastewater but also economically viable wastewater treatment and supply are essential. Due to the inefficiency of the past wastewater treatment practices, HCWW has taken over majority of the water treatment facilities to make the operation sustainable and financially independent. As mentioned in the cost analysis section (12 and 13), the inadequate pricing of the wastewater for Jatropha plantation would harshly reduce the business feasibility. However, HCWW and other treatment companies also need to collect adequate cost for treatment for their sustainable operation. In order to meet such goals, overall arrangement among relevant stakeholders and cost effective wastewater supply chain development is required.

Item	Remarks
1. Ensuring stable wastewater supply	● Allowing long-term supply agreement ● Considering the longer term conditions such as tariff settlement
2. Economically viable wastewater tariffs for Jatropha plantation developers	● Special consideration for pricing such as limited time discount or minimum pricing ● Smart arrangement of wastewater suppliers and Jatropha developers to avoid unnecessary competition for the wastewater security
3. Cost reduction of the wastewater treatment	● Minimum water treatment for treated wastewater users with the careful examination of (1) Primary, (2) Secondary and (3) Tertiary applications ● Adaptation of the low cost water treatment techniques such as oxidation ponds rather than modern treatment facilities

12.4 Strategic Allocation of Jatropha Plantation

Allocation of the plantation is another essential factor to control the feasibility of the Jatropha plantation development. Although more than 90% of the Egyptian land is desert land and not used at this moment, security of a large piece of land in such desert area is not easy task. It is also importance to strategically allocate the plantations for the competitive biofuel production. In order to maximize the profitability of the Jatropha biofuel supply chain development, comprehensive study on land use, characteristics of the land, climate, logistic system, utilities and other key factors shall be examined and made it available for developers' consideration with modern tools such as GIS form.

Item	Remarks
1. Master plan development for nationwide wastewater resources use with new and existing city development	● Comprehensive study on soil and geological studies for the strategic allocation of wastewater treatment facilities and Jatropha plantation with application of modern technologies such as satellite ● Strategic consideration of new city development to supply economical wastewater for Jatropha plantation ● Strategic consideration of competitive biofuel supply chain development by wastewater resource availability and economical material flow
2. Smart allocation of non arable land and wastewater treatment plant	● Economical consideration of land preparation, soil type, and suitable irrigation ● Strategic allocation of plantation for Upper Egypt development with the biofuel supply chain ● Strategic consideration of wastewater plant location to facilitate economically viable Jatropha plantations for private investors
3. Arrangement of land ownership transfer	● Coordination of governmental authorities for the strategic allocation of large scale plantations

12.5 Political Will and PPP Scheme

Without government's commitments, Egyptian biofuel industry is hardly able to take off because technologies and privates efforts are not sufficient enough to make the industry feasible. As frequently described in the previous sections, governmental authorities would be deeply involved in land allocation and wastewater supply. As a result, without clear vision and strong leadership of the government, it is hardly to coordinate authorities. Since the total scale of the investments is quite large and competitiveness is the key to realize the industry, mutual collaboration with privates are essential to make the industry feasible. Recently in many developing countries, effective collaboration with privates for public needs, known as public and private partnership scheme (PPP), has successfully delivered social needs cost effectively. Because the Jatropha biofuel industry will cover conventional business sectors, it is highly recommendable to maximize the effective use of privates' efforts in the industry development.

Item	Remarks
1. Clear vision and policy on biofuel industry development	● Clear vision and consistent policy on biofuel industrial development for the sake of energy security and export promotion ● Gov.'s leadership toward renewable energy capacity development including biofuels
2. Government's leadership to promote favorable environment for FDI	● Providing favorable investment environment in renewable energy development ● Supporting foreign investors to start businesses

Item	Remarks
	● **Facilitating secure environment for authority related matters** ● **Promotion strategies to attract private investors through PPP**
3. Coordination of stake holders	● Leverage government authorities to enhance the cooperation each other for the sake of establishing one stop window for investors ● Simplifying the complex jurisdictions among many authorities ● Unification of power and government window for the Jatropha investment to avoid unnecessary competition among authorities ● Concentrating resources (budget, experts, facilities, etc.) to effectively achieve the economically viable business model

12.6 Environmental Considerations

Security of the environmental health is the fundamental of the wastewater application. Though the SUTSWA programs have proved safety application of the treated wastewater, assurance of the safety management in the large scale practices must be secured by practical enforcement schemes.

Item	Remarks
1. Avoidance of ground water contamination	● Careful analysis of wastewater behavior ● Designing irrigation system to avoid the potential impacts on ground water resource ● Monitoring program to ensure the safety of ground water
2. Ensuring the environmental health	● Adequate technical training for labors ● Good practice guidelines for wastewater management ● Appropriate monitoring program for the long-term impact assessment for unexpected matters

12.7 No Competition against food production

It is not only Egyptian policies but also international consensus to ensure "No competition against food production." It has been very sensitive matter to avoid any competition against food cultivation, especially after the historical high price of the food prices in 2008, which directly affected the low income residents depending on government's food subsidies. Although the food supply was enough level in 2008, expectation in the biofuel investments led the historical hype of the food prices. "No competition policy" must be clearly promoted from the beginning to avoid fears for food securities and sprit of incorrect information on wastewater application.

Item	Remarks
1. Clear policy on no food competition	• Clear policy on food security and no competition against food production • Strengthening the enforcement of government's policy on wastewater usage
2. Security of no Jatropha production in farmland	• Governmental policy on land allocation for non-edible farming activities • Strengthening the prohibition and monitoring program for no Jatropha cultivation in farmland
3. Security of fresh water use for food production	• Strengthening the prohibition and monitoring program for freshwater/ground water use for Jatropha

13. Summary of Recommendations and Recommended Action Plans

Advanced efforts on treated wastewater application for energy crop production in Egypt have proved unique opportunities and competitive potentialities in biofuel industry development. Further development of such desert farming is not only beneficial for a competitive industry development but also contribution of renewable energy development for an energy security measure, economical use of wastewater resource, enhancement of safety wastewater management, and regional development.

However, the series of the analyses in this study proved that existing condition does not allow realizing such potentials without technical improvement and governmental arrangements. In order to realize the Egyptian biofuel industry development, we recommend the following.

Table. 13.1 Summary of Recommendations for Egyptian Biofuel Industry Development

Item	Summary
1. Increase Productivity of Jatropha Seed	● High yield breeding program ● Improvement of cultivation and harvesting technique ● Profitable use of byproducts
2. Cost Reduction of Irrigation System and O&M	● Strategic allocation of Jatropha plantation for existing wastewater plants ● Cost reduction of drip irrigation system for large scale plantation ● Advanced R&D for applied surface irrigation for large scale plantation ● Cost reduction of O&M costs ● Cost effective logistic system development
3. Security of Wastewater Supply	● Ensuring stable wastewater supply ● Economically viable wastewater tariffs for Jatropha plantation developers ● Cost reduction of the wastewater treatment
4. Strategic Allocation of Jatropha Plantation	● Master plan development for nationwide wastewater resources use with new and existing city development ● Smart allocation of non arable land and wastewater treatment plant ● Arrangement of land ownership transfer
5. Political Will and PPP Scheme	● Clear vision and policy on biofuel industry development ● Government's leadership to promote favorable environment for FDI ● Coordination of stake holders
6. Environmental Considerations	● Avoidance of ground water contamination ● Ensuring the environmental health
7. No Competition against food production	● Clear policy on no food competition ● Security of no Jatropha production in farmland ● Security of fresh water use for food production

In order to address such matters, we recommend the following action plans:

Table. 13.2 Recommended Action Plans for Egyptian Biofuel Industry Development

Phase	Actions
1. Urgent Needs: Experimentation & Creation of Investment Climate	• Detailed feasibility study covering the wastewater supply, land and geological database, suitable land allocation for Jatropha plantation and wastewater treatment as well as new city development • Formulation of a Bio-Energy Policy • Implementation of high yield breeding program for Jatropha with the support of international experts • Selection and implementation of large scale pilot plantation project • Leverage public authorities and preparation of PPP scheme for the full scale Jatropha plantaion development by privates • Preparation of a "Green energy fund" that encourages the green energy development investments by private sectors
2. Mid-Term Needs: Commencement of Jatropha Plantations	• **Implementation of commercial scale polantation** • **Installation of oil extraction plants for crude vegetable oil production (PPO)** • **Exportation of PPO for EU market** • **Preparation of biofuel refinery for bio jet fuel and testing jet fuel for aviation within Egypt**
3. Long-Term Needs Completion of Supply Chain Development for Jatropha Bio-Jet Fuel Supply in the Market	• Full production of bio jet fuel • Export jet biofuel to EU market • Distribution of bio-jet fuel to Egypt air • Distribution of synthetic bio diesel for EU or Egyptian market (byproduct of bio-jet fuel)

14. Recommendation for JICA

As recommended in section 13-14, government of Egypt needs technical and institutional improvement for the unique industrial development, which would significantly affect Egyptian sustainable development policy in energy, environment, water resource, economy, and regional development. Although relevant authorizes have been seriously considering the realization of such projects, scattered efforts have yet reached sustainable development models in both wastewater treatment system and Jatropha biofuel supply chain. Due to the complexity of the institutional relationship and shortage of the technical support, their efforts are still far from commercially viable level. Despite authorities' serious interests, it is hardly to achieve a competitive industry development without timely and appropriate support. Though there are varied challenges described in section 13-14, assistance for selected key challenges could significantly improve the possibility of the biofuel industry development in Egypt. For the potential assistance for government of Egypt, two (2) short term and three (3) mid to long-term assistance programs are recommended.

SHORT TERM ASISSTANCE

14.1 Detail Feasibility Study on Egyptian Biofuel Industry Development

Shortly followed by this study, further detail feasibility study is recommended to address the high-level policy makers and key stake stakeholders in the actual stage. Following are the recommended objectives of the study.

- Nationwide study on wastewater and non-arable land availability with geographical and soil mapping survey
- Priority site selection for Jatropha plantation development
- Basic design of the Jatropha plantation for the selected sites
- Feasibility study on nationwide biofuel supply chain development including oil extraction, refining, and logistics
- Detailed examination on policy, regulation, and laws in biofuel industries and to-do list for improvement
- Recommendations for Jatropha industry development roadmap

14.2 Assistance for Productivity Improvement

Due to the short of productivities, expected annual profits from Jatropha sales will hardly exceed the annual O&M cost without productivity improvement. At this moment, there are some high yield breeds available on the market, it is necessary to adapt Egyptian environment. The cost analysis showed the existing high yield breeds are not even high enough for the Egyptian models. High yield breeding is the basic technique to make the agribusiness feasible and profitable. Though there are highly potential institutions in Egypt, it would be necessary to assist the capability of "Jatropha breeding" and technological transfer of advanced Japanese technologies in breeding.

- High yield breeding program with the support of Japanese advanced breeding technologies
- **Technical transfer of the cultivation technology from advanced countries**
- Technical transfer of the competitive technologies for byproduct usage

MID-LONG TERM ASISSTANCE

14.3 Financial and Technical Assistance for the Wastewater Plant Development in Upper Egypt

Financial and technical assistance for development of treated wastewater systems would greatly contribute to the Egyptian biofuel industry development. Once the technical and institutional matters are solved with short-term assistance, a large number of wastewater plant projects are likely to start, in Upper Egypt. In order to realize the biofuel industry development, security of "Low cost" wastewater supply is one of key factors to solved at the actual operation stage.

Considering the need for large investment for such projects, JICA may be provide technical assistance and soft loan for such wastewater treatment development in Upper Egypt. Since high level water treatment is not required for Jatropha cultivation, low cost treatment practices such as a series of oxidization ponds would be suitable for "Low cost wastewater production and supply. Since the oxidization pond treatment has been widely used, especially in Upper Egypt, technical assistance may not be important. However, further cost reduction and cost effective treatment technologies should be carefully assessed and sufficient soft loan shall be provided to contribute to the competitive wastewater treatment and supply.

14.4 Green Fund for Renewable Energy Development Projects

A financial scheme such as a green fund could greatly help expected renewable energy projects including wind, photovoltaic and solar heat, and biofuel projects in Egypt. Maturity of technologies and scale of the investments vary so that potential scale and timing of the expected investments shall be carefully assessed. As EU countries have been supporting Egypt in renewable energy fields, especially wind and soar, coordination of the donors may be required.

Since HCWW is responsible for wastewater treatment and its supply with other source of funding, the applicability of the green fund would be the Jatropha plantation, oil extraction, and synthetic biofuel refineries by private sectors. In many case in Egypt, public companies dominate an industrial sectors applicable in energy sectors so that applicability of such fund shall include a public and private JV company as well. In order to sustainably manage the fund, the applicability may be extend to energy saving projects as well.

14.5 Financial Assistance for Egyptian and Japanese JV Companies for Jatropha Biofuels

Furthermore, JICA may be able to provide direct financial assistance for Egyptian and Japanese JV companies for biofuel supply chain development. The JICA finance might be defined as public infrastructure sector or renewable energy sectors with PPP scheme, typically BOT (Built Operate and Transfer) or BOO (Build Operate Own). Though some renewable energy businesses become competitive level compared to the conventional fossil fuel model, majority of renewable energy businesses still require strong support and commitments from public sectors. In other words, such higher risk projects shall be under the JICA finance scheme.

The applicability of the finance can be defined as follow:

- Japanese company's participant ion in biofuel supply chain vestments
- Majority of the companies' components are supplied by Japanese companies
- Companies with advanced technological development, which can be widely applicable for other countries' renewable energy development

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APPENDIX

A1 Summary of the Round Table for Jatropha Biofuel Industry Development in December 2009

A2 MOH Ministerial decree of establishing a committee to rearrange afforestation watered by treated wastewater and responsibility to HCWW from MALR and other governorates

A3 Summary of Egyptian Biofuel Industry Development Study (JCA2007)

A4 Egyptian Code for Using the Treated Wastewater in the Field of Agriculture (ECP501-2005)

A5 Key Indicators

A6 Accord of UNFCCC COP/15

A7 Official Statement of ICAO for the Response to the UNFCCC COP/15 Accord

A8 Official Statement of IATA for the Response to the UNFCCC COP/15 Accord

A1 Summary of the Round Table for Jatropha Biofuel Industry Development in December 2009

Meeting of the
Public Private Partnership for Egyptian Biofuel Industry Development
Toward US$1.6 billion Bio-Jet fuel market in EU
Sunday, 27th of December 2009, Cairo – Egypt

DATE: Sunday, 27th of December
TIME: 10:00 – 14:00
PLACE: Conference room in the Egyptian Organization for Standardization and Quality, MTI

LIST of ATTENDED STAKEHOLDERS (alphabetical):
Egyptian participants
AGYPTAIR, AGYPTAIR CARGO, Cairo University, Central Laboratory for Agricultural Climate, Egypt National Air Navigation Services Company, Egyptian Environmental Affairs Agency, Egyptian General Organization for Standardization and Quality (MTI), Egyptian Natural Gas Holding Company, Holding Company for Water & Wastewater, Menoufia Company for Water and Wastewater, Ministry of Civil Aviation, Ministry of Higher Education and State Ministry for Scientific Research, Ministry of Trade and Industry (MTI), National Research Center (Environmental Biological and Natural Science), National Research Center (Environmental Science Division), New and Renewable Energy Authority, Soils, Water & Environment Research Institute (Agricultural Research Center), Supreme Energy Council
Japanese participants
Embassy of Japan, Japan International Cooperation Agency

OBJECTIVE:
In order to share the facts and results of JICA Egyptian Biofuel Industry Development Study in 2009, a stakeholders' roundtable was held on 27 December at a conference room in EOS, MTI with the collaboration with MTI and JICA. MTI and JDI, the consultant to the JICA study, selected the relevant stakeholders especially focusing on wastewater and biofuel feed production sectors based on the JICA study. With the consultation with the stakeholder's high level representatives. Each attendee was appointed in order to seek for the future collaboration in Jatropha biofuel industry development among relevant authorities.

AGENDA

	Opening speech
10:00	- Dr. Mohamed Hany Barakat, Chairman of the Egyptian Organization for Standardization and Quality, First under secretary, Ministry of Trade and Industry (MTI) ・ Representative, Japan International Cooperation Agency (JICA) ・ Dr. Shoichi Kobayashi, Chairman, Japan Development Institute (JDI)

	Technical Session Part 1
10:15	1. ***Targeting market for Egyptian biofuel and Facts from cost analysis,*** By Eng. Shinya Nagaoka, JDI 2. **Facts of manmade forest program and challenges** By Eng. Ali Asal, Director General, Afforestation & Environment, Ministry of Agriculture and Land Reclamation 3. **Facts of wastewater use, afforestation program, & master plan on wastewater treatment up to 2017** By Dr. Mahmoud Shahin, Agricultural Engineer, Holding Company for Water and Wastewater
11:15	Questions and Answers
	Technical Session Part 2.
12:00	4. **World trend of alternative fuel development toward 2020 and beyond** By Dr. Mohamed El Hakim, General directorate of Air Traffic Planning of NANSC and the primary member of Committee on Aviation Environmental Protection (CAPE) of International Civil Aviation Organization (ICAO) 5. **Reality of Egyptian operators and Action plan for the EU regulation** By Eng. Mohamed Hussein Mohamed, Chief of central department for future planning studies, Ministry of Civil Aviation (MCA)
12:30	**Questions and Answers**

	Conclusive Session
13:00	**Recommended action plan for Egyptian bio-jet fuel supply chain development** By Dr. Shoichi Kobayashi, JDI
13:15	**Open Discussion** Moderator: Dr. Ahmed Fouad Mandour, Executive Director of Food Technology Center, MTI
13:45	**Closing Remarks** - Dr. Ahmed Fouad Mandour, MTI

KEY REMARKS

Opening Speech of Dr. Hany Barakat

Good morning everybody, today we are going to talk about a very important subject and on the top of the priorities. Renewable Energy and Environment is a top priority for sustainable development

Egypt is characterized by high rate of sun shine and also high and stable wind speed that enables the development of solar energy and wind energy. The world has started to open the file of the biofuels and the plants that transform the solar energy into biofuels.

Since around one year ago a new technology has been developed depending on planting in the desert and using the treated waste water to produce biofuel. The European Union has started to put the standards and specifications of such fuel. The conventional diesel oil is mixed with biodiesel by 10% and things have moved on very vast and nowadays the European Union has issued some regulations for the aviation companies that enable the expansion and increase in the usage of biofuels.

The Japanese side has started studying the possibility of expanding the plantation of Jatropha in Egypt. Today we will discuss the results of the study which is divided into a technical part and another part for feasibility of producing biofuels in Egypt

I would like the Egyptian side to participate actively in the discussions and to inform about the future steps, what is required? What are the incentives? Is there a gap between the research and application?

The Ministry of Trade and Industry is ready to support and finance the future steps. MTI is preparing to make the standards and specifications of the biofuel as a product.
We need to discuss how to make biofuel a value added and what is the required assistance to achieve this goal? Today we have excellent representation from different stakeholders and we look forward to your active participation in this workshop.

I want to express my sincere appreciation to JICA and JDI for their work and their assistance.

Open Discussion: **Comments by participants**

Dr. Guzine Ibrahim El Diwani, NRC

We have been working in Jatropha since 1998. We already got very promising results, now only after 6 months the trees start production.
We have a lot of waste water and we already have excellent experiences compiled. Why we as Egyptians need others to plan for us and think for us. We need to coordinate our efforts and start.
We have seen some efforts from the Korean government trying to get the waste water from Abu Rawash plant and transfer it to some area called "Gabal El Wahat" to plant Jatropha and they were going to pay the expenses of delivering waste water to this area but unfortunately, after consulting different ministries, the ministry of defense refused and said this land is owned by the ministry. This is very strange actually, we thought that was a very good project but it was stopped by the Ministry of Defense's decision. Does ministry of trade support this decision? We have to identify the decision maker.

Response of Chairperson and moderator Dr. Ahmed Mandour

Ministry of Trade is not in a position to comment on this decision, but anyway if there is some issue of national security, it should be respected

Speaker, *Dr. Mohamed El Hakim, NANSC*

We have to take things seriously considering all concepts; the right and benefit of the companies producing treated water; we look for desert lands which can't be improved and so on.
Oil will deplete and we have to find a substitution. This is our obligation towards the future generation.
We also have to learn from the experiments and past experiences, we also have to think how to comply with the regulations for example, decrease number of flights or improve the engines or mixing fuel or others

Dr. Moustafa S.El-Hakeem, EEAA

I have been honored that I have gone to India to get the Jatropha seeds which are now planted in Luxor. At that time, we were thinking to get best results through research and production. During that period, there was the national authority for waste water allocating waste water in cooperation with ministry of agriculture and ministry of housing and ministry of environment.

Now the authority goes to holding company of water and waste water and currently there is a steering committee already established among several ministries. We have already an existing system; we want to have a base by cooperation among National Research Center, Desert Research Center and Agricultural Research Center. We got bored of attending meetings and just talking and talking, we have to start working.

Dr. Sohair I. Abou-Elela, NRC

It is very important to start ....OK environment and productivity should be considered, but we have to start and immediately

We have to work on a prototype and see the result. Now we have also been testing the use of salt water, we have also reached to some enzymes and ultrasound that can improve the yield. There should be a prototype for agriculture and industry.

Speaker, Eng. Mohamed Hussein from Ministry of Civil Aviation

I see that everyone is talking about agriculture and planting and cultivating Jatropha, the issue is not just planting and cultivation, we have to produce oil, this is highly important and we have to pay attention to it.

Dr. Zyad Ahmed El Menshawi, Consultant for Agricultural development, Holding Company for Water and Waste Water

Of course we are talking about the whole cycle; plantation, squeeze of oil and biodiesel. This operation needs a national effort of all concerned parties, putting in consideration "commercial production", we also need executive procedures and there should be private investors.

This Jatropha plantation and biofuel production is an issue that concerns very much the petrochemicals sector.. Where are the officials representing petrochemicals on this table?

We have to know also that now authority of planting Jatropha mainly falls within the holding company of water and waste water after the recent decision of Minister of Housing

Response of MTI Chairperson

Petrochemicals have been invited and they should be joining unless some emergency issue popped up

Speaker, *Dr. Mohamed El Hakim, NANSC*

This workshop should be the nucleus of a committee to be coordinated by Ministry of Trade with representation from different ministries concerned. The committee should have a strategic goal which is the production of fuel, as the final product from planting Jatropha. The process is not difficult, it is filtration, astrification and then it can be used.

Speaker, Eng. Ali Asal from Ministry of Agriculture (sitting next to Takeuchi-san)

I was in Brazil and this country has progressed from being a developing country to being the 8th rank among developed countries due to production of ethanol from sugar cane. There are several experiments of Jatropha plantation in Egypt, some is supported by the Italian government, we should notice the quality of water needed and also that the extraction process is not a conventional one.

Dr. Emad Hassan, director of EE Unit under Prime Minister

I'm Dr. Emad Hassan consultant and director of EE Unit established under the Prime Minister. The mandate of our unit does not explicitly specify biofuels but energy saving and subsidy and pricing which involves the renewable energy development, among which biofuels which we cannot ignore,

1st question we need to ask is "WHO'S RESPONSIBLE"...It's very interesting
Since 6 or 7 months the ministry of defense organized a workshop on Jatropha together with ministry of environment. And petrochemicals authority has a very important role; they have done some studies on biofuels as well.

What we really miss is the political vision before the research vision. Now we graduated from the economic and social dimension of biofuel development,, i.e we know the car will drive but we need policy direction

WHY IS IT IMPORTANT??
As an export opportunity OR energy security to diversify resources OR as a means to dipose waste water

One reason should be more important than the other. We have to solve this puzzle to know who is the responsible party or is it a committee involving several parties.

Actually MTI is by far the concerned ministry. I was surprised to know that MTI is sponsoring this activity. OK .. it is possible if we consider Jatropha as industry.. If Ministry of Trade and Industry sponsor this issue, it will probably be from the perspective of SME development

We need to prepare TOR for next step. We want responses from decision makers.. Is it job creation? Or export OR only EU market? If it's only EU market, then it's only an export opportunity
To allocate land we need to look at the opportunity cost, for example using the desert land in solar energy can be one of the options. Please look at every aspect and think of the questions that need to be answered in order to take this subject to higher level in the Supreme Energy Council.

Dr. Emad was interrupted by person from Ministry of Environment saying

This issue has been already on table of the Supreme Energy Council since 2007, and several ministers talked about it; like minister of agriculture, petroleum and environment

Dr. Emad responding

May be in 2007 this issue was not priority, believe me there are many opinions in several key positions that are against biofuel and also may be in 2007 the way of addressing this issue to the Supreme Energy Council was not correct and the approach was not right. We have to put all the important facts in front of the decision maker.

Same person from Ministry of Environment saying

Yes in 2007, the issue was not discussed as biofuel development, but as a usage of waste water in forests and afforestation including planting Jatropha

Dr. Emad resuming

My Recommendation is to prepare TOR in order to be able to identify the best benefit and priority of Jatropha plantation. This TOR should be studied in a feasibility study, and the outcome of which should be raised to the Prime Minister

Dr. Zyad Ahmed El Menshawi, Consultant for Agricultural development, Holding Company for Water and Waste Water

One of the benefits would be the safe usage of water
The export should be totally refused. It's too naive to export seed and not to produce oil. Biofuel should be consumed domestically for our national security. We have to use the treated waste water and calculate the

cost of its transportation. In Upper Egypt, the available land is not more than 100,000 feddans and in delta there is no available land. Our limit is that we can produce B2

Speaker, *Dr. Mohamed El Hakim, NANSC*

Ministry of Civil Aviation did not inform us how much biofuel is needed or it's current consumption of fuel. We need to know

Speaker, Eng. Mohamed Hussein from Ministry of Civil Aviation

We did not yet estimate our requirements of biofuel but anyway we have on-going plans for fuel saving.

Dr. Zyad Ahmed El Menshawi, Consultant for Agricultural development, Holding Company for Water and Waste Water

No doubt biofuel will be a value added for the Egyptian aviation sector

Dr. Sohair I. Abou-Elela, NRC

Egypt has existing projects and plans for renewable energy development mainly because government is subsidizing energy. This is why we're saying biofuel should be exported. If the government subsidizes biofuel, then it can be used domestically.

Dr. Guzine Ibrahim El Diwani, NRC

From economic, environmental and health view points, Jatropha plantation is beneficial, especially for disposing waste water, thereby improving the health condition. But without producing biofuel, other wooden trees would be better for getting wood.

Speaker, *Eng. Ali Asal from Ministry of Agriculture (sitting next to Takeuchi-san)*

Our first experiment of planting Jatropha was not meant to be for biofuel but as a means of afforestation, improving environment and as a way of safe disposal of waste water. We started with 3000 feddans in Upper Egypt between Assuit and Aswan.

Dr. Soheir Abu El Ela, Professor of Technology of Treatment of liquid waster, National Research Center

No one is against Jatropha for environmental protection or for biodiesel but let's conclude

1- We need a bank of information about what has been done in Egypt so far. A kind of database

2- A steering committee is needed to work together and have a unified vision and mission. First we should set a goal and then our mission to accomplish this goal supported by a pre feasibility study to see what is the top priority benefit of planting Jatropha

Speaker, *Dr. Mohamed El Hakim, NANSC*

We're working under umbrella of ICOE. If ICOE certified biofuel in aviation, we'll follow. If it is certified, we'll implement it

Concluding remarks of MTI Chairperson

MTI will prepare a memo of what has been discussed and all the recommendations during the workshop and will circulate among participants by email. MTI will report the findings to Minister of Trade in order to put it on table in the Supreme Energy Council for discussion.

A2 MOH Ministerial decree of establishing a committee to rearrange afforestation watered by treated wastewater and responsibility to HCWW from MALR and other governorates

<UNAUTHRIZED TRANSLATION>

Arab Republic of Egypt
Ministry of Housing,
Utilities and Urban
Development
Minister's Office
Postal Code 11516

Decree
Minister of Housing
And Utilities and Urban Development
Number (439) for year 2008

Minister of Housing, Utilities and Urban Development

- After review of the law number 203 for the year 1991 regarding issuing regulation Public Sector companies and its executing regulation.
- And the Republic decree Number 135 for the year 2004 issued on 2004/4/27 for establishing the Holding Company for the Water and Wastewater and its affiliated companies.
- And note of the chief adviser of the consultant board to the cabinet, number 4526 for the year 2008, including prime minister's approval on reallocation of the previously allocated land from the Ministry of Agriculture and Land Reclamation and from some governorates for forests of trees, to the Holding Company for the Water and Wastewater, in execution of the recommendation of the ministerial group for services in its meeting, which was held on 2004/11/6, which also necessiates establishing a committee representing all relevant organizations to implement it.
- And on what the chairman of the Holding Company for the Water and the Wastewater proposed us by his note dated 2008/8/17.

Decree

<Article 1>

Establishing a committee to adjust the rights and the duties derived from allocation of previously allocated land from the Ministry of Agriculture and Land Reclamation or from some governorates for forests of trees to the Holding Company for Water and Wastewater and its affiliated companies, and to issuance of necessary decrees that will represent an evidence of ownership of the land for the referred companies, headed by Dr. Abdelqawi Mohtaz Khalifa, Chairman of the Holding Company for the Water and Wastewater, and other members' whose names are as follows:

1. General / Assaid Nasr Arafat	Member of administrative board of the Holding Company for Water and Wastewater
2. Advisor / Mohamed Yusri Zein Al-Abdin	Head of advisory group to the cabinet
3. Advisor / Assam El-Din Abdedlaziz Gad-el-haqq	Deputy Head of State Council and legal advisor to the Ministry of Housing and Utilities and *Urban Development*
4. Advisor / Osama Yusef Shalby	Deputy Head of State Council and legal advisor to the Ministry of Housing and Utilities and Urban Development
5. General / Ahmad Mohamed Amrag Al-Faiyoumy	Holding Company for Water and Wastewater
6. Dr. / Ziyad Ahmad El-Menshawi	Holding Company for Water and Wastewater
7. Mr. / Mahmoud Ahmad Shahin	Holding Company for Water and Wastewater
8. Mr. / Mohsen Abdelmagied Abdelrahim	Holding Company for Water and Wastewater
9. Eng. / Mohamed Ahmed Mostafa	Head of Central Department for Afforestation, Ministry of Agriculture
10. Representative for Ministry of Housing and	The relevant Minister will assign

<UNAUTHRIZED TRANSLATION>

Utilities and Urban Development

11. Representative for Ministry of State for Local Development	The relevant Minister will assign
12. Representative for Desert Development	The relevant Minister will assign
13. Representative for Survey Authority	The relevant Minister will assign
14. Representative for Ministry of Environment	The relevant Minister will assign
15. Representative for governorate in which the allocated Land lies	The relevant Governor will assign

<Article 2>
Working group referred in the Article 1 undertakes following responsibilities:

1. The committee is responsible to adjust the rights and duties that will be derived from reallocation of the previously allocated land from the Ministry of Agriculture and Land Reclamation or from some governorates for forests of trees to the Holding Company for Water and Wastewater and its affiliated companies
2. Handing over these lands to the Holding Company for Water and Wastewater

<Article 3>
Amount of 700 Egyptian Pound is paid for every head of committees and members as allowance for attendance, such that such allowance is paid by the Holding Company for Water and Wastewater.

<Article 4>
A committee has a right to make separate smaller committees to study and prepare reports and what is assigned for them, and to raise their reports to the main committee.

<Article 5>
This decision is effective from the date of issuance and the concerned authorities should implement it.

Issued on 2008/11/20

Ministry of Housing,
Utilities and Urban Development

Ahmad El-Maghrabi

A3 Summary of Egyptian Biofuel Industry Development Study (JICA2007)

Summary and Recommendations

1. **Experiment on Jatropha in Egypt proved to be successful**
The National Programme for The Safe Use of Treated Sewage Water For Afforestation has already demonstrated the potential of Jatropha in Egypt by proving that the Jatropha cultivation with treated wastewater has a higher productivity of oil-seeds compared to other arable/semi-arable cultivation with natural condition.

2. **Potential benefits from a "Egyptian Jatropha Biofuel Program" will be substantial for Egyptian Economy in the following areas**:
(1) Creation of one billion dollar new industry (new biofuel industries in Egypt),
(2) Creation of one million jobs (direct and indirect new employment),
(3) Practical development program for rural development,
(4) Creation of green buffers for anti-desertification (profitable use of waste land),
(5) Beneficial use of waste water with further sewage system extension,
(6) Cost reduction of drinking water production in Lower Egypt,
(7) Contribution to worldwide efforts against global warming (CDM applicable).

3. **Public Private Partnership (PPP) is the most suitable strategy** to realize the one billion biofuel industry in Egypt. Each party has clear roles and needs to collaborate closely in development of public's bioenergy policy and sewage system improvement, and privates' biofuel supply chain development.

4. **Egyptian Biofuel Policy is required to be declared** as solid determination of Egyptian government on bio-energy utilization as alternative energy, leading to enhanced private investments in this new industry. For a meaningful "Bioenergy policy", a governments' committee on renewable energy should be set up under the leading agency such as the Ministry of Trade and Industry. At least, the following key agencies should be included in the renewable energy committee: (1)the Prime Minister's office, (2)Ministry of Trade & Industry, (3)Ministry of Housing, (4)Ministry of Agriculture, (5)Ministry of Environment (6)Ministry of Energy, (7)Ministry of Finance, and (8)Ministry of Investment (MOI)

5. **Use of the waste water system is another key to the success** on the part of public sector's engagement. With a smart collaboration of publics' sewage improvement and privates' biofuel supply chain development, the government is able to improve the publics' environmental health with minimum costs. The budget for the improvement may be funded by international donors.

6. **Biofuel Supply Chain Development should be advanced by the private sector**. It should be

encouraged to engage in establishing sustainable industries in Egypt with waste water and waste land to be provided by the public sector. The supply chain includes land reclamation and irrigation system, Jatropha plantation and oil-seed production, oil extraction and refinery, and international sales of BDF, including possible domestic BDF distribution in the future.

7. **Upper Egypt with a focus on the area from Assiut toAswan is the most suitable location for the pilot biofuel industry development.** Initial seed-bank plantation should be started at existing/extended Jatropha plantations in Luxor and Sohag as soon as related agencies and project participants are agreeable

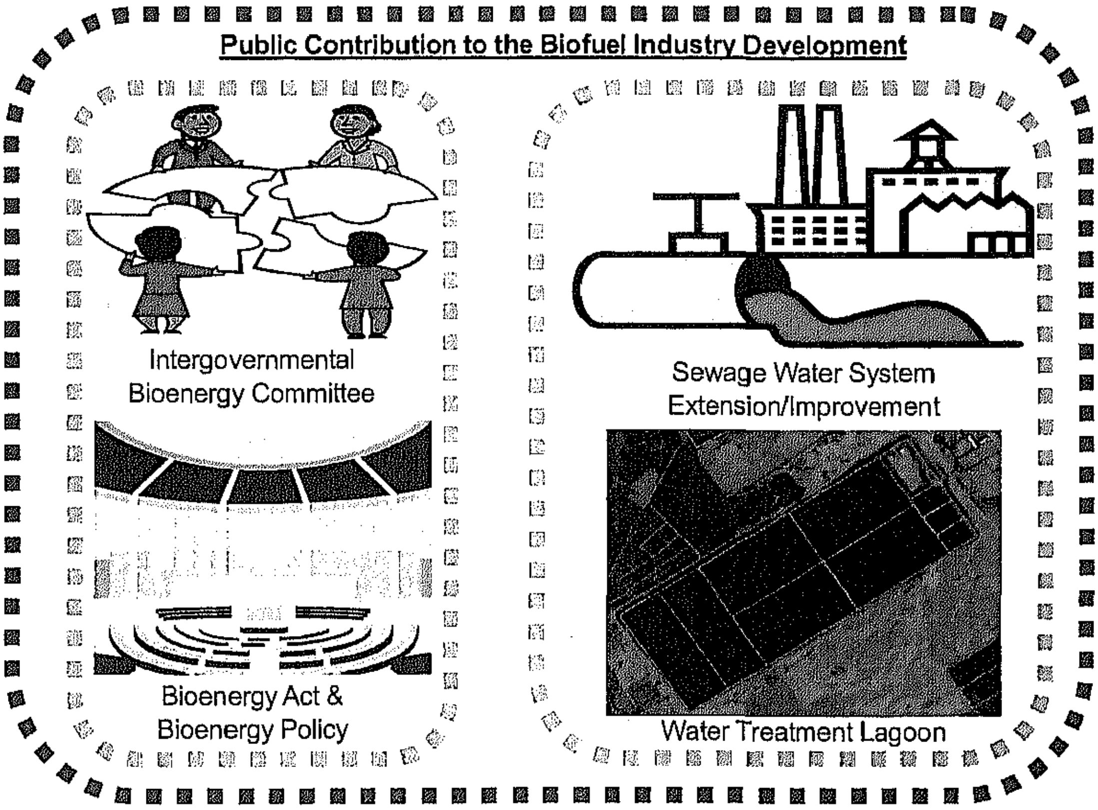
8. **Additional feasibility study for the "Jatropha BDF pilot project" is required** after this preliminary study. It should cover the strategic plan for the bioenergy committee, the wastewater system improvement, the Jatropha supply chain development plan. It should be a coordinated plan for potential investors, plantation, oil extraction and refinery plant, exporting system, the socio-economic impact and environmental impact study, and recommendations. Such study can be carried out as a technical assistance by aid agencies such as JICA or others.

9. **Concept of the Egyptian Jatropha BDF Industry Development**

In order to realize commercially viable biofuel industries, the Egyptian business model needs to be developed with a strong partnership between public/government and private sectors. Unlike other biofuel development in Asia, America, and Africa, a public contribution in an extension of further swage water treatment system and an implementation of biofuel policies are necessary components of the Egyptian business model. In short, the Egyptian Jatropha BDF business model cannot be achieved without the public contribution.

The concept of the Egyptian BDF model is as follows;

1. Public contribution to put biofuel policies in force,
2. Public contribution to extend swage water system and simple treatment system,
3. Private contribution to establish commercial plantation with treated water irrigation,
4. Private contribution to extract Jatropha oil and produce BDF,
5. Private contribution to establish BDF exporting system,
6. Public contribution to facilitate the BDF exporting hub/port.



Private Contribution to the Biofuel Industry Development

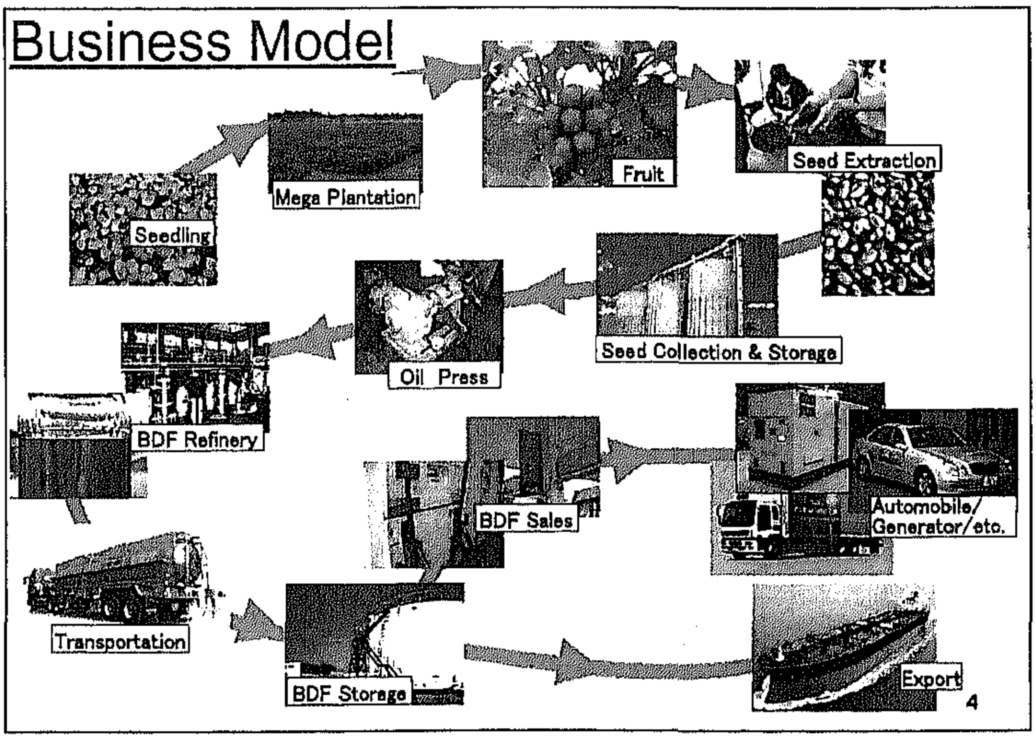


Figure. Concept of BDF Business Model

A4 Egyptian Code for Using the Treated Wastewater in the Field of Agriculture (ECP501-2005)

The Egyptian Code for Utilizing the Treated Municipal Wastewater in the field of Agriculture

ECP 501-2005

Arab Republic of Egypt

Ministry of Housing, Utilities & Urban Development

The Housing and Building National Research Center

Contents of the Code 501

Annex 1: The Egyptian Directory Guide for utilizing the Treated Municipal Wastewater in the field of Agriculture

Annex 2: Methods of Analysis performed to assess pollution status occurring in each of Soil,

Plant and Water
First Chapter: Soil Analysis
Second Chapter: Plant Analysis
Third Chapter: Water Analysis
Fourth Chapter: Examination of Biological Pollutants

Followings are **UNAUTHRIZED TRANSLATION and REFERENCE PURPOSE ONLY.**

Chapter 4

Standards and Measures for Reusing Certain Types of Treated Municipal Wastewater for Agricultural Purposes

4.1 According to this code, the use of raw wastewater is prohibited. Wastewater that has not undergone at least primary treatment may not be used in any agricultural purposes.

4.2 The code classifies municipal wastewater by level of treatment into three grades: A, B, and C. These grades are determined by the efficacy of the treatment processes undergone toward the minimum limits corresponding to some physical, chemical, and biological standards. This chapter shall provide a detailed description for these standards.

The aforementioned classification is based on the provisions stated in Law no. 93 of 1962 and its Executive Regulation, and on the provisions of Ministerial Decree no. 44 of 2000, which define raw municipal wastewater as that which results from home, commercial, and industrial uses, without treatment undertaken to turn it into treated water.

4.3 Grade (A) Treated Municipal Water:

Grade A is an advanced treatment that can be attained through upgrading secondary treatment plants to include sand iteration, disinfection, and other processes. In view of the high cost of such treatment, it is reserved to be used in special cases when circumstances require.

4.31. Physical and chemical standards required for good advanced treatment are as follow:

Biological Oxygen Demand (BOD_5): no more than 20 mg / Liter.

Suspended Substances (SS): no more than 20 mg/liter.

4.3.2 Standards required with regard to the percentage of micro-organisms are as follows:

Probable number of colonic bacteria in 100 cm^3: should not exceed 1000.

The number of cells or eggs of intestinal nematodes (No. / Liter): should not exceed 1.

4.3.3 To conform to the physical, chemical, and biological standards illustrated in the previous item, the technology of activated sludge, or any alternative technology, should employed. Afterwards, the resulting water should be directed to supplementary units for advanced treatment. For example, units for adding coagulation chemicals, direct or contact filtration, or sterilization may be used.

4.3.4 To achieve the required limits of disinfecting treated water from micro-organisms, we should apply at least one of the following alternatives:

A – Chlorine Purification Units:

Actual stand time: 20 minutes at least.

Concentration of remaining Chlorine: 0.5 mg / Liter after the actual stand time.

B – Ultra Violet Purification Units (UV). Safety procedures should be provided in this case.

4.3.5 The holding entity provides for the following alarm systems in wastewater treatment plants that produce treated municipal water of Grade (A):

- An alarm triggers if there is a break in the circuit whereby electricity cannot flow. An alternative source (generator) should be available of a capacity enough to operate the basic treatment units at least.
- An alarm triggers if there is a failure in pumps and air distributor.
- An alarm triggers if there is a failure in purification equipments or when the percentage of remaining chlorine is low.

4.4 Grade (B) Treated Municipal Water:

- Grade (B) represents secondary treatment performed by existing wastewater treatment plants in Egyptian villages and towns. Secondary treatment is undertaken by any of the following techniques:
  - Activated Sludge
  - Oxidation Ditches
  - Trickling Filters
  - Stabilization Ponds
- Physical and chemical properties of Grade (B) treated wastewater should conform to the standards stipulated in the Articles 66 and 67 of Law No. 48 of 1982, which is illustrated in following Table No. (4.4), except for the number of cells or eggs of intestinal nematodes (No. / Liter).

4.5 Grade (C) Treated Municipal Water:

- Grade (C) represents the type of treated water produced by treatment plants that confine their operations to preliminary treatment (filters and sand and oil removal basins) and primary treatment (sedimentation basins).
- Physical and chemical standards required for treated municipal water of Grade (C) are as follow:

  Biological Oxygen Demand (BOD_5): no more than 20 mg / Liter.

  Suspended Substances (SS): no more than 20 mg/liter.

  There are no specific conditions or standards with regard to the elimination of micro-organisms for this grade.

Description	Substances Maximum Limit stipulated for in Treated Municipal Water (mg/liter – unless otherwise provided)
Temperature	35 Celsius
pH	6 – 9
Biological Oxygen Demand	60
Chemical Oxygen Demand (Dichromate)	80
Chemical Oxygen Demand (Permanganates)	40
Dissolved Oxygen	4 at least
Oils and Lipids	*10*
Dissolved Substances	2000
Suspended Substances	50
Colored Substances	Free from colored substances
Sulfide	1
Cyanide	-
Phosphate	-
Nitrates	50
Fluoridates	-
Phenol	-
Total Heavy Metals	1
All Types of Lethal substances	
Probable number of colonic bacteria in 100 cm^3	

4.6 Table No. (4.2) summarizes the standards required for A, B, and C levels of treated wastewater pursuant to the description provided in this chapter.

4.7 Table No. (4.3) illustrates the guidelines concerning chemical substances' maximum limits in treated wastewater used in irrigating plants and crops. These limits take into account all levels of treatment.

4.8 The independent entity that operates the project of treating wastewater for reuse in agriculture may improve the quality of wastewater treatment to a higher level, whether through additional treatment, purification, or dilution, after obtaining an approval from the concerned ministries.

Table No. (4.2) Standards Required for the Grades of Treated Municipal Wastewater Reused in Agricultural Purposes*

Limits and Standards	Treatment Level	Grade A	Grade B	Grade C
Maximum Limit of Physical and Chemical Properties of Treated Wastewater	Biological Oxygen Demand(1) mg/liter	< 20	< 60	< 400
	Suspended Materials, mg/liter	< 20	< 50	< 250
Maximum Limit of Biological Properties of Treated Wastewater	Probable Number(2) of Colonic Bacteria in 100 cm^3	< 1000	< 5000	Indefinite
	Probable Number of Intestinal Nematodes, No./liter	< 1	< 1	Indefinite

(1) After filtration.

(2) In case it is difficult to conduct Escherichia Coli test, it may be substituted by Fecal Coliforms.

* This table is a subsequent amendment for the Ministerial Decree no. 44 of 2000, amending the Executive Regulation No. 93 of 1962 concerning the discharge of liquid wastes.

Table (4-3)

Guidelines for chemical criteria of treated wastewater reused for irrigation purposes

Element Long term use [1]	Maximum concentration	Milligram/L Short term use [2]
Aluminum (Al)	5.00	20
Arsenic	0.10	2
Beryllium (Be)	0.10	0.5
Cooper (Cu)	0.20	5
Fluorine (F)	1.50	15
Iron (Fe)	5.0	20
Lithium (Li)	2.50	2.5
Manganese (Mn)	0.20	2
Nickel (Ni)	0.20	2
Lead (Pb)	5.00	10
Selenium (Se)	0.02	2
Cadmium (Cd)	0.01	0.05
Zinc (Zn)	5.00	10
Chromium (Cr)	0.10	1
Mercury(Hg)	0.002	0.002
Vanadium (V)	0.10	1.00
Cobalt (Co)	0.05	5
Boron (B)	1.0	2.00
Molybdenum (Mo)	0.01	0.05
Phenol	0.002	0.002
Total dissolved solids (TDS)	2000	3000
Total phosphate ion (PO4)	30	30
Chloride ion (CI)	400	400
Sulfate ion (SO4)	500	500
Bicarbonate ion (HCO3)	400	400
Sodium adsorption rate (SAR)	6-9	6-9
Sodium cation (Na)	230	230
Magnesium cation (Na)	100	100
Calcium ion (Ca)	230	230

Source: FAO, 1992, National Academy of Science-National Academy of Engineering (1973)

1- Water could be used continuously and in all soil types.

2- Water could be used up to 20 years in all types of fine-grained soil either neutral or alkaline.

Chapter 5

Plants and crops prohibited or irrigated by treated wastewater

5-1 This code defines the following prohibited uses of the treated wastewater:

5.1.1 The treated wastewater is prohibited to be used, whatever the treatment level is, in planting vegetables whether eaten raw or cooked.

5.1.2 The treated wastewater is prohibited to be used, whatever the treatment level is, in planting all kinds of fruit trees eaten raw without peel such as guava and grapes, etc.

5.1.3 In any event, the treated wastewater is prohibited to be used in irrigating export crops, including cotton, rice, onion, potatoes, medicinal plant, aromatic plants, citrus plants, and whatsoever included in the concerned administrative decisions of strategic crops to avoid the counter marketing advertising.

5.1.4 The treated wastewater is prohibited to be used in irrigating children gardens and schools.

5.2 The classification of plants and crops allowed to be irrigated by the treated wastewater:

According to this code, the plants and crops allowed to be irrigated by the treated wastewater is divided into 3 agricultural groups, which in turn are subdivided into 11 groups. This classification is based on the local conditions to cope with the reuse of treated wastewater with its three degrees.

Table (5.1) indicates the referred classification.

Table (5-1) Classification of plants and crops irrigable with treated wastewater*

Grade	Agricultural group	Description
A	G 1.1 Plants and trees grown for greenery at tourist villages and hotels	Grass, Saint Augustine grass, kinds of cactus, ornamental palm trees, climbing plants, fencing bushes and tree, wood trees, and shade trees
	G 1.2 Plants and trees grown for greenery inside residential areas at the new cities	Grass, Saint Augustine grass, kinds of cactus, ornamental palm trees, climbing plants, fencing bushes and tree, wood trees, and shade trees
B	G 2.1 Fodder / feed crops	Sorghum
	G 2.2 Trees producing fruits with peel	On conditions they are produced for canning and manufacturing purposes such as lemon, mango, olive trees, date palms, and nuts such as almond and pecan
	G 2.3 Trees used for forestation of highways and green belts around cities	Casuarinas, camphor, Athol tamarix, oleander, fruit producing trees, date palms, and olive trees
	G 2.4 Nursery plants	Nursery plants of wood trees, ornamental plants, and fruit trees
	G 2.5 Roses and cut flowers	Local roses, eagle roses, bulbs (e.g. gladiolus, Bird of Paradise, etc.)
	G 2.6 Fiber crops	Flax, jute, hibiscus, and sisal
	G 2.7 Mulberry for producing silk	Japanese mulberry
C	G 3.1 Industrial oil crops	Jojoba, castor, and Jatropha
	G3.2 Wood trees	Kaya, camphor, and other wood trees

G: group

* It is allowed to use upper grade treated wastewater to plant similar groups of lower grade treated wastewater without contradiction to what mentioned at the item (7.4).

Sixth Chapter

The Regulations and conditions related to irrigation methods

6.1 This code defines the using of any of the following irrigation methods of the irrigable plants and crops with the treated wastewater:

A. Flood Irrigation (Furrow irrigation): The ground surface is completely covered by water.

B. Basin Irrigation: The water is moved to basins through hoses.

C. Furrow Irrigation: The water is covered a part of the land.

D. Drip Irrigation (localized irrigation): It realizes the least contact between treated wastewater and both the field workers and irrigated plants.

E. Subsoil Irrigation: An irrigation method similar to drip irrigation. It would be of greater benefit in limiting the contact between the field workers and treated wastewater used in irrigation.

F. Bubbler Irrigation: a localized irrigation method which is under pressure with organization of flow rate.

G: Sprinkler Irrigation: low pressure and high flow rate pop-up sprinklers of an angle of less than 11 degrees with the horizontal extension.

6.2 This code agrees in its conditions related to select of irrigation method with instructions manual *prepared by the FAO, showed in detail at the table (6.1).*

Table (6.1)

Elements of selection of irrigation method using the treated wastewater and protection measures

Irrigation methods	Selection elements	Protection measures
Flood Irrigation	- The lowest cost method	- It is necessary to apply effective system to protect field workers and who deals with crops and consumers
Furrow Irrigation	- low cost method - land needs to be leveled	- It is necessary to apply effective system to protect field workers and who deals with crops and consumers
Sprinkler Irrigation	- medium water use efficiency - land needs not to be leveled	- It is only allowed to use low pressure and high flow rate pop-up sprinklers with angle of less than 11 degrees
Subsoil and localized Irrigation	- The highest cost method - The highest water use efficiency - the method has a positive effect on land productivity for plants and crops	- the field workers must be well trained - needed technical precautions must be taken to prevent pipelines