

Research Paper on
Strategy for Supply Chain Development of
Bio-Diesel as an Alternative Fuel in Pakistan

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Abstract

Bio-diesel is a clean burning alternative fuel, produced from domestic, renewable resources. It is Biodegradable, nontoxic, and essentially free of sulfur and aromatics. Bio-Diesel is usually blended with hydro-carbon diesel with ratios 10-90 (called B-10) or 20-80 (called B-20). This Bio mix is a tested model in various countries for use as alternative fuel.

Bio-Diesel can be produced from a number of seed oils (used and un-used). The production process for resources vary from one to another in terms of minor operational deviations. The flow line from stakeholder to consumer consists of growing of seeds, oil extraction, chemical treatments and consumption. This flow line involves a number of characters that can play their specific roles behind the stage.

The paper proposes a strategy for development of supply chain mechanism for use of Bio-Diesel as an alternative fuel in Pakistan. The rational of paper is introduction of Bio-Diesel including its viable sources in Pakistan and its subsequent benefits, principle

motivators for the production of Bio-Diesel in Pakistan and world wide development in this field.

The actual theme of this paper is supply chain development strategy in Pakistan, which covers demand management, identification of inventory requirements, devising the production process flow, deployment models and basic infrastructure requirements.

The attributes covered are availability of raw materials, production processes, handling, transportation, distribution and storage between in different stages. In the end, authors have described expected challenges and uncertainties in deploying supply chain of Bio-Diesel as an alternate fuel in Pakistan, and the possible solutions.

This paper does not take into account the economic aspect as a focal element of consideration. The reason being that at this point of time, the best possible solution may terminate due to economic considerations. The intention is to device such system that can economize itself with expansion and deployment.

1. PREAMBLE

1.1 Introduction to Bio-Diesel:

Bio-diesel is a clean burning alternative fuel, produced from domestic, renewable resources. It is Biodegradable, nontoxic, and essentially free of sulfur and aromatics. In modern world the use of Bio-diesel is preferred due to environmental reasons. In Pakistan the Bio-diesel is unknown. Bio-Diesel is usually blended with hydro-carbon diesel with ratios 10-90 (called B-10) or 20-80 (called B-20). This Bio mix is a tested model in various countries for use as alternative fuel.

The universally understood advantages of using Bio-Diesel are:

- Utilization of Domestic Natural Resources as Raw Material
- Promotion of Green Resources
- Substitute to Hydrocarbon Diesel
- Cheaper Infrastructure required
- Reduced Engine Emissions
- Availability Possible in Far Flung Rural Areas
- No Competition

1.2 International Statistics:

Bio-Diesel is currently commercially produced in Germany, Italy, Austria, Czech Republic, Malaysia and United States, and is most advanced in the United States and Europe, which currently produce 2 billion and 1 billion liters of Bio-Diesel per year respectively. In Germany there are over 1000 outlets where Bio-Diesel is cheaper than standard diesel. France, currently the largest user of Bio-Diesel in the world, has a minimum mix of 5% in all diesel sold.

2. ENVISIONED SUPPLY MODELING:

Bio-Diesel can be used in the form of different models in Pakistan to start with.

Following sectors have been targeted to study the supply chain:

- Transport Sector
- Industrial Sector
- Power Generation Sector
- Agriculture Sector

There are broadly two forms of models to initiate the interface of bio-mass technology with domestic infrastructure. One is a closed loop solution, which introduces a concept of **self-made Bio-Diesel** for the consumer. Other is the conventional model involving number of direct and indirect stake holders.

For the closed loop system, the entire cycle from raw material to production to consumption is managed by the user. Infrastructure is established through customization of existing options. Non-public communities and commodities having a large scale collective requirement of Bio-Diesel are the best fit for this model. These can generate their raw material through available infrastructure, manage the production in local vicinity and consume their and then.

The other model will address commercial users for which, there has to be an independent system with independent stakeholders in place for storage, transportation and supply of raw material. Likewise, independent production units purchase the raw material and deliver product to the distributors for retail.

The strategy for supply chain broadly addresses both the models from a single eye. The micro details of implementation will be the derivatives of strategy.

Considering the above-mentioned models and botanical studies on Bio-Diesel resources, following are selected for production of Bio-Diesel in the beginning.

- Oil extracted from Pongamia Pinnata seeds
- Oil obtained through transesterification of waste vegetable oil

2.1 Supply Chain with respect to Bio-Diesel:

Bio-Diesel, like any typical engineering cycle, involves maximum elements of supply chain, which are listed below:

- Demand management
- Production
- Storage at all levels
- Transportation between all levels
- Distribution
- Consumption

2.2 Experimented Yields:

Raw Material	% Seed Yield	% Oil Yield
Pongamia Pinnata	2.5 tons per hectare	25 lit bio-diesel / 100 kg seed
Waste Vegetable Oil	N/A	80 lit bio-diesel / 100 lit WVO

3. THE SUPPLY CHAIN OF BIO-DIESEL:

3.1 Demand Management:

3.1.1 Raw Materials Availability:

- Pongamia Pinnata Seed

Pongamia Pinnata can be cultivated as a non-cash crop and does not necessarily occupies the land, which is

reserved for regular / routine cultivation. In first phase existing plantation of these plants can be used. This plantation is scattered in Pakistan and no reliable data exists for their locations. However, the scattered availability will introduce a constraint of difficulty in seed collection. Thus planned plantation is must on a large scale.

In this regard government has to take following steps:

- Offer of financial aids to farmers.
- Announcement of special incentives like free saplings, seeds
- Announcement of purchase price of seed before plantation (refer to practices of agricultural cash crops).
- Plantations on state lands.

In addition to availability, wholesale markets are also required for distribution of seeds. For that, the existing markets of cash crops can be customized and used.

- Waste Vegetable Oil

In this category two main sources are available:

- **Domestic**

House hold users.

- **Industrial**

Hotel industry, Restaurants chains, Industry consuming edible oils.

Collection of WVO from both the users is a complex process and needs to be established properly. Some suppliers of WVO are already existing that can be tapped. For house hold users there may be a welfare oriented collection mechanism like offering a bottle of clear water in replacement of one bottle of WVO.

This may be further improved by introduction of bigger containers and then to collection points at some places.

Following steps are required for availability of WVO:

- Determination of fixed price for WVO.
- Expansion and customization of WVO wholesale markets.
- Expansion and customization of collection and supply mechanism.
- Public awareness through media.

3.2 Storage of Raw Material:

Storage of raw materials can be built in the wholesale markets. Seeds can be stored with normal agricultural practices. Metal tanks with prevention from contamination are good enough for storage. Storage capacity must fulfill the seasonal variations.

A **designated Govt. department or Trading Corporation of Pakistan** should control the supply of seeds to consumer. Thus, there should be capacity building strategy at a gradual pace.

3.3 Transportation of Raw Material:

The transportation mechanism is available in the country at wide scale with plenty of options. Both road and rail transportation systems are recommended for seeds as well as WVO for transportation to wholesale market and production units. The choice of road and rail option depends upon availability of road / rail network and further requirement. Seeds can be handled in existing dampers and likewise, WVO

in tankers. Here it is important to note that WVO requires dedicated tankers due to its exclusive chemical properties and those tankers can not accommodate material other than WVO.

3.4 Production of Bio-Diesel:

Bio-Diesel can be produced by two methods with respect to the types of raw material sources. The production set-ups can be established in Pakistan through a phased approach.

3.4.1 Oil Extraction from Seeds:

Existing oil extraction machines can be used in the first phase. But these machines have low capacity to produce Bio-Diesel. Later on, exclusive oil extraction machines can be brought into use in the extraction plants of Bio-Diesel with capacity to process seed ranging between 1-2 tons per day. Such machines are available in foreign countries with specific options for large scale Bio-Diesel production. The mechanics of these machines is not very complicated and can be re-engineered in Pakistan through indigenization.

3.4.2 Transesterification:

Transesterification is the chemical conversion of WVO to Bio-Diesel. The flow of process can be managed both in the form of flow line and batch production. The process layout for both options is internationally available with consideration of lean set-up and maximum efficiency. Design and fabrication of equipment is not complicated. Reference models can be imported and re-produced. The system integration in the form of production plant is a specialized role.

Government should set-up model units and develop vendors that are specialized in requirement analysis, arrangement of equipment and setting up the plant.

For a small scale Transesterification unit (like 50 – 100 Liters per day) no heavy equipment is required and it can be arranged easily in the initial phase. Later on, units with 500 – 1000 Liters per day capacity can be established, which is also easy to fabricate.

3.4.3 Storage of Bio-Diesel:

The production plants of Bio-Diesel should have appropriate storage place for the end product depending upon the plant capacity.

3.5 Distribution of Bio-Diesel:

Mechanism for distribution of Hydro-Carbon-Diesel to sale points already exists. There is a need of building capacity in existing mechanism. The same can be used with expansion, if required.

3.6 Blending of Bio-Diesel:

Blending can be introduced at any good stage in the entire flow depending upon the whole system in place. To start with, one easily doable and recommended option is to blend in the fuel supply of consuming engine. Difference in specific gravity of Bio-Diesel and hydrocarbon diesel allows the straight mixing and settling when induced through separate dispensers. For this option, separate storage tanks are required at the distribution points.

With the passage of time, mechanized blending equipments can be deployed at oil refineries to produce ready-to-use Bio-Diesel there and then in large quantities. This option

requires transportation of Bio-Diesel to blending facilities at the refineries and extended storage there. However, the benefit is a more centralized approach towards handling and delivery of end product to the distributors.

3.7 Consumption:

Initially, Govt. has to set-up some pilot projects to use Bio-Diesel. The system, with usage, will automatically increase its efficiency. This is explained in the later part of paper.

3.8 On-spot / Self production:

For self production, elements of supply chain that are available in the in-house mechanism are obtained from there and rest are utilized from the over all system.

4. QUALITY ASPECT:

4.1 Quality of Production:

It is understandable that Quality Standards for production of Bio-Diesel do not exist in Pakistan. Internationally available standards can be used in the initial phase. In the later stages, indigenous standards can be developed considering the domestic scenario.

4.2 Certification of Product:

Bio-Diesel has to be chemically compatible with Hydro-Carbon Diesel but it can have same variations as acceptable in the international models (ASTM standards). **The prevailing system in Pakistan to check the quality of fuel is to be used for Bio-Diesel.**

4.3 Certification of Process:

The entire process of obtaining Bio-Diesel from raw seeds shall be documented and approved by the competent authorities and controlled. The facilities and processes for production of Bio-Diesel shall be qualified in the same manner as that of ISO certifications. Only certified agencies shall be permitted to undertake the production of Bio-Diesel.

Government should designate department / company to certify the producers of Bio-Diesel.

4.4 Environmental Concern:

Overall Bio-diesel emissions are lower than gasoline or diesel fuel emissions (with the exception of NO_x). Compared to hydrocarbon diesel, Bio-Diesel produces no sulfur, no net carbon dioxide, up to 20 times less carbon monoxide and more free oxygen. Bio-Diesel has the following emissions characteristics when compared with petroleum diesel fuel:

- Reduction of carbon dioxide emissions (CO₂) by 100%
- Reduction of sulfur dioxide (SO₂) emissions by 100%
- Reduction of soot emissions by 40-60%.
- Reduction of carbon monoxide (CO) emissions by 10-50%
- Reduction of hydrocarbon (HC) emissions by 10-50%

4.5 Safety Requirements:

Safety requirements are to be devised for Bio-Diesel. These instructions are available internationally and in local petroleum industry. For devising safety requirements for Bio-Diesel, guidelines can be taken from existing practices in local petroleum industry viz a viz the difference in requirements of petroleum products and bio-fuels.

these requirements must be devised as per local conditions.

5. DEPLOYMENT OPPORTUNITIES:

As Bio-Diesel opens a new avenue in Pakistani Petroleum Industry, thus its deployment must be a systematic step by step approach. Deployment of Bio-diesel in Pakistan must follow following steps:

- **Establishment of Pilot Model.**

- Government owned pump and its operation for at least 02 years to sustain the supply chain in a cost effective manner.
- Conversion of vehicle fleet of some Govt. department on Bio Diesel.
- Conversion of a Govt. owned industry / factory on Bio-Diesel.
- Supply of Bio-Diesel for agricultural machinery in a specific area.

After at least one year of sales at these pilot models, complete analysis is to be performed to calculate cost effectiveness of the system, effectiveness of supply chain mechanism, cultural growth

After successful running of this pilot model, Govt. is to take steps to introduce the same pilot models in some other major cities.

- Legislations for supply, distribution, production, transportation, handling and blending of Bio-Diesel.

- Establish basic system to support the supply chain development programs in country.

- Promotion of Bio-Diesel Culture.

- Seminars
- Workshops
- Gathering all agencies on single platforms.

- Special relief to the following through tax subsidies.
 - Farmers
 - Oil Production plants
 - Suppliers of WVO
 - Sales points (pumps).
- Target Setting for Government Agencies.
 - Agricultural department for plantation of seeds.
 - Forest Department for plantation
 - Local Govt. for collection of WVO.
 - Ministry of Industries for oil extraction & chemical treatment plants
 - Ministry of petroleum for setting up blending options
 - Pakistan Railways to partially switch over on Bio-Diesel.
 - NHA / Pakistan Railways for plantation along road and track side.
 - Bank loans for new pumps, plantation fields, extraction units.
- Fierce competition from existing petroleum industry
- Existing usages of WVO
- Non existing infrastructure, legislation, supply chain of raw material
- Expected higher price compared to existing petroleum
- Un-awareness in general public and most importantly in the Govt. sector.
- Expected Imbalance Between Supply & Demand
- Poor Coordination, Communication and Understanding among Players
- Lack of Project Endorsement

7. RECOMMENDATIONS:

Based on the above study the authors recommend following:

- Government of Pakistan needs to get committed for the use of Bio-Diesel as an alternative fuel, followed by efficient program management.
 - Bio-Diesel will not only provide energy security but also make the dream of greener Pakistan come true.
 - Pakistan Railway with an annual consumption of approximately 35 million liters HSD can completely switch on B10 by 2008. Land and Infrastructure of Railway can be used for plantation of raw material resources. The oil production and stakes on raw material can be kept optional for Railways or a third party.
 - 50 villages can be switched on B10 for operating agricultural machinery by 2008. This can be a closed model, where entire chain can be managed with in the specific villages to meet the demand.
 - 10 industries can switch their engines on B10 by 2008.
 - 10 retail outlets in urban areas can supply B10 by 2008.
- ## 6. EXPECTED CHALLENGES:
- Currently the use of Bio-Diesel is zero and this is a new thing happening in Pakistan. Every new happening has some barriers that to be managed and reduced efficiently. Some the important challenges to extensive use of Bio-diesel are explained below:

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