

The Role of Renewables in the Transport Sector

1. Current energy scenario

1.1 Background: Past & present

Biofuels have the potential to displace a substantial amount of petroleum around the world over the next few decades. A clear trend in this direction can be seen by the attempts of countries like Brazil, USA, Canada and EU countries to incorporate biofuels into their national energy portfolio. Biofuels for transport include ethanol, bio-diesel and several other liquids and gaseous fuels. With increasingly stringent environmental emission standards coming up, many countries are looking at non – conventional pathways of mitigating pollution. Hence, the increased focus on biofuels. Both developed and non – developed countries have taken a keen interest. Asian countries like India, Malaysia, China and Thailand are today seriously considering the use of biofuels in the transport sector.

1.2 Current levels of energy use/mix for Sri Lanka

Figure 1 represents the different types of primary energy sources currently used for catering these needs. It is also noted that more than 35% of the population do not have access to grid electricity and nearly 76% of the households can not afford gas or petroleum for cooking and depend on firewood or other forms of biomass for their daily food preparation.

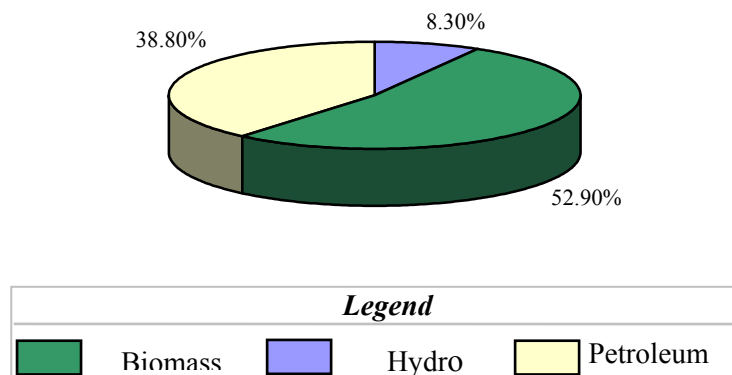


Figure 1: Primary energy sources (% of total)

During the last two decades, the capacity of electricity production has rapidly increased (see Figure 2), with the aim of meeting the increasing demand at a rate of about 8% per annum. This is mainly based on hydro and thermal plants.

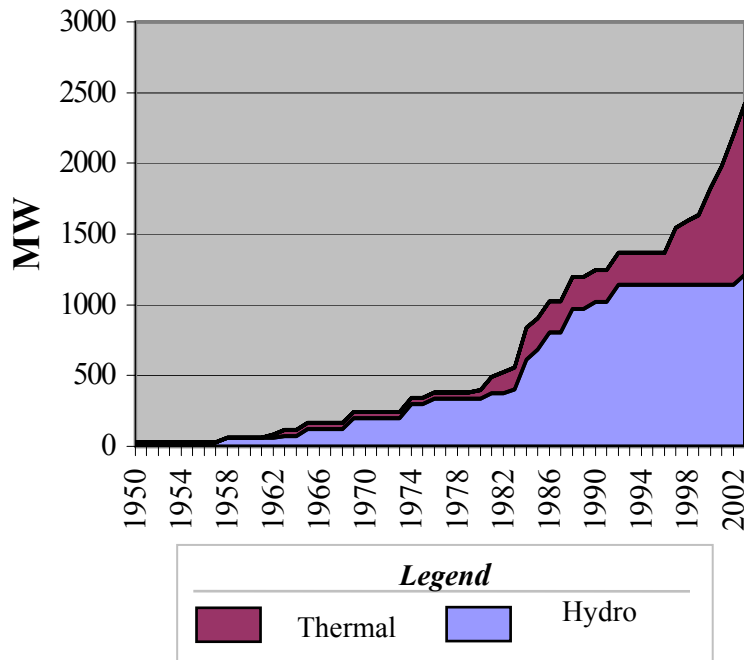


Figure 2: Installed electricity capacity

These figures clearly indicate the growing trend of the use of imported petroleum fuels in the Sri Lanka's energy scenario, since the thermal plants are dependent on oil. However, a recent policy decision will mean that much of the future expansion of the electricity production will come from imported coal (refer section on Grid connection and Off-grid Generation).

1.3 Current end use

The energy consumption in Sri Lanka by sector is represented in three elements (Figure 3). The first is the industrial sector, which encompasses the major energy-consuming industries, like metal industry, chemical industry, agriculture and others. The second sector is the transport sector, including all transportation modes, including those connected with industries, commerce, services and agriculture or households. The third takes into account rest of the energy use in commercial & household sectors.

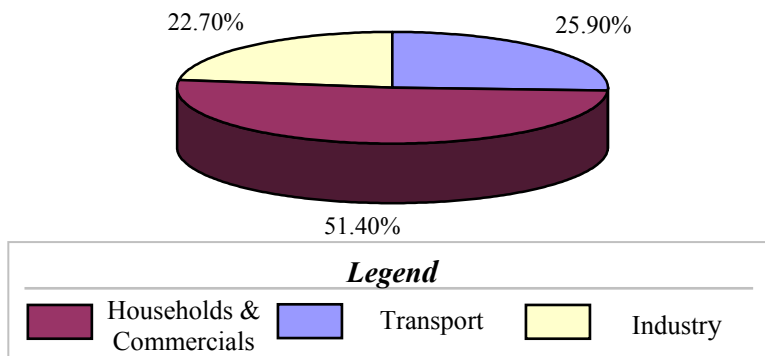


Figure 3: Energy consumption by sector (% of total)

Sri Lanka with an estimated population of over 19 million is almost totally dependent on petroleum fuels for transport with a consumption of around 1.9 million MT of diesel and petrol per year (for 2005). The major players accounting for transport fuels are the state owned Ceylon Petroleum Corporation (CPC) and Lanka IOC Ltd (LIOC). CPC both produces transport fuels at its refinery and distributes, whilst LIOC functions as a distributor only. Since Sri Lanka does not have indigenous sources of fossil fuels, the total petroleum requirement is imported. Almost two-thirds of the petroleum fuel is consumed in the transport sector. In Sri Lanka land transportation is the dominant mode of internal transportation. Sri Lanka needs to look at non – conventional pathways of powering its transport sector if its vehicle fleet is to meet future emissions requirements. One such alternative is to use biofuels; however the country is now only just examining the potential of including biofuels in its energy portfolio.

2 Demand of energy usage in the transport sector

2.1 Current active vehicle fleet by sector

The current vehicle fleet is provided in Table 1

Table 1 Estimated no. of vehicles for Sri Lanka (2004)

Vehicle Type	No
Cars and light vehicles-Gasoline	214,518
Cars and light vehicles – Diesel	24,415
Pick-up & Dual purpose – Gasoline	23,461
Pick-up & Dual purpose – Diesel	141,503
Buses – Gasoline	1,406
Buses – Diesel	43,338
Trucks - Diesel	117,461
Land Vehicles - Diesel	110,274
Motor-cycles - Gasoline	1,007,349
Trishaws - Gasoline	271,915

2.2 Projection of Gasoline and Diesel demand 2015

The following data has been extracted from the report on Urban Air Quality Management in Sri Lanka prepared by the Air Resource Management Centre in the year 2004. The report provides data on Vehicle Type, the Fuel Type, No of Vehicles of each category, the average kilometres run per year and the fuel economy of the vehicle category. The data provided has been adopted to arrive at the fuel demand for each category of vehicle.

Table 2 Estimated average usage and economy of vehicle classes

Vehicle type	Average km/year	Fuel economy litres/100km
Cars and light vehicles - Gasoline	8,000	13.4
Cars and light vehicles - Diesel	15,000	9.2
Pick-up & Dual purpose - Gasoline	8,000	16.6
Pick-up & Dual purpose - Diesel	21,000	12.1
Buses – Gasoline	30,000	16.6
Buses – Diesel	41000	31.33
Trucks - Diesel	52,000	28.6
Land Vehicles - Diesel	12,000	28.6
Motor-cycles - Gasoline	6225	4.3
Trishaws - Gasoline	12,000	5.2

Source - “Urban Air Quality Management in Sri Lanka” - Air Resource Management Center (AIRMAC) - Ministry of Environment and Natural Resources Sri Lanka. - 2004

Table 3 Predicted total fuel demand of the transport sector for three scenarios

Year	Based on last 5 years average growth of the fleet Scenario 1a		Based on last 10 years average growth of the fleet Scenario 1b		Based on polynomial trend Scenario 2	
	Total Gasoline Demand	Total diesel demand	Total Gasoline Demand	Total diesel demand	Total Gasoline Demand	Total Diesel demand
2006	626,142,073	4,439,462,185	751,299,674	3,266,012,166	786,853,833	3,236,028,690
2007	715,438,568	4,867,689,466	797,880,254	3,468,504,921	885,924,115	3,439,891,564
2008	817,687,987	5,341,878,991	847,348,829	3,683,552,226	994,654,103	3,642,585,986
2009	934,802,977	5,867,404,158	899,884,457	3,911,932,464	1,113,043,798	3,844,111,957
2010	1,068,983,749	6,450,316,921	955,677,293	4,154,472,277	1,241,093,199	4,044,469,476
2011	1,222,762,079	7,097,440,146	1,014,929,285	4,412,049,558	1,378,802,306	4,243,658,544
2012	1,399,052,163	7,816,473,493	1,077,854,901	4,685,596,630	1,526,171,120	4,441,679,161
2013	1,601,209,388	8,616,114,929	1,144,681,905	4,976,103,621	1,683,199,641	4,638,531,326
2014	1,833,098,296	9,506,200,355	1,215,652,183	5,284,622,046	1,849,887,868	4,834,215,040
2015	2,099,171,180	10,497,864,221	1,291,022,618	5,612,268,613	2,026,235,801	5,028,730,302

All figures are in litres

Figures 4 and 5 illustrate the figures from Table 3 in terms of changing demand for gasoline products based on the 3 scenarios of prediction.

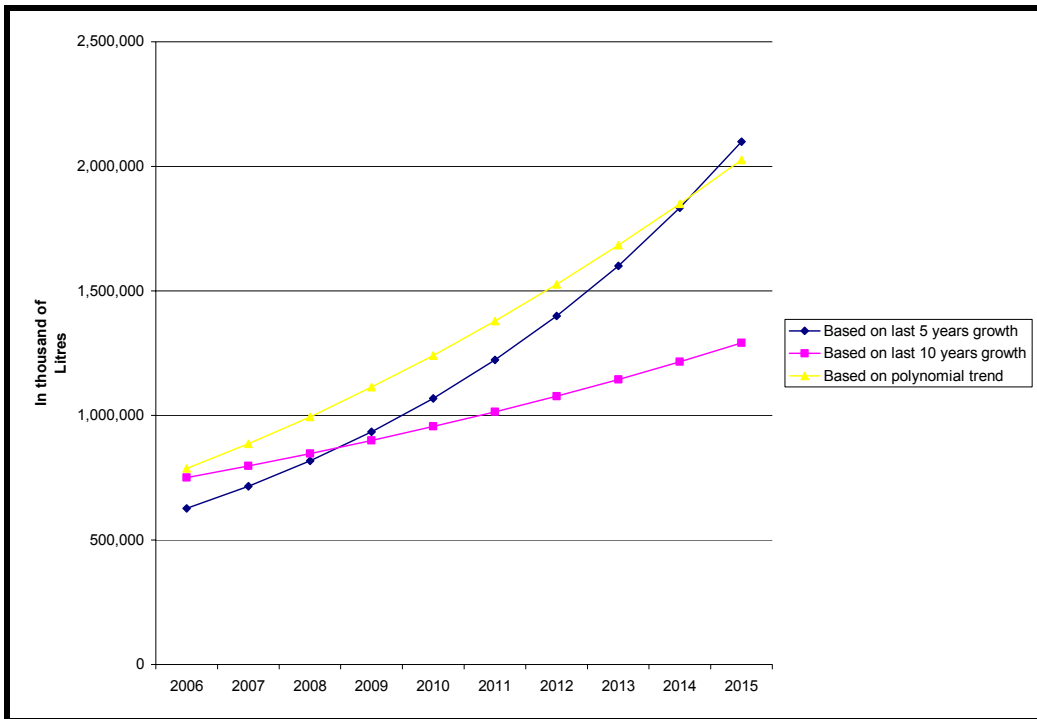


Figure 4 Petroleum demand for the 3 demand scenarios

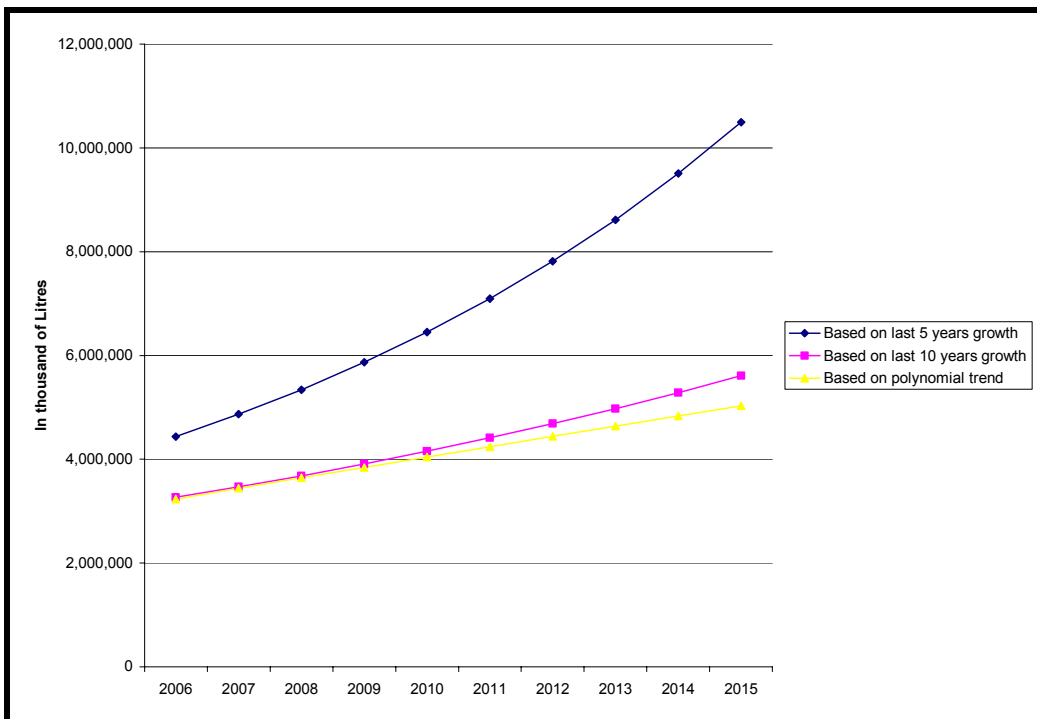


Figure 5 Total Diesel demand based on the 3 scenarios of prediction.

2.3 Future transport options

Table 4 is a simple analysis of the amount of ethanol and bio-diesel that could be used if 10% of the anticipated usage was taken up with these products..

Table 4 Predicted total biofuel demand of the transport sector in all scenarios (litres)

Year	Based on last 5 years average growth		Based on last 10 years average growth		Based on polynomial trend	
	Ethanol Demand	Biodiesel demand	Ethanol Demand	Biodiesel demand	Ethanol Demand	Biodiesel demand
2006	62,614,207	443,946,219	75,129,967	326,601,217	78,685,383	323,602,869
2007	71,543,857	486,768,947	79,788,025	346,850,492	88,592,411	343,989,156
2008	81,768,799	534,187,899	84,734,883	368,355,223	99,465,410	364,258,599
2009	93,480,298	586,740,416	89,988,446	391,193,246	111,304,380	384,411,196
2010	106,898,375	645,031,692	95,567,729	415,447,228	124,109,320	404,446,948
2011	122,276,208	709,744,015	101,492,929	441,204,956	137,880,231	424,365,854
2012	139,905,216	781,647,349	107,785,490	468,559,663	152,617,112	444,167,916
2013	160,120,939	861,611,493	114,468,190	497,610,362	168,319,964	463,853,133
2014	183,309,830	950,620,035	121,565,218	528,462,205	184,988,787	483,421,504
2015	209,917,118	1,049,786,422	129,102,262	561,226,861	202,623,580	502,873,030

In addition to the internal market, in the longer term there might be a potential for exports. It is expected that low cost cane-derived ethanol could be produced to displace about 10% of gasoline and 3% of diesel worldwide. Furthermore, it is expected that this ethanol would mostly be produced in developing countries. Hence, the establishment of a substantial international trade in ethanol can be envisaged. Sri Lanka with its sugar industry may exploit this opportunity if desired. Unfortunately, many countries have import tariffs on liquid biofuels and to date the World Trade Organization (WTO) has not looked into issues related to opening up international trade of biofuels. This is complicated by the fact that almost every country has its own biofuel standard with slightly different specifications.

3. Possible limiting factors

3.1 Institutional and Technical

The main technical barrier for the promotion of biofuels can be noted as the compatibility with existing engine technology and the amount of adaptation that will be necessary. Generally speaking, most of these issues have been resolved and substitution of petrol by petrol-ethanol mix gives few problems if the proportion is kept at around 10%. Again trials in Europe with vegetative-based bio-diesel have indicated that the level of modification needed to the standard engine is relatively limited.

Development of this technology at a scale to have a marked impact on the replacement of fossil fuels will need to overcome the inevitable financial constraints and the institutional barriers imposed by financial institutions to provide credit at commercial rates.

Institutional Barriers

These can be described as the lack of communication and co-operation among the stakeholder institutions to achieve the common goal of promotion of biofuels and related technology transfer. This may also be indirectly linked to information barriers where some institutions may not be aware of their role as a stakeholder in a particularly emerging sphere of activity on a regional or global scale. Lack of institutional communication and corporation between the public and the private sector institutions for complementary strengths resulting from attitudes and work ethics could become a huge barrier.

Policy Barriers

The government policies on, industrial, technology, environment, economic and social development and transport will have direct or indirect bearings on the promotion of biofuels and related technologies. The Government's policy planning and implementing engine should be made aware and sensitized about the current technical and market trends, direct and indirect benefits including socio-economic-environmental. The absence of these policy initiatives results from the non-existence of a mechanism to sensitize the government's policy makers on the importance of such technical developments.

3.2 Availability of the Resources

Land

The Sri Lanka Forestry Sector Master Plan (FSMP) published in 1995 is based on three basic hypotheses:

- The total surface of agricultural land will remain approximately constant
- Improved technologies will lead to an increased productivity
- This increase will be proportional to the population increase.

Table 5 below presents the distribution of land use by type of biomass resource according to these predictions of the FSMP.

Table 5. Distribution of land by type – current state and previsions

Land type		Area (1000 ha)		
		1994	1997	2010
Urban land		26.6	28.2	31.8
Agricultural land		3875.9	3992.0	4187.4
	Paddy and other annuals	844.4	844.4	844.4
	Sugar cane	16.8	16.8	16.8
	Tea	189.8	189.8	189.8
	Rubber	196.5	196.5	196.5
	Coconut	300.7	300.7	300.7
	Homesteads	858.5	930.6	1005.1
	Perennials	100.2	102.6	109.5
	Sparsely used crop land	1369.0	1410.6	1524.6
Natural forests and mangroves		2046.5	1908.6	1613.3
	Closed-canopy forests	1574.0	1467.1	1240.1
	Sparse forests / Scrub lands	463.8	433.3	366.3
	Mangroves	8.7	8.2	6.9
Forest plantation		88.3	95.3	119
	Productive	66.4	69.4	79.4
	Poor quality	21.9	25.9	39.6
Wetland and barren land		410.3	410.3	410.3
Other open land		68.0	86.0	170.3
Total		6515.6	6515.6	6515.6

(Source: *Sustainable biomass production for energy in Sri Lanka, Biomass & Bioenergy, Issue No.26*)

Figure 6 presents an overview of the location of the main biomass resources.

3.3 Production Capacity for Ethanol

The Sri Lankan transport sector is totally dominated by petroleum fuel usage such as LPG, petrol (gasoline) and diesel oil. Biofuels are currently not used at all. Nevertheless, Sri Lanka does have a small ethanol producing industry integrated with sugar production. Ability to produce ethanol from sugar molasses does exist at the sugar factories at Sewanagala (capacity 110MT/Day of sugar) and Pelwatte (capacity 330MT/Day of sugar) which are now two privatized companies. Any ethanol produced here is used exclusively in the alcoholic beverage industry as there is no market for industrial alcohol.

Sugarcane has been grown both under irrigated and rain fed conditions in Sri Lanka since the mid 1950's. The climatic conditions pose some difficulties for rain fed cultivation of sugar cane in the intermediate dry rainfall zones. The long dry season in June to September affects cane growth night temperatures rarely fall below 20°C adversely

affecting the formation of sucrose in sugar cane which needs cool nights for its formation.

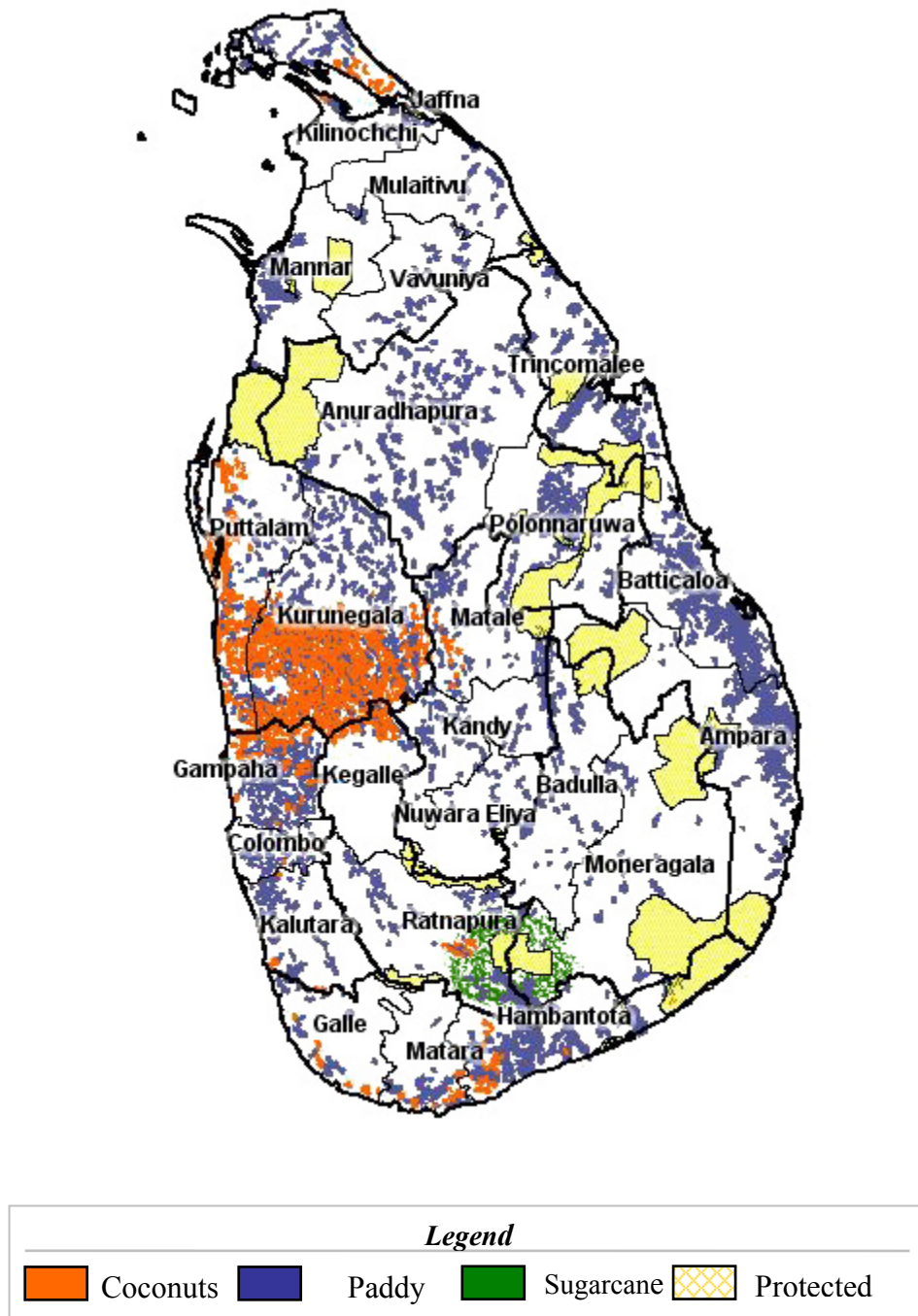


Fig 6 : Geographical partition of main agricultural primary products

Table 6 Sugar cane production in Sri Lanka

Indicator	1995	2003	2004 (up to June)
Sugarcane extent (ha) with ratoons	11,099	7,308	9,039
Area harvested (ha)	8,176	5,395	6,140
Production (Mt'000)	71	57	58
Production value	-	Rs 2 bill*	-
Yield settler (Mt/ha)	68	82	62
Alcohol prod(Mn Lts)	-	7.25*	-
Value of alcohol imports	-	Rs 5 bill*	-
Contribution to GDP	-	0.12%	-

Source: Central Bank annual report 2004, *Sugarcane Research Institute

Table 7 Cane production at Sewangala and Pelawaththa

Item	Unit	2002			2003		
		Sewanagala	Pelawaththa	Total	Sewanagala	Pelawaththa	Total
1. Total area under cane(with ratoons)	hectares	3,885	3,988	7,873	3,500	5,060	8,560
2. Area harvested	hectares	2,798	3,105	5,903	2,798	3,377	6,175
3. Cane harvested	mt ' 000	151	104	255	196	212	407

Source – Central Bank of Sri Lanka Annual report 2004

Table 8 Production capacities at the Sewanagala and the Pelwatta factories.

	Pelawatta	Sewanagala	Total
Cane crushed (MT/day)	3300	1200	4500
Sugar Production - (10% yield) (MT/day)	330	110	440
Final molasses 4.5% - 5.5% (MT/day)	149-181	60-75	209-256
Ethanol yield from 1MT of Final Molasses (liters)	620-665	250-275	870-940
Ethanol Yield per day (liters)	92,380-120,365	15,000-20,625	107,380-140,990

Source – Sugar factories

The capacity to produce biodiesel at an industrial scale is currently non – existent in the country. Any experience in its production is minimal with no facilities for production. The vegetable oil industry is mainly dominated by the edible oil sector. The non edible oil industry consists mainly of soap manufacture. In fact Sri Lanka currently faces a shortfall in local edible oil supply resulting in imports. All indications are that the edible oil industry will be competing strongly with non – edible oil industries in the future.

Assuming that 50% of the Ethanol production is directed to Industrial Ethanol, per year both sugar factories would produce around 21million litres. On the basis of a 10% replacement of petrol for the ethanol blending, comparing Tables 4 and 8 indicates that even at current rates of usage this amount of ethanol would only meet one-third of requirements. In order to meet the remaining 70% additional cropping would need to be established .from further exploitation of land. An area of around 9,600 hectares of sugar cane in additional land would have to be harvested. Further sugar factory capacities would need to be considered since at the moment Sri Lanka is only producing 10% of its sugar demand for the country.

4. Role of the Govt

One of the most important steps in the technology transfer process is to review the existing institutional structures and policies related to the study area. There are many institutions and agencies as well as national policies, rules and regulations, strategies and procedures, which have direct or indirect influence on the promotion of biofuels and enabling the related technology transfer process.

4.1 Institutions related to bio-fuels

The main objective of this section is to review the scope and structure of stakeholder ministries relevant to the study area.

Government Ministries

There is no single ministry or agency responsible for making policy declarations related to promotion of biofuels and related technology transfer, but many of the following ministries have direct or indirect relation or influence.

- Ministry of Railways and Transport
- Ministry of Power and Energy
- Ministry of Petroleum and Petroleum Resources Development
- Ministry of Environment
- Ministry of Science and Technology
- Ministry of Enterprise Development and Investment Promotion
- Ministry of Industrial Development
- Ministry of Policy Development and Implementation

The Ministries consist of different Agencies, Departments and Statutory Institutions and their functions and duties of the key Ministries are summarized below:

(i) Ministry of Railways and Transport

Government organizations involved with the transport sector can be divided into two main

categories: those directly responsible for operating or directing forms of transport or transport infrastructure, and those whose relationship is more indirect, such as through funding, energy expenditure, and so on.

The Minister of Railways & Transport also holds the portfolios of the Minister of Transport Boards and the Minister of Private Omnibus Transport. Each of these Ministries is administered by a Secretary reporting to the Minister. Sri Lanka Railways, Sri Lanka Transport Board and the Department of Motor Traffic are the key institutes under this ministry

(ii) Ministry of Power and Energy

Until December 2005, the present Ministry of Power and Energy's purview encompassed the area of petroleum fuels as well. Recently, the Ministry of Petroleum and Petroleum Resources Development has been established with its scope covering petroleum fuels. The Ministry of Power and Energy functions with the vision of 'Sri Lanka will have an efficient and dynamic energy sector, which would facilitate economic development and adopt international best practices'.

The Mission of the Ministry was to meet the demand for energy services with affordable, reliable, diverse, safe and environmentally acceptable choices for the people of Sri Lanka. The final draft of the national energy policy and strategies document released in February 2005 presents nine policy declarations. The specific declaration to promote indigenous energy resources mentioned as "*Indigenous energy resources will be developed to the optimum levels to minimise dependence on non-indigenous resources, subject to economic, environmental and social constraints*" would encompass the promotion of biofuels. However, with the establishment of the Ministry of Petroleum in late 2005, one could still expect this policy declaration to be effective under the new ministry.

The Ministry of Power consists of the following Statutory Institutions and companies:

- Ceylon Electricity Board (CEB)
- Energy Conservation Fund (ECF)
- Lanka Electricity Company (LECO)
- Lanka Transformers (Pvt.)Ltd. (LTL)
- Energy Supply Committee (ESC)

A new act for the establishment of Public Utility Commission has also been passed by the Parliament in October 2002 to regulate certain utilities industries including electricity intending restructuring of the power sector.

Among the above mentioned statutory institutes, the ECF has the mandate to implement energy demand management and conservation programs covering energy in general and end uses in agriculture, industry, commercial, domestic and transport sectors (ECF Act 1985). In this context, providing assistance to conduct pilot studies needed to promote biofuels promotion in Sri Lanka will fall under the purview of the ECF.

(iii) Ministry of Petroleum and Petroleum Resources Development

This ministry was established in late 2005, taking over some of the responsibilities of the Ministry of Power and Energy. In addition to the present activities carried out by the Ceylon Petroleum Corporation such as refining, imports, distribution and marketing, emphasis to develop the petroleum exploration activities in the island. Is also encompassed

Ceylon Petroleum Corporation is a key stakeholder in biofuel application in the country. It possesses all facilities to store, blending, distribution and marketing infrastructure. Already it has been included biofuel in gasoline specifications as an oxygenate. But diesel specifications do not show any such component. Similar to the any other part of the world, Sri Lanka also is more concerned on environmental impact on fuel usage, priority will be given to more environment friendly fuel blends. As such government may consider on providing subsidies through this ministry because it can be benefited in several aspects.

(iv) Ministry of Environment

The Ministry of Environment has the mandate to provide leadership for formulating national environmental policy and its review. Departments and Statutory Institutions that are within the purview of the Ministry are:

- Central Environment Authority (CEA)
- Department of Forests
- State Timber Corporation
- Geological Bureau and Mines Bureau
- Department of Wildlife Conservation
- Wildlife Trust
- National Zoological Gardens

The Central Environmental Authority (CEA) established in August 1981 with the objective of integrating environmental considerations in the development process of the country is the most important stakeholder from above, in the context of biofuels. It now functions as the implementation agency of the Ministry of Environment and has the responsibility to protect the environment from air pollution, water pollution and industrial pollution (<http://www.cea.lk>, 2004).

CEA also has the following specific objectives:

- Protection, management and enhancement of the environment.
- Regulation, maintenance and control of the quality of environment.
- Prevention, abatement and control of pollution.

Although the Ministry and its agencies such as CEA do not directly involve with transfer of technologies, there are several policy documents developed by them related to environment, which will definitely have an indirect influence on the promotion and biofuels technology transfer.

The key policy documents developed under the Ministry of Environment include:

- National Environment Act (NEA)
- National Environment Action Plan (NEAP)
- Forestry Sector Master Plan (FSMP)
- Clean Air 2000 and Clean Air 2007
- Climate Change Action Plan
- Pollution Abatement Strategy

(v) Ministry of Science & Technology

The subjects and functions of the Ministry are:

- Implementation of Policies, Plans and Programmes in respect of Science and Technology Assisting the Minister in Policy Development and Implementation in respect of Economic Reform
- Capital Investment and Capital Structure of State Corporations and Boards
- Reform of Public Enterprises
- Formulation of programmes and projects based on National Policy in respect of Science, Technology and Human Resources Development and the direction of the implementation of such programmes and projects
- Scientific and Industrial Research
- Meteorological Service and Research
- Development of Information Technology

There are many Departments and Statutory Institutions attached to this Ministry. The key Agencies relevant to the present study are listed below:

- National Engineering, Research and Development Centre (NERD Center)
- National Science Foundation (NSF)
- Industrial Technology Institute (ITI)
- Arthur C. Clarke Centre for Modern Technologies
- Natural Resources Energy and Science Authority of Sri Lanka
- Sri Lanka Standards Institution
- National Science & Technology Commission
-

Activities of the Ministry in BioFuel production for Transport sector applications:

- A committee was constituted to prepare a report on addressing the role of biofuels in meeting the multiple needs of the country. This committee has identified many technologies for research and development. In addition this committee has also identified policy measures to facilitate the deployment of biofuels as an alternative to fossil fuels.
- The Ministry is examining the use of compressed bio methane as the fuel for transport application. For this purpose a private sector institution has been identified to collaborate with the ministry to clean, compress and use bio gas from a municipal garbage digester facility.
- The Ministry is conducting plantation trials on Jatropha to determine the yield data in actual Sri Lanka dry zone conditions, in view of embarking on pilot studies on Biodiesel.

Among the above institutes, NERD Center, NSF and ITI are the key institutes involved in activities related to industrial research and development by way of conducting industrial research to facilitate commercialization, providing assistance to capacity building & networking among research institutes and originating pilot projects for technology promotion.

(vi) Ministry of Enterprise Development & Investment Promotion

Ministry consists of number of divisions:

- Macro Policy Division
- Industrial Policy Division
- Entrepreneurship Development Division
- Small & Medium Industry
- Sectoral Divisions (Sectoral I, Sectoral II, Sectoral III and Sectoral IV)
- Investment Promotion Division
- Corporation & Statutory Boards Division
- Management Information & Computer Services Division

There are many Departments and Statutory Institutions coming under the Ministry of Enterprise Development, Industrial Policy & Investment Promotion and some of the key relevant Agencies are:

- Board of Investment of Sri Lanka (BOI)
- Industrial Development Board (IDB)
- National Institute of Business Management
- Department of Small Industries
- National Designs Centre

Among these Agencies, BOI are the most relevant organizations for the present scope of work in bio fuels.

BOI was established by the Board of Investment of Sri Lanka Law No.4 of 1978 with the following objectives:

- to stimulate the growth, expansion and development of Sri Lanka's economy by encouraging and promoting investments and thereby facilitating the establishment of enterprises throughout Sri Lanka:
- to formulate investment policies, plans, promotional incentives and marketing strategies for attracting foreign and local investment for the industrial services and agricultural sectors:
- to diversify the sources of foreign exchange earnings and to increase the export earnings:
- to promote Sri Lanka as international business hub, and to promote and facilitate the creation of an off shore financial center in Sri Lanka.
- to regulate, co-ordinate and monitor the functioning of the commissions.
- to facilitate the upgrading of skills of the workers in Sri Lanka by initiating training and vocational programmers for the promotion of skills that will meet the needs of investors: and
- to do all such other acts as may be necessary or conducive to the attainment of any or all of the above objectives.

Investment Promotion Plan:

The Act provides for the preparation of an Investment Promotion Plan. The Board is required under the Act to submit to the Cabinet of Ministers on behalf of the Commissions, a three-year rolling plan or plans for the promotion of investments in Sri Lanka, formulated in consultation with the Commissions. The focus of such plan or plans should be to stimulate investment for economic development, promote Sri Lanka as an international business centre, foster and general economic development of each region among other such matters. However, due to the lack of integration of renewable energy related development activities with countries development policies and plans, there are no significant investments in the sector and transfer of technology is minimal. Nevertheless, opportunities can be created.

(vii) Ministry of Industrial Development

The main objectives of the Ministry include:

- To promote industries in accordance with overall government policies to achieve a higher level of industrialization where technology and knowledge-based activities play a major role.
- To create a new industrial culture where there is harmony between employers and employees and to create an entrepreneurial spirit that will encourage long-term investment.
- To link industries to local input sources through market-friendly subcontracting and thereby strengthens the SME sector.

- To use the five Economic Zones to regional industrial development and geographical spread of industries.
- To link industries to niche overseas markets by promoting competitiveness via productivity enhancement, new technology, managerial and skill development
- To encourage infant industries by providing a floor and a roof with other prerequisites under the industrial incubator programme

The main Subjects and Functions are:

- Implementation of Policies, Plans and Programmes in respect of Industries.
- Promotion and Development of industries in accordance with industrial policy
- Industrialization
- Co-ordination with Ministries of Regional Development
- Co-ordination and establishment of Industrial Zones
- Promoting investment in the industrial sector
- Administration of the promotion of industries

Although transfer of technology is an essential element in industrialization, which is the main objective of the Ministry of Industry, the growth of the industrial sector during the last decade is not very satisfactory. In particular, contribution from manufacturing sector to the national GDP is around 15%. This indicates that transfer of technology in the industrial sector has not been up to a satisfactory level and therefore appropriate actions should be taken by the Ministry to promote technology transfer.

(viii) Ministry of Policy Development and Implementation

The main Subjects and Functions assigned to the Ministry include,

- Formulation and Development of National Policies
- Formulation and appraisal of plan implementation strategies
- Perspective Planning for all sectors of the National Economy
- Formulation of National Economic Policies, Programmes and Strategies
- Preparation of National Development Plans and Public Investment Programmes
- Co-ordination of Public and Private sector activities for economic development
- Co-ordination of economic Policy in relation to international economic agencies
- Liaison with donor agencies and international financial institutions
- Social, economic and administrative restructuring
- Foreign Aid and Technical Co-operation
- Monitoring and Progress Review
- Formulation and appraisal of plan implementation strategies
- Monitoring progress of Public and Private sector investment programmes

- The Co-ordination of the implementation programmes of Government and Non-Government agencies for the achievement of national objectives
- The evaluation of the performance of institutions and enterprises engaged in economics activities

The key Departments and Statutory Institutions relevant to the present project are:

- Monitoring and Progress Review Division
- Institute of Policy Studies
- Department of National Planning
- National Development Trust Fund
- National Secretariat for Non-Governmental Organizations
- Department of External Resources

Lack of proper awareness and inadequate support from national policies are some key barrier for the promotion of biofuels and related technologies.

4.2 Current policy initiations for the promotion of bio-fuels

There are number of policy documents related to energy and environment sector. These policies have a direct bearing on the development of RE sector since it could play a significant role in meeting future energy needs of the country with minimum environmental degradation. Most relevant policy documents are summarized below.

(i) National Energy Policy (Draft)

The National Energy Policy Committee has presented a draft policy document in 2005. The proposed energy policy consists of nine policy declarations, which can be implemented through a set of specific strategies involving each of the elements and a set of general strategies which take into account the combined implementation of several of these elements.

The general strategies for the implementation of energy policy elements mainly cover institutional and other macro reforms applicable to electricity, petroleum, gas, biomass and environmental aspects. Under the reforms in the biomass sector, it is proposed that a Bioenergy Agency be established to promote and consolidate the production, marketing and efficient use of fuel wood. Such an institution will also be responsible for liberalising, commercialising and promoting growing of trees for energy and encouraging substitution of imported energy sources where technically feasible and economically viable.

(ii) National Forestry Policy

This document was formulated by Forestry Policy Working Group, MFE in 1995. The scope of the policy is forestry in broad sense, including its bio-physical, environmental,

socio-political and economic components. This is the foundation of forestry legislation and for developing supportive institutions. Based on MFE (1995), the core of the National Forestry Policy is summarised highlighting its objectives and policy elements.

Policy Objectives

- To conserve forests for posterity, with particular regard to bio-diversity, soils, water, and historical, cultural, religious and aesthetic values;
- To increase the tree cover and productivity of the forests to meet the needs of present and future generations for forest products and services; and
- To enhance the contribution of forestry to the welfare of the rural population, and strengthen the national economy with special attention paid to quality in economic development.

(iii) Forestry Sector Master Plan (FSMP)

Forestry Sector Master Plan (MFE, 1998) has proposed policies and strategies to optimize the forestry sector's role in national energy supply and assist people in meeting their energy needs. FSMP has clearly recognized biomass as the main sources for future energy applications and it is evident from the list of strategies proposed for the promotion of fuel wood plantation. Further to these, following key observation can be made by analyzing the issues, measures proposed to deal with issues and the strategies.

- Energy plantations poses no threat to deforestation and help to improve the biodiversity.
- Institutional development through establishment of dedicated agency.
- Recognition of capacity building needs
- Recognition of the need for appropriate financial mechanisms

(iv) National Environmental Action Plan

The National Environmental Action Plan (NEAP) 1998-2001 has been prepared by the MFE in order to set the national environmental agenda for the 21st Century.

Related to energy sector in particular, the following are the recommendations:

- Carry out an environmental assessment for the entire energy sector and encourage energy auditing;
- Review energy policy and electricity generation plan to address environmental concerns; and
- Conduct feasibility study on use of alternative fuels, especially RE sources for power generation, industry and transport.

All the above recommendations clearly identify importance of renewable energy related options on all energy sectors over the conventional fossil energy sources, thereby promote appropriate technology transfer.

However, specific recommendations giving emphasis on the promotion of transfer of technology to be included in order to obtain and maximize the benefits from the vast energy generation potential based on large scale dedicated energy plantations in the future.

4.3 Regulatory aspects –Emission Control

The most prominent factor which determines the level of air pollution from a vehicle is the fuel quality. Harmonizing fuel quality is the present trend in the world. As far as Sri Lanka is concerned, benzene, aromatic additives in gasoline and sulphur in diesel should receive the highest priority in development of medium and long term strategies for fuel standards. The main quality parameters of gasoline are the octane number, volatility, sulphur, lead, silicon, oxygenates, olefins, aromatics and benzene content. Similarly for the diesel, cetane number/index, volatility, density and the content of sulphur and polyaromatic. The real challenge that the Sri Lankan authorities are facing is to compromise between quality and cost of diesel. Diesel prices directly affect the economy of the country. Imported low sulphur diesel is blended with the local production to achieve the desired sulphur level (.5% w/w). Since 2002, leaded petrol is not in the market. The octane shortfall in consequence is compensated by benzene and other additives.

There are two main streams of fuel quality regulations namely, vehicle manufactures regulations (World Wide Fuel Charter) and fuel manufactures regulations. World Wide Fuel Charter represents a wish list for the auto manufactures and has no legal or regulatory standing. It standardized the fuel specifications around the world at different levels of performance. In developing fuel standards, the fuel manufactures (i.e. refineries) try to work closely with neighbouring countries for harmonizing fuel standards. Air Recourse Management Centre (Air MAC), under the Ministry of Environment is working on selecting fuel quality standards that need to be tightened in order to address the problem of urban air pollution in Sri Lanka. They have estimated the incremental costs of meeting the proposed specifications with a timetable for achieving deferent levels of specifications. Government of Sri Lanka has already amended the National Environmental Act No.47 of 1980 with addition of air emission, fuel quality and vehicle importation, which came to effect on the 1/7/2003.

Sri Lankan government has set its new fuel quality regulation which came into effect from the 1st January 2003. See the attached appendix (Special Gazette notification). In developing fuel standards, countries work closely with neighbouring countries and aim to harmonize standards when ever possible.

The main obstacle to adopting latest vehicle emissions technology (equivalent to Euro 3 and 4) in Asia is the fuel quality, especially lead and sulphur levels in gasoline and sulphur levels in diesel. These parameters should receive the highest priority in the development of medium- and long-term strategies for fuel standards. In order to

implement realistic fuel standards and make associated costs more acceptable to consumers, countries should institute more and better awareness campaigns. Such campaigns must emphasize the public health consequences of not improving fuel quality. Subsidies that favour fuels which produce high emissions, should be eliminated; tax policies which encourage the use of the cleanest fuels, should be adopted.

Transport fuel demand in Sri Lanka is characterized by very low gasoline to diesel ratio. This defines the future steps in the mechanism for the improvement in fuel quality. Considering the air quality aspects, structure of the Sapugaskanda Refinery and present trends in the neighbouring countries, following specifications have been proposed for the gasoline and diesel.

Table 9. Proposed Diesel Specifications for Sri Lanka

	Diesel Fuel 2005	Diesel Fuel 2010	Diesel Fuel 2015	Diesel WWFC- CAT. - 2
Sulphur, wt ppm, max	3000	1000	500	300
T9S, deg.C max	380	380	365	355
Density @ 15 deg. C	860	860	660	860
Cetane Index, min	46	46	50	50
Poly-Aromatics, wt.% max	12	12	5	5

Table 10. Proposed Gasoline Specifications for Sri Lanka

	Gasoline 2005**	Gasoline 2010	Gasoline 2015	Gasoline WWFC- CAT.-2
RON,typ. Min	90 (*)	90 (*)	90 (*)	91
Lead, g/l max	0.013	0.008	0.005	below detection
Benzene, vol. % max	4.0	3.0	2.0	2.5
Aromatics, vol.% max	45	45.0	40.0	40.0
RVP, kPa, max	60	60	60	60

* Assumed that 95 RON unleaded gasoline continued to be imported.

** Assumed that super diesel continued to be imported.

A possible option for the Sri Lankan Refinery at this stage is to install an isomerization plant to minimize the benzene and aromatic content in the fuel. All other elements in the standards could be met by importing of super quality product and blending with local product to get the desired quality. However in a long term perspective Sri Lanka has to go for the MMT (Methylcyclopentadienyl Manganese Tricarbonil) or MTBE (Methyl Tertiary Butyl Ether) as octane enhancers as a possible way to meet the future benzene and aromatic level. But, a sustainable long-term technical option taking into account the

state of the active vehicle fleet would be to shift towards biofuel blends which have better emission characteristics enabling to meet fuel quality standards in a practical sense.

4.4 Emissions/impacts reduction potential

One of the most important factors in switching to biofuels in the transport sector is the relative reduction in vehicle pollutant emissions. With increasingly tight vehicle emissions regulations coming up, biofuels have mainly been touted as being environmentally friendly. When used in their 100% “neat” form or more commonly as blends with conventional petroleum fuels, biofuels can reduce certain vehicle pollutant emissions which exacerbate air quality problems, particularly in urban areas.

Biofuels (ethanol and FAME biodiesel) generally produce lower tailpipe emissions of CO, hydrocarbons, SO₂ and particulate matter than gasoline or conventional diesel fuel. Ethanol blended gasoline, however, produces higher evaporative hydrocarbons (or volatile organic compounds, VOC's). Impacts of both ethanol and biodiesel on oxides of nitrogen (NO_x) are generally minor, and can be either an increase or a decrease depending on conditions. Biofuels are generally less toxic to handle than petroleum fuels and in some cases they have the additional environmental benefit of reducing waste through recycling. Waste oils and grease can be converted to biodiesel and cellulosic rich wastes can be converted to ethanol.

Ethanol blends such as E10 typically reduce emissions of a variety of pollutants. Among the biggest impacts from using ethanol are on reducing CO emissions. Use of a 10% ethanol blend in gasoline is widely documented to achieve a 25% or greater reduction in CO emissions by increasing the oxygen content and promoting a more complete combustion of the fuel. But the net impacts of using ethanol on emissions of volatile organic compounds (VOC's) and NO_x are less clear. When ethanol is added to gasoline evaporative VOC's can increase due to higher Reid Vapor Pressure (RVP) of the ethanol mixture. Emissions of most toxic air pollutants decrease when ethanol is added to gasoline, primarily due to dilution of gasoline, which emits them. Emissions of acetaldehyde, formaldehyde and pexyacetyl nitrate(PAN), however, increase when ethanol is added. But toxic emissions of benzene, 1,3 – butadiene, toluene and xylene all of which are considered more dangerous, decrease with the addition of ethanol.

Lower pollutant emissions are one of the primary benefits of using ethanol – diesel blends. Compared to conventional diesel fuel, ethanol blends of 10% to 15%, along with a performance additive, provide significant emissions benefits. Blending of ethanol into diesel reduces tailpipe exhaust emissions (PM, CO, NO_x) relative to conventional diesel fuelled engines.

Even though the physical and chemical properties of biodiesel are similar to those of petroleum diesel, both pure biodiesel and biodiesel blends generally exhibit lower emissions of most pollutants than petroleum diesel. Biodiesel has virtually no aromatic compounds and sulphur. Although emissions vary with engine design, vehicle condition

and fuel quality, with the exception of NO_x, potential reductions from biodiesel blends are considerable relative to conventional diesel and increase linearly with increasing blend levels.

Of particular concern to diesel producers are requirements to reduce the sulphur content of diesel fuel to meet increasingly stringent emissions requirements. Reducing the sulphur content also improves fuel lubricity. On the other hand blending only small quantities of biodiesel with conventional diesel does not bring the average sulphur content down appreciably. For example, it has been found that to reduce 350 ppm sulphur diesel down to 50 ppm, a blend of more than 85% biodiesel is required. Once the engine is optimised for use with the blend, biodiesel typically raises NO_x emissions by a small amount relative to petroleum based diesel vehicles.

One of the most critical issues is the reduction in Green House Gases (GHG) due to bio-fuel use. Both ethanol and biodiesel provide significant reductions in GHG compared to gasoline and diesel fuel on a “well to wheel” basis (i.e. complete chain of fuel production and use, including feedstock production, transport to the refinery, conversion to final fuel, transport to refuelling stations and final vehicle tailpipe emissions). It should be emphasized that virtually all CO₂ emitted during vehicle combustion of biofuels does not contribute to new emissions of CO₂, because the emissions are already part of the fixed carbon cycle. A key question is the quantification of CO₂ and other GHG emissions released during all phases of fuel production. Research on the net GHG reduction impacts of biofuels is progressing but far from conclusive.

Sri Lanka will have to study closely the impact of the aforementioned factors on an already worsening situation in urban air quality and will be prime factor when evaluating the suitability of biofuels. Avenues of exploiting the CDM (Clean Development Mechanism) provided under the Kyoto Protocol should also be explored with respect to GHG emissions as carbon trading could bring in additional revenue.

Other areas to be explored are the impacts of biofuels on soils and habitats from growing bioenergy crops, on removing crop and forest residues and using these to produce biofuels, on water quality from biofuels production and use and on disposing of various solid wastes. Generation and nature of employment too should be a governing factor. Safety related issues and the effect of biofuel spillage on neighbourhoods should be explored. In fact a comprehensive study of environmental & socio economic implications should be carried out. Creating public awareness on these factors should be a key consideration.