7. ENERGY

This chapter analyses the current state of the energy sector looking first at primary energy sources, and secondly at the power generation sector. Data have been drawn from

Liban (EDL). Environmental impacts from the energy sector results from fuel storage (reservoirs, underground storage tanks), loading/unloading and distribution (tankers, loading decks), and fuel consumption (motor vehicles and thermal power plants).

7.1 Targeted Description

The petroleum and gas sector is currently the responsibility of the Ministry of Energy and Water. The executing agency is the General Directorate of Petroleum (GDoP), which used to fall under the authority of the-then Ministry of Industry and Petroleum.[1] The GDoP is responsible for licensing import activities, import crude and fuel oil, and setting prices for petroleum products. Apart from a modest (and declining) amount of hydropower, Lebanon is entirely dependent on imports of fuel for energy. Not including hydropower, primary energy consumption in Lebanon was about 4.9 Mtoe in 1999, up from 3.5 Mtoe in 1993 (METAP/ERM, 1995), which is equivalent to about 0.95 toe/person (or 39.9 GJ/person).[2]

7.1.1 Energy Imports

Primary energy sources include gasoline, gas oil, fuel oil and diesel oil, in addition to several other petroleum products which account for less than 10 percent of fuel imports (aircraft oil, liquid gas and tar). In 1999, imports of primary energy sources reached 4,963 ktonnes (see Table 7.1), up from 4,192 ktonnes in 1995 which is equivalent to an increase of 18.5 percent. All the available primary energy is consumed. The consumption of energy has increased steadily over the past years, as illustrated by Figure 7.1.

Table 7. 1
Fuel Imports Between 1995 and 1999 in kTonnes

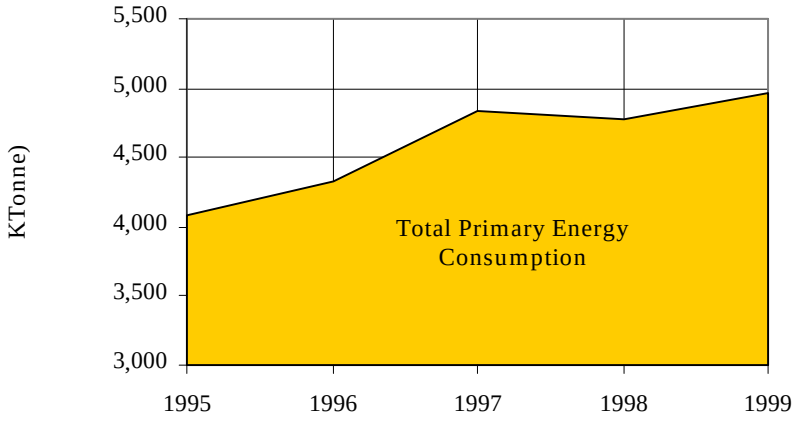
Fuel Type	*1995*	*1996*	*1997*	*1998*	*1999*
Gasoline	1,346.9	1,420.7	1,320.0	1,411.7	1,344.1
Gas oil	1,010.3	763.8	1,038.1	881.3	867,0
Aircraft oil	109.6	115.6	108.5	106.9	126.2
Liquid gas	121.6	123.7	141.2	138.0	135.3
Fuel oil	1,432.7	1,623.3	1,805.0	1,588.4	1,525.1
Diesel oil	-	166.5	337.4	543.3	881.1
Tar	67.7	112.5	87.6	109.5	83.3
Kerosene	103	-	-	-	-
Total	**4191.8**	**4326.1**	**4837.8**	**4779.1**	**4963.0**

Source: General Directorate of Petroleum, MoEW

[1] Law 247/2000 shifted the Directorate of Petroleum from the-then Ministry of Industry and Petroleum to the Ministry of Energy and Water. The-then Ministry of Industry and Petroleum is now the Ministry of Industry.

[2] *Toe* is Tonnes of oil equivalent. 1 Toe is equivalent to 41.8 Giga joules (Gj)

Figure 7. 1
Evolution of Total Primary Energy Consumption (1995-1999)



Source: Directorate General of Petroleum, MoEW

7.1.2 Petroleum Bill

ernational oil prices and

Data on the cost of diesel oil imports was not available. This cost is however significant and would represent an important share of the annual bill (diesel oil imports represented almost 18 percent of total petroleum products in 1999 and presumably a much large

energy sector to international oil prices is also evidenced in Table 7.2. For example, the government bill for petroleum products declined by almost 26 percent between 1997 and 1998 (from US$840 million to US$624 million), and rose 29 percent from 1998 to 1999 (reaching US$805 million).

Table 7. 2

	1995	*1996*	*1997*	*1998*	*1999*
Benzene	240.9	290.9	280.7	224.6	268.7
Gas oil	159.1	184.4	246.7	179.1	274.7
Aircraft fuel	19.9	23.5	20.6	14.2	22.3
Liquid Gas	33.2	37.3	41	28.6	34.7
Fuel oil	168.5	216.6	239.4	165.8	194.2
Diesel oil	NA	NA	NA	NA	NA
Tar	8.4	16.3	12	11.8	10.7
Kerosene	NA	NA	NA	NA	NA
	630	769	840	624	805

Source: Central Bank, Annual Reports

7.1.3 Power Generation

owned entity under the jurisdiction of the MoEW. EDL operates eight thermal plants and at least five major hydroelectric plants. Three other hydroelectric plants also produce electricity (Nahr Ibrahim, El Bared and Litani) and sell the electricity to EDL. Table 7.3

five leading hydroelectric plants and eight thermal plants. During this period, power generation increased almost 67 percent to reach 8,186 Kilowatt Hour (KWh). In addition, Lebanon imports electricity from Syria via a shared grid system. Electricity imports began in 1995 at 292 KWh and have since almost tripled to reach 846 KWh in 1999.[3] In 1999, total electricity consumption in Lebanon (generation and imports) was 9,032 KWh, up from 5,207 KWh in 1995.

Table 7. 3
Power Generation Between 1995 and 1999 in KWh

Source	*1995*	*1996*	*1997*	*1998*	*1999*
Hydropower					
Kadisha	41.0	37.5	75.1	66.9	52.3
El Safa	12.9	22.0	25.6	23.8	11.2
Nahr Ibrahim *	87.0	87.9	84.6	87.2	67.0
El Bared *	48.2	48.2	64.9	53.4	34.6
Litani *	508.1	570.4	485.6	554.8	166.2
Subtotal	*697.2*	*765.9*	*735.8*	*786.1*	*331.3*
Thermal conversion					
Zouk (fuel oil)	3,083.1	3,485.3	3,818.6	3,210.2	2,929.5
Zouk (Gas oil)	60.6	42.9	67.5	45.1	30.2
Jiyeh (Fuel oil)	1,073.9	1,571.6	1,614.5	1,834.3	1,686.0
Hreyshe-Qadisha (Steem)	-	-	378.9	398.7	333.0
Baalbeck (Gas oil)	-	212.6	435.7	398.9	383.8
Sour (Gas oil)	-	224.3	498.5	450.7	460.5
Zahrani	-	-	125.2	634.1	1,003.1
Beddawi	-	-	42.4	598.2	1,028.6
Subtotal	*4217.6*	*5536.6*	*6981.3*	*7570.2*	*7854.7*
Total	**4914.8**	**6302.6**	**7717.1**	**8356.3**	**8186.0**

Note: EDL purchases electricity from hydroelectric power plants marked with an asterisk

Source: EDL, Directorate of Finance

The thermal power capacity has greatly increased over the past five years. New gas turbines were installed at Sour and Baalbeck (in service since the end of 1996). Two combined-cycle plants of 435 MW each were installed between 1998 and 2000 in Zahrani and Beddawi (Deir Ammar). Thermal power plants use different fuel types including diesel, fuel oil, and natural gas. In 1999, the efficiency of thermal power plants reached only 33 percent: i.e., for each one Mtoe of burnt fossil fuel, thermal power plants produce only 0.33 Mtoe of electricity. A similar rate of low energy conversion efficiency applies to domestic water heaters. Hence the need to introduce solar heating.

[3] EDL, Directorate of Finance

Power generation from hydroelectric plants has fluctuated in recent years, peaking in 1998 at 786 KWh, then sharply declining to just 331 KWh in 1999. This drop may be attributed to on-going MoEW efforts to build a series of hill lakes and water reservoirs in remote areas at high altitude (see Section 8.2 on water uses).

Table 7.4 presents the nominal capacity of individual thermal and hydroelectric power plants. Nominal capacity refers to the rate of electricity generation under optimum operating conditions. However, all thermal power plants operate below their corresponding nominal capacity. In particular, the Zahrani and Beddawi plants currently operate at half their nominal capacity. Also, production lines are often put out of service for repairs and/or routine maintenance, thus further reducing power generation compared to nominal capacities.

Table 7. 4
Nominal Capacity of Thermal and Hydroelectric Power Plants

Thermal Plants		*Hydroelectric Plants*		
Name	*Power Capacity (MW)*	*River*	*Plant Name*	*Nominal Capacity (MW)*
Zouk	435	Litani	Abdel-Al	34.0
Zouk	175	Awali	Awali	108.0
Jieh	142		Joun	48.0
Hreyche	272	Nahr Ibrahim	Nahr Ibrahim 1	15.0
Baalbeck	70		Nahr Ibrahim 2	12.5
Sour	70		Nahr Ibrahim 3	4.8
Zahrani	435	El Bared	Bared 1	13.5
Beddawi	435		Bared 2	2.8
		Abou Ali	Bsharre	1.5
Total	**2,034**			**240.1**

Source: ALMEE, 2001

Oil, Gas, and Coal sectors. The oil and gas sector is controlled by the Government. The Ministry of Energy and Water (MoEW) is responsible for licensing petroleum imports and for setting the price of petroleum products. The government, several large industries (e.g., Chekka and Sibline Portland cement plants and Selaata fertilizer plant), and 22 companies import petroleum products, primarily through sea lines, and store those products at more than 30 locations along the coastline (CDR/ECODIT-IAURIF, 1997). Moreover, two Portland cement factories import coal, *Cimenterie Nationale (CN)* and *des Ciments Libanais* (SCL). Lebanon has no operating oil refineries.

7.1.4 Electricity Pricing

The price of electricity supplied for domestic use ranges from LBP35 to LBP200 anged since 1995. Small industries pay a flat rate of LBP 115/KWh, down from LBP 130 in 1995. Other industries supplied from a medium voltage grid pay LBP 320/KWh during peak hour. In addition, subscribers pay a municipal surcharge (equivalent to 10 percent of consumption), plus operation and maintenance fees (about LBP 5,000 per month) and subscription fees (about LBP 7,000 per month).

Table 7. 5
Price of Electricity Supply

End User	*Monthly Consumption (KWh/mo.)*	*Price (LBP/KWh)*	*Price (US cents/KWh)*
Residential	up to 100	35	2.3
	100 300	55	3.6
	300 - 400	80	5.3
	400 500	120	8.0
	> 500	200	13.2
Small Industry	Flat	115	7.6
Agriculture	Flat	115	7.6
Public	Flat	140	9.3

Source: EDL

The price of electricity in the high range of monthly residential consumption (above 200 KWh / mo.) is LBP200 or $13.2 per KWh. This unit price compares with the most expensive electricity prices offered in some other countries such as Italy, Portugal and Spain (see Table 7.6). However, based on consumer price indices, the average residential subscriber consumes about 450 KWh[4] and thus pays a total of about LBP40,000

residential consumer is in the low range of electricity prices offered in other countries, such as Mexico, Norway, and Poland (see Table 7.6).

Table 7. 6
Prices of Electricity in Lebanon and Elsewhere (Residential Consumers)

Country (1999)	*Price (US cents/KWh)*
Italy	14.7
Lebanon	5.0[a]
Mexico	5.9
Norway	6.3
Poland	6.4
Portugal	14.1
Spain	14.3
Turkey	8.4

Source: http: / / www.eia.doe.gov / emeu / international / electric.html#Prices, except Lebanon

[a/] Unit price paid by the average residential consumer (450 KWh / mo. at LBP 35,000)

7.1.5 Autonomous Power Generation

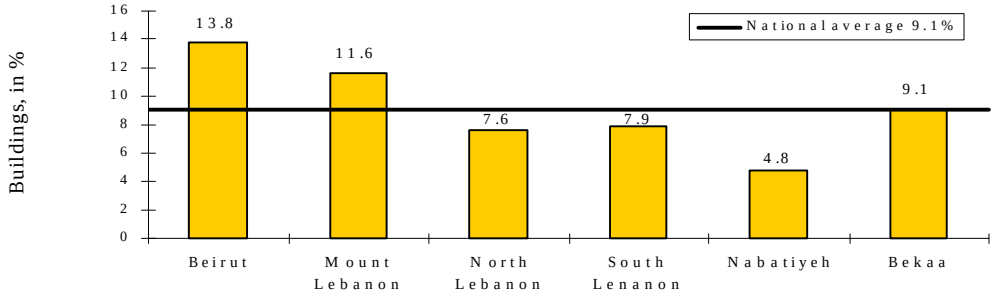
Despite significant improvements to the distribution network since 1993, power shortages and rationing are still widespread, particularly during summer and following major storms. As a result, people have reverted to alternative power supply systems as back- [5] for computers and private power generators. Neighborhood power generators are back in business and supply electricity to subscribers *informally*. In

[4] Data supplied to ECODIT by Consultation and Research Institute (CRI)

[5] Uninterrupted Power Supply

1996-97, nearly 10 percent of all buildings were equipped with private power generators (mostly in Beirut and Mount Lebanon).[6] See Figure 7.3 for the distribution of power generator at the Mohafaza level and Section 4.2.5 at the Caza level.

Figure 7. 2
Buildings Equipped with Power Generators By Mohafaza (1996-97)



Source: CAS Studies, 1996-98

7.2 Pressures on the Environment

Energy storage, production and distribution exert pressures on the environment. Impacts resulting from energy consumption by the industry and transport sectors are discussed in Sections 3.2 and 5.2, respectively. Petroleum products, charcoal, and other combustibles represent 97 percent of the primary energy available in Lebanon. The combustion of these energy sources release significant amounts of pollutants into the atmosphere. In addition, leaking underground storage tanks containing petroleum products and accidental oil spills could lead to significant pollution of soil, fresh water resources, and the sea.

7.2.1 Emissions into Atmosphere

The combustion of fossil fuels releases several pollutants such as sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulate matter (dust, lead). In addition, the combustion of petroleum products is a major source of carbon dioxide (CO_2), a GHG. The sustained increase in diesel consumption over the past few years poses serious risks to human health and the environment. Diesel imports and associated emissions of SO_2 and dust more than quadrupled between 1995 and 1999 (see Table 7.1). More than half of NO_x emissions come from the combustion of gasoline, most of which is *regular* leaded gasoline. Lead emissions are therefore also significant (see Section 9.1.2 on lead emissions).

Fuels have different uses: gasoline is used mainly by the transport sector, coal is imported by cement factories, and thermal power plants burn fuel oil. As a result, pollutants and pollution loads from fuel combustion vary among sectors. The transport sector is the primary emitter of NO_x. Most of the SO_2 emissions are released by the power generation sector followed by the manufacturing industries. All sectors produce

[6] CAS Studies, 1996-98

significant quantities of CO_2, the most abundant greenhouse gas. Table 7.6 shows 1994 GHG emissions from energy consumption by thermal power plants and industry. The

which will produce new GHG inventories. See section 9.1.5
obligations under the United Nations Framework Convention on Climate Change.

Table 7. 7
Emissions of GHG From Energy Consumption by Sector (in KTonnes)

GHG	*CO_2*	*CH_4*	*N_2O*	*NO_x*	*CO*	*NMVOC*	*SO_2*
Energy	11,679	1.4	0.1	54.1	473.7	87.3	79.6
Industry	1924.1	-	-	Minor	Minor	273.9	3.4

Note: Emissions estimated in accordance with IPCC guideline for base year 1994. That year, Lebanon imported 4,107 tonnes of liquid fuels. In 1999, this number was 4,963 tonnes, or 21 percent more than in 1994.

Source: MoE/UNDP, 1999

7.2.2 Leaking Underground Storage Tanks

There are about 1,646 gas stations in Lebanon with Mount Lebanon and the North hosting 63 percent of all stations (see Table 7.8***)***. Generally, every gas station has at least two underground storage tanks (USTs). There is no consolidated information on the number and characteristics (age, capacity, lining material, physical integrity) of USTs. A large number of USTs are likely in a very poor state and could be leaking, thus leading to severe soil and groundwater contamination. Without adequate and routine monitoring and inspection, leaking USTs are difficult to detect. In view of the polluting potential of unmonitored gas stations, the MoE has developed environmental guidelines for the design and construction of new gas stations (MoE Decision 5/1, dated 25/1/2001). Existing gas stations however remain unmonitored.

Table 7. 8
Number of Gas Stations per Mohafaza

Mohafaza	*Number of stations*
Beirut	139
Mount Lebanon	544
North Lebanon	492
South Lebanon	203
Bekaa	268
Total	**1,646**

Source: MoE/ETEC, 1998

7.2.3 Accidental Oil Spills

The major users and importers of petroleum (e.g., thermal power plants and cement factories) have their own storage facilities connected via sea pipelines to unloading decks off shore. Unloading and loading of petroleum products through these pipelines could result in routine spills as well as accidental discharges, with possible long-term adverse consequences on marine ecosystems. With technical assistance from UNEP

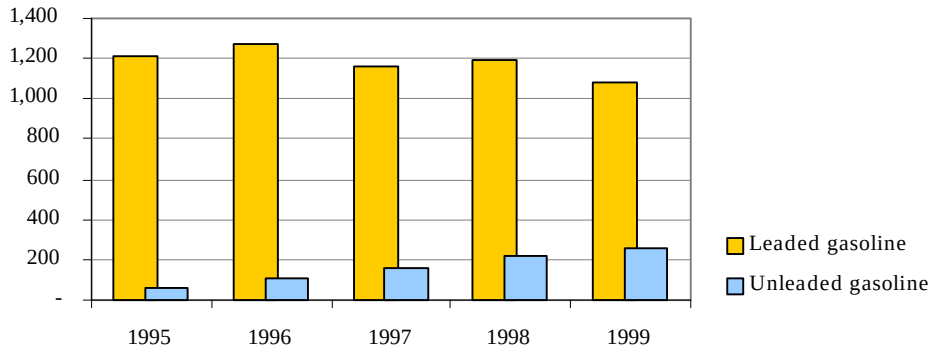
and local input from the National Center for Marine Sciences, a draft action plan was [7] In case of spills, emergency measures would include early containment of slick using booms and suction pumps to remove the oil. In practice, however, Lebanon still does not have specialized vessels and vacuum equipment for removing oil films from the surface of the sea. Containment using booms followed by dispersal using chemical dispersants are however available. Dispersed oil coagulates into small tar balls which eventually sink to the bottom of the ocean. Biodegradation of tar balls at the bottom of the sea is a slow and complex biochemical process.

7.3 Key Policies and Actions

Pursuant to Law 341/2001 on reducing air pollution from the transport sector (see Section 5.4.2), the GoL has put in place price incentives for the use of unleaded gasoline. Unleaded gasoline was first introduced in Lebanon in small amounts in 1993 to meet demand of new car models equipped with catalytic converters (Hashisho and El-Fadel, 2001). Since then, unleaded gasoline has assumed an ever more important share of total gasoline consumption, from less than five percent in 1995 to almost 20 percent in 1999 (see Figure 7. 3), and presumably more since.

The maximum lead content in unleaded gasoline, as specified by the Ministry of Energy and Water, is 0.008 ml/l, compared to 0.15 ml/l for super grade gasoline (98 Octane) and 0.4 ml/l for regular grade (92 Octane). Therefore, as unleaded gasoline becomes more widely used, lead emissions will decrease proportionally (see Section 9.1.2 on total lead emissions).

Figure 7. 3
Imports of Leaded and Unleaded Gasoline (1995-1999)



Source: Directorate General of Petroleum, MoEW

Pursuant to Law 341/2001, a gallon (20 liters) of unleaded gasoline was LBP 1,000 cheaper than regular gasoline as of July 2001. This has created an important price incentive for using unleaded gasoline. The energy pricing policy favoring unleaded gasoline will in July 2002 be raised to LBP 2,000. These measures will contribute to increased consumption of unleaded gasoline and reduced lead emissions.

[7] *Pers comm*, Wehbeh S, MoE/Department of Prevention of Impacts from Technology and Natural Hazards

Is the phase out of leaded gasoline dependent on the energy sector in Syria?

out of leaded gasoline in Lebanon cannot be achieved before its phase-out in Syria, which is the main supplier of gasoline for the Lebanese market. While it is true that the market share of Syrian gasoline is the highest, it is still comparable to the share of other supplying countries [mainly France, Italy and Greece]. The higher share of Syrian gasoline may be justified in terms of -out program in

Source: Hashisho and El-Fadel, 2001a

7.4 Outlook

At least two developments will affect the energy sector in Lebanon in the coming years: the substitution of diesel oil with natural gas for operating the Beddawi and Zahrani thermal plants and the privatization of the power generation and distribution sectors. As the GoL tries to privatize the power utility sector, potential buyers can be expected to inquire about the environmental liabilities potentially associated with the power sector. In addition, solar power could significantly influence electricity consumption at the level of households. Mysteriously, however, Lebanon has not yet seized the potentially significant economic and environmental opportunities offered by solar heating. Meanwhile, the GoL has secured a UNDP/GEF grant to develop energy efficient buildings guidelines (see Section 4.3.3. for a project brief). Current proposals to tap energy from landfills using waste-to-energy technologies have also been examined. Appendix G provides an overview of solid waste dumps and the results of a feasibility study to convert waste to energy from the Borj Hammoud landfill site.

7.4.1 Operating Thermal Plants on Natural gas

The GoL has signed an agreement with the Syrian government to supply natural gas from Syria to operate the Beddawi (north Lebanon, nominal capacity 435 MW) and Zahrani (center region, nominal capacity 435 MW) power plants. Preliminary designs indicate that the project will be implemented in two phases. During the first phase of the project, a coastal pipeline will extend 40 km from across the Syrian border to Beddawi and will be executed in 2002 at a cost of US$ 12 million.[8] During the second phase, a second pipeline will be constructed extending 132 km from Beddawi to Zahrani. Completion of both pipelines will entail US$ 100 million in annual savings, thus significantly alleviating Lebano

7.4.2 Privatizing the Electricity Sector

Recent developments at the MoEW suggest that the GoL is thoroughly exploring opportunities for privatizing the power generation sector. This is perceived by some as

power demand. In particular, current proposals suggest that power generation as well as electricity distribution (and collection of fees) will be privatized while electricity transmission (medium and high voltage network) will remain state owned and operated.

[8] *Pers comm* Fadi A, EDL/Member of Managing Board (*Majles el Idarah)*

In addition to the monthly bill they receive from EDL, many people have to pay monthly subscriptions to a private power supplier, generally in the neighborhood, to provide a backup supply of electricity; subscription rates may vary from US$50 to US$200 per month, irrespective of actual consumption. To the extent that privatization would lead to more efficient and cost-effective production and distribution of electricity, private power generators would not be needed in the future, which would lead to improved quality of life (less noise) and reduced street-level air pollution.

7.4.3 Promoting Renewable Energy

Use of solar energy to heat water continues to be very limited in Lebanon! In comparison, neighboring countries such as Cyprus, Jordan, Israel, and Palestine have for years relied heavily on solar water heating panels for domestic uses (almost all buildings have solar heaters on the roof). Greece is following suit, building one of the largest solar plants in the world on the island of Crete and enacting a law that would prohibit people from using anything but solar power to heat their water.[9]

The GoL needs to study the technical, economic and financial feasibility of solar heating in Lebanon and to put in place, together with the private banking sector, the necessary financial incentives (loans, subsidies) to promote the use of solar heaters by Lebanese households and land developers.

According to ALMEE estimates, the installation of 400,000 solar heaters in Lebanon, over a 10-year period, would entail electricity energy savings of about 8 percent, with the following associated positive impacts (ALMEE, 2000):

- Avoiding the need to expand the power production capacity by 100 MW (avoided capital cost of over US$100 million);
- An energy bill lower by about US$30 million over 10 years; and
- Sharp reductions in atmospheric pollution from thermal power plants.

7.4.4 Establishing the Lebanese Center for Energy Conservation and Planning

In October 2001, and with support from UNDP/GEF, the GoL launched an ambitious five years - US$4.4 million - energy project. The goal will be to reduce current trends in GHG emissions in Lebanon by improving demand-side energy efficiency through the creation of a multi-purpose Lebanese Center for Energy Conservation and Planning (to be hosted at the MoEW). The project also aims to provide necessary engineering and energy marketing services pertaining to energy conservation, and to assist the GoL in strengthening its policy aspects and increasing public awareness pertaining to energy planning and conservation. The Center will simultaneously undertake barrier removal activities and provide energy efficiency services to both public and private sector industries in an effort to making them commercially viable operations. Information dissemination, awareness programs, policy analysis and program design are also foreseen during project implementation.[10]

[9] Information retrieved from http://www.thisiscyberia.com/Environment/news.asp

[10] Project information based on UNDP *Project Fact Sheet* Cross Sectoral Energy Efficiency and Removal of Barriers to ES