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COMBINED HEAT AND POWER: A COST-EFFECTIVE OPTION FOR ENERGY EFFICIENCY IMPROVEMENT IN THE ESCWA INDUSTRIAL SECTOR

01-0839

COMBINED HEAT AND POWER: A COST-EFFECTIVE OPTION FOR ENERGY EFFICIENCY IMPROVEMENT IN THE ESCWA INDUSTRIAL SECTOR

A. INTRODUCTION

The relative importance of the manufacturing sector in the economy of the ESCWA region today continues to grow, but in a slow pace. In 1999, the share of manufacturing industries accounted for 11.2 percent of the total GDP, while in 1990 it was 9.0 percent[1]. During this period, the manufacturing value added (MVA) has been almost doubled and reached 45,270 million US dollars.

The industrial sector in the ESCWA region accounts for about 21 percent of petroleum products and 27% of electricity consumption. Substantial energy efficiency improvement and considerable reduction in greenhouse gas (GHG) emissions, could be achieved in the sector through policies and initiatives that simulate market transformation and new technologies which would help to improve end-use energy efficiency by recovering waste heat. One of the high priority and cost-effective options used for this purpose is the combined heat and power (CHP), or cogeneration.

In the present paper, the assessment of CHP potential in the industrial sector of selected ESCWA countries will be discussed. The selected countries are: Egypt, Lebanon and Syria. This selection was basically because of the availability of reasonable raw data to perform the assessment.

CHP systems generate electrical/mechanical and thermal energy simultaneously, recovering much of the energy normally lost in separate generation. With efficiencies around 80 percent, plants are able to make significant fuel savings, and thus cost and emissions savings, over conventional forms of electricity generation and heat-only boilers. Generation of electricity on or near the point of use also avoids transmission and distribution losses and defers expansion of the electricity transmission grid.

B. CHP POTENTIAL IN THE INDUSTRIAL SECTOR OF SELECTED ESCWA MEMBER COUNTRIES

1. The Case of Egypt

Energy demand in Egypt has increased in the recent years as a result of the improvement of the standard of living, construction of new industrial zones and expansion of the commercial and residential sectors. On the other hand, increased awareness of the limits on oil and gas reserves, and valid expectation of higher future prices of imported energy, means that the call for improvements in energy efficiency should be taken seriously.

Over the past few years, the Egyptian government has been simulating economic growth with ongoing deregulation and privatization efforts. The private sector has played an important role in this growth, with annual growth domestic product (GDP) increasing by roughly 5 percent.

(a) The pattern of energy consumption in Egypt

The primary energy consumption in Egypt has been increased from 32.33 mtoe in 1994/95 to about 42.19 mtoe in 1998/99 with an average growth rate of about 6.6 percent [2]. Primary energy consumption in Egypt depends mainly on petroleum energy (petroleum products and natural gas), which represents about 91.8 percent of the total primary energy consumption in 1998/99, as illustrated in Figure I.

The final energy consumption in Egypt has been increased from about 28.25 mtoe in 1997/98 to about 29.54 mtoe in 1998/99, with an average growth rate 4.57 percent. The sectoral distribution of this

energy is illustrated in Figure II. As shown, the industrial sector is the major energy consumer, sharing about 46.5 percent of the end use energy consumption. This amount of energy consumption has negative environmental energy impact particularly the release of carbon dioxide (CO_2), the major greenhouse gas.

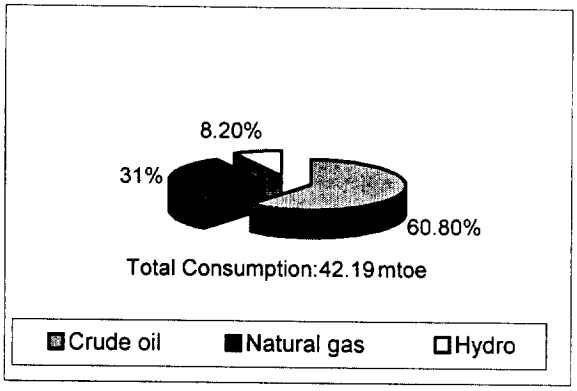

Figure I. Primary Energy Consumption in Egypt

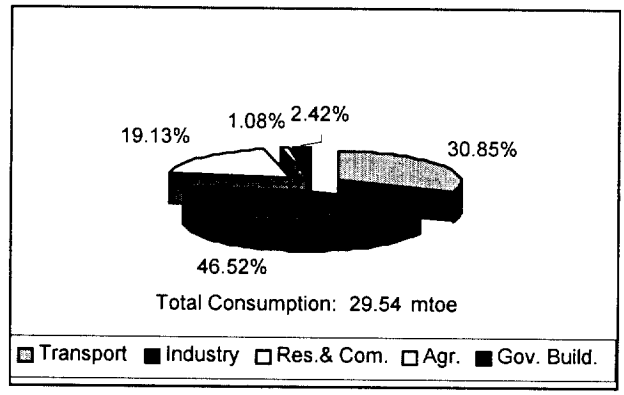

Figure II. The sectoral Consumption of end-use energy in 1998/99

The sectoral consumption of electricity increased from 52,977 GWh in 1997/98 to about 56,600 GWh in 1998/99 with an annual growth rate of 6.84 percent (Table 1). The two major consumers of electricity are the residential and commercial sector, representing 41 percent of the total electricity consumption, and the industrial sector, representing about 40.5 percent in 1998/99, followed by the government and public utilities sector, representing 13.33 percent, and finally the agriculture sector, representing only 3.89 percent of the total electricity consumption.

TABLE 1. THE SECTORAL CONSUMPTION OF ELECTRICITY

Sector	1997/98 (GWh)	1998/99 (GWh)	Growth rate (%)	Share 1998/99 (%)
Industry	22,079	22,900	3.72	40.46
Residential & commercial	20,471	23,200	13.33	40.99
Agriculture	2,131	2,200	3.24	3.89
Government/public utilities	8,296	8,300	0.05	14.66
Total	52,977	56,600	6.84	100

Source: Organization for Energy Planning, Annual Reports, Egypt, 1999.

(b) The industrial sector in Egypt

The contribution of manufacturing industries in the gross domestic products (GDP) reached about 15.1 percent in 1999 [1] with a value added of 13,427 million USD and their consumption of energy reached 13,743 ktoe[2] representing 46.52 percent of the total end-use consumption. This consumption figure reflects great need to increase the efficiency use in the Egyptian economy.

The manufacturing industries in Egypt includes various industrial activities which are normally classified as:

- *Metals industry*, includes integrated and non-integrated iron and steel, non-ferrous, pipes, forging and aluminum industries;

- *Chemical industries,* include fertilizers, chemicals, pesticides, dyes, paper (34), coke, oils tires, industrial gases, wood manufacture and matches industries;

- *Textiles industry,* include cotton spinning and wearing, dyeing, synthetic silk, wool, linen, gut, carpet and garments industries;

- *Food industries,* include sugar (from cane and beet roots), distillation, tobacco, salt and soda, oil, milk, vegetables and fruits preservation, bakery, confectionary, chocolates and soft drinks industries;

- *Cement and Refractories,* include cement, salts, glass and crystal, Refractories, clay and china;

- *Engineering Industries,* include shipyard works, rail way, light transport, cars, springs, transportation fittings, steel structures, construction, industrial services, steel boilers, domestic appliances, workshop machines and tools, electric cable, radio and TV, refrigeration and air condition;

- *Other industries,* include all industries unclassified under any of the above groups such as, pharmaceutical, bricks, military industries, and private sector industries (textiles, glass ceramics, leather and light industries).

As per the year 1998, the textile industry sector was the largest in number of plants, about 5500, followed by the metallic industries, machinery cars spare parts and assembly, household appliances industries which amounts to 5200 plants and food processing sector which includes about 4500 industrial facilities. The wood manufacturing chemical industries, building material and paper industries contribute a big portion of the Egyptian industrial base.

Despite of the great efforts that have been done for efficient use of energy in the industrial sector, still many efforts have to be done. It was indicated by a previous study [3], that the total size of the potential energy efficiency market in Egypt is estimated at LE (Egyptian Pound) 3.6 billion (about US$ 0.9 billion). The industrial sector accounts for 95 percent of the total, including chemicals (accounting for 18%), metals (18.9%), building materials (18.7%), food industries (14.7%) and textiles (11.0%).

(c) The pattern of energy consumption in the Egyptian industrial sector

The main consumer of energy in Egypt is the industrial sector. In 1998/99, the industrial sector consumed 13,743 mtoe, classified in terms of energy sources (excluding renewable energy) as follows: 3,750 ktoe (27.3%) residual fuel oil, 1800 ktoe (13.1%) diesel/gas oil, 3,923 ktoe (28.6%) natural gas, 1,969 ktoe (14.3%) electricity, 926 ktoe (10%) other petroleum products. This energy is distributed roughly on different manufacturing sectors as illustrated in Figure III[4].

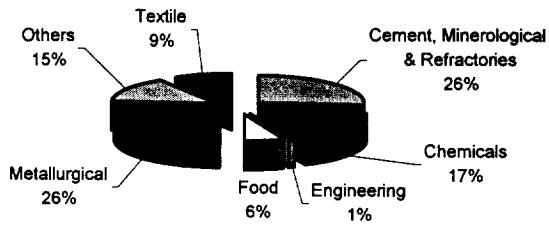

Figure III. Pattern of Energy Consumption in Egyptian Industrial Sector

(d) The potential CHP capacity in Egyptian industry

In Egypt, CHP is basically applied in the industrial sector. In 1992 the total installed CHP capacity was 363 MW, most of which are using steam and gas turbines. From 1992-1998, a very limited number of CHP projects were added to the existing installed capacity. This was due to the economic, regulatory and institutional barriers, as well as to the unclear picture of the electricity market. Two demonstration projects, of capacities 0.525 MW and 1.8 MW, were implemented in 1993 and 1996 respectively. In 1999, about 70 MW were added to the existing capacity, of which 17.25 MW was installed by Talkha Fertilizers and 60 MW by the Egyptian Petrochemicals Company. Both facilities were connected to the grid.

Table 2 shows the installed CHP capacity and the expected potential in different industrial sectors updated to the year 1999.

TABLE 2. INSTALLED AND EXPECTED CHP CAPACITIES IN DIFFERENT INDUSTRIAL SECTORS (1999)

Industrial Sector	CHP Capacity (MW)			
	Installed	Share (%)	Expected	Share (%)
Food	108.5	24.7	541	45.0
Chemicals and Pharmaceutical	101	23	173	14.4
Textiles	116.0	26.4	174	14.5
Metals	0.525	0.1	50	4.2
Petroleum	105	23.8	197	16.4
Other Industries	9.04	2.0	65	5.5
Total	**440**	**100**	**1200**	**100**

(e) *Expected benefits by CHP implementation*

CHP systems are site-specific. The selection of a CHP technology for a specific application depends on many factors, including the amount of power needed, thermal needs, the duty cycle, space constraints, fuel availability, utility prices, interconnection issues and emission regulations. However, rough estimates were made, using spreadsheets, to evaluate the expected amount of savings by implementing the potential CHP capacity.

The analysis was performed on suggested CHP modules (prototypes), based on the current market trends of the CHP equipment and the actual costs supplied by different vendors. Table 3, shows a summary of the expected energy savings, capital investment and saved carbon dioxide (CO_2).

TABLE 3. ENERGY, ECONOMIC AND ENVIRONMENTAL BENEFITS OF CHP ENERGY EFFICIENCY APPLICATION IN EGYPTIAN INDUSTRY

CHP Options	Fuel Type	Avg. Annual Energy Savings (toe/MW)	Potential Capacity (MW)	Avg. Capital Costs (1000 $/ MW)	Annual Energy Saved [(1)] (GWh)	Avg. Capital Investment (million US$)	Avg. S.B.P. (yrs.)	IRR	Total saved CO_2 (1000 ton)
Steam Turbines	Fuel Oil	1777.8	486	650	3731.90	315.90	2.5	From 15% to 42%	1907.33
Gas Turbines	Natural Gas.	1893.1	165	1070	1235.82	176.55	4.2	From 12% to 15%	474.38
Gas Engines	Natural Gas	1644.8	549	877	3768.69	481.473	4.58	12%	1622.87
Total			**1200**		**8736.41**	**973.923**			**4004.58**

(1): At utility.
S.B.P.: Simple Payback Period.
I.R.R.: Internal Rate of Return.

As shown in the table, the amount of energy saved at the utility side may reach 8736 GWh associated with CO_2 reduction of approximately 4 million tons. The simple payback period ranges from 2.5–4.6 years.

(f) Barriers

In Egypt, the promotion of combined heat and power is facing several market and regulatory barriers; these barriers include:

i. Current regulations do not recognize the overall energy efficiency of CHP or credit the emissions avoided from displaced grid electricity generation;
ii. The new policy and legislation regarding private power is not yet well defined. Such a policy would probably have to be initiated by the Supreme Energy Council;
iii. The market is still unaware of developments in CHP technology that have expanded the potential for CHP;
iv. Very low tariffs for surplus CHP electricity sold to the grid;
v. The lack of incentives for CHP producers; and
vi. Inadequate database generation and dissemination.

(g) Conclusions and recommendations

As a result of privatization and changes in the energy sector, it is expected that a more aggressive approach to pursuing CHP will be established in Egypt. However, the following recommended actions have to be considered:

- A national CHP policy is needed that provides incentives to Egyptian industry and recognizes the benefits of CHP over central power stations. The national CHP policy should not be developed solely as energy sector reform but as part of on-going economic reform as well;
- Implementation of database oriented to energy efficiency and CHP;
- Many efforts have to be made to eliminate, or reduce, the existing barriers;
- Financial and environmental incentives have to be provided to encourage small power producers.

2. The case of Lebanon

About 97 percent of the primary energy used in Lebanon is imported fossil fuel. The energy bill in 1997 amounted to 840 million US$, nearly 10 percent of total Lebanese imports[5]. It is expected that, with the present rate of energy demand, energy consumption in Lebanon will double in about ten years. This situation creates a great challenge for the rational use of energy in all sectors.

(a) The pattern of energy consumption in Lebanon

In 1996, Lebanon consumed 4647 ktoe as a primary energy. The classification of this energy, excluding asphalt products, is as follows: 1578 ktoe residual fuel oil, 1521 ktoe gasoline, 991 ktoe diesel oil, 134 ktoe coal, 140 ktoe LPG, 116 ktoe jet-fuel/kerosene, 30 ktoe wood and about 817 GWh hydro energy.

The final energy consumption for 1996 was 3668 ktoe shared between sectors as follows: transportation 45 percent, industry 25 percent, and residential and public buildings 30 percent. Gasoline represents about 40 percent of the total final energy consumption and mainly used in transport sector; diesel/gas oil represents 23 percent and is used in transport, industry, heating and mainly in thousands of back-up private generators complementary to the electricity produced by Electricité du Liban (EDL). The residual fuel oil is used mainly in power generation (83%), and the rest (17%) is used in industry for steam generation and heating.

Electrical energy consumption in 1996 reached 7650 GWh representing 16 percent of the final energy consumption; the distribution of this energy by sectors is illustrated in Figure IV.

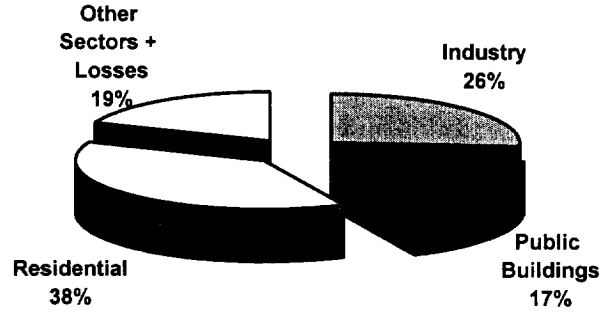

Figure IV. Electricity Consumption by Sectors

(b) The industrial sector in Lebanon

In 1998, the number of industrial facilities in Lebanon counted 22,025 establishments[6], the bulk of which (88.6%) belongs to 8 major industrial branches: food and beverages, textiles, clothing and fur, leather and tanning, wood products (excluding furniture), non-metal products, metal products, furniture and assimilated products. Lebanese industry is characterized by huge number of small units; since about 16,223 facilities (73.7%) employ less than 5 workers, and 20,961 (95.2%) employ less than 10, while only 67 facilities (0.3%) employ over 100 workers. Considering that the medium-sized enterprises are those employing between 10 and 50 workers, and large enterprises are those employing more than 50; only 4.2 percent of Lebanon's industrial companies are medium-sized, and 0.6 percent are large enterprises.

(c) *The pattern of energy consumption in the Lebanese industrial sector*

Data for energy consumption in industry are available only for the year 1994, in which Lebanese industry consumed about 939 ktoe of energy for heat and power [7]. Electricity consumption was 2817 GWh representing 25.9 percent of the energy used in the sector; this energy comes from two sources: 1728 GWh generated locally using simple diesel generators and 1089 GWh imported from the national EDL grid[7]. During 1994, the residual fuel oil and diesel, used directly in combustion processes, represented 26.9 and 26.6 percent respectively, of all energy used in industry. The rest is LPG and coal (used mainly in cement production).

With 1994 as a base line year, table 4 shows the trend in energy consumption in Lebanese industry for the years 2000-2015 under the assumption of an economic growth rate of 3 percent which is consistent with the government projections[8].

TABLE 4. ENERGY DEMAND IN LEBANESE INDUSTRIAL SECTOR

ktoe

Energy source	**Actual**	**Projected**		
	1994	**2000**	**2005**	**2015**
Electricity	243	282	325	432
Diesel/Gas oil	249	283	315	391
Residual duel oil	253	295	342	459
LPG	23	28	32	43
Coal	184	179	208	278
Total	**952**	**1067**	**1222**	**1603**

Source: See Reference No.(8).

Actual figures of petroleum products consumption, for the major energy consumers in the industrial sector (140 plants), were provided by the Association of Lebanese Industrialists.[8]. Classification of this consumption by type of fuel and its distribution on industrial branches are shown in table 5. From the table it is clear that the actual consumption of fuel oil agrees with the projected one (see table 4), while the diesel/gas oil is much different. The reason is that bakeries, as well as many small facilities, which consume more than 160 ktoe of diesel/gas oil are not included in the survey.

TABLE 5. A SUMMARY OF ACTUAL FUEL CONSUMPTION BY SUB-SECTORS OF MAJOR CONSUMERS

Industry	No. of Plants	1999			2000		
		Fuel oil	Diesel	LPG	Fuel oil	Diesel	LPG
Food	38	49,381.1	23,999.6	390	39,575	23,375	288
Textiles	12	1,498.1	1,346.4	--	1,400	136.2	--
Paper	18	34,425.7	10,246.1	--	34,398	1,377.2	--
Chemicals	26	32,050	9,209.8	9.5	32,200	10,818.7	--
Cement & Non-metallic minerals	12	169,538.5	19,505.7	4,635.2	173,973	20,912	6,050
Basic metals	5	8,500	8,632.3	1,048	8,500	9,028	1,150
Fabricated metal products	22	300	11,683.4	130	300	10,061.1	135
Wood & wood products	7	--	584.4	27	--	461.6	--
Total (tons)	**140**	**286,693.4**	**85,207.7**	**6,239.7**	**290,246**	**88,697.6**	**7,623**
Total (toe)		**278,666**	**93,984**	**7,020**	**282,119**	**97,834**	**8,576**

Source: Association of Lebanese Industrialists, Beirut, 2001.

(d) The potential CHP capacity in Lebanese industry

High CHP potential is expected in Lebanese industry, due to the following reasons:

- The industrial sector generates about 61 percent of its electric demand through isolated diesel engines with low thermal efficiency that does not exceed 20 percent[7];
- The cost of electricity in Lebanese industry reaches 0.20 US$/kWh during the peak hours, and with an average value around 0.11 US$/kWh, which is one of the highest tariffs in the world;
- Fuel prices are considerably high and subject to world market fluctuations;
- Utility technical losses are 15-18 percent, while non-technical losses are more than 40 percent;
- The average specific fuel consumption of power plants is relatively low and ranges from 240-300 gm/kWh.

Based on consumption figures, developed in tables 4 and 5, rough estimates for the potential CHP in Lebanese industry have shown a total size of 160 MW, distributed between sectors as shown in table 6.

TABLE 6. THE POTENTIAL CHP CAPACITY IN LEBANESE INDUSTRY CLASSIFIED BY SIZE

Industry	Proposed CHP Sizes (MW)		Total (MW)
	0.25 – 1.0	1.0 – 5.0	
Food	10	12	22.0
Textiles	2.0	-	2.0
Paper	4	15	19.0
Chemicals	6	11	17.0
Cement and Non-metallic minerals	-	95	95
Basic metals	2	3	5.0
Total	**24**	**136**	**160**

(e) *Expected benefits by CHP implementation*

The techno-economical analysis, using spreadsheets of the potential CHP capacity in Lebanese industry has shown high feasibility and much attractive financial indicators. A summary of these results is illustrated in table 7.

TABLE 7. ENERGY, ECONOMIC AND ENVIRONMENTAL BENEFITS OF CHP EFFICIENCY APPLICATION IN LEBANESE INDUSTRY

CHP Option	**Fuel type**	**Avg. annual energy savings (toe/MW)**	**Avg. capital costs (1000$/MW)**	**Avg. S.B.P. (yrs.)**	**IRR (%)**	**Avg. saved CO_2 (kg/MWh)**
Steam turbines	Fuel oil	1685	650	1-2.9	26-80	670
Reciprocating gas engines	Dual fuel(*)	1166	900	2-3.6	18-41	612

S.B.P: Simple Payback Period.
(*) Including natural gas.

As shown from the table, the average amount of energy savings may reach 1685 toe/MW of installed capacity, the simple payback period ranges from 1-3.6 years, and the reduction of CO_2 ranges from 612-670 kg/MWh.

(f) Barriers

In order to promote the CHP energy efficiency option in Lebanese industry, several market and regulatory barriers will have to be overcome. These barriers include:

(i) The lack of awareness of issues pertaining to energy efficiency, in general, and CHP in particular;

(ii) The lack of demonstration experience for different energy efficiency technology options;

(iii) The lack of financing. There are no dedicating financing schemes or incentives for energy efficiency and/or environmental initiatives;

(iv) The illegal connections to the national grid;

(v) High prices of energy efficiency equipment in the local market;

(vi) The lack of national policy to promote more efficient use of energy;

(vii) The lack of experience and training the energy efficiency field, such as auditing, monitoring and implementation.

(g) Conclusions and recommendations

Techno-economic analysis has shown the cost-effectiveness of CHP implementation in Lebanese industry. The analysis has shown large amount of energy savings and substantial reduction in CO_2 emissions.

In view of the above, it is recommended to accelerate the diffusion of CHP in Lebanese industry by:

- Develop a national CHP policy that provides incentives to Lebanese industry;

- Develop training programmes for plant engineers and technicians;
- Many efforts have to be made to eliminate, or reduce, the existing barriers;
- Develop new customs policies and laws that encourage energy efficiency industry and commerce;
- Financing and environmental incentives have to be provided to encourage small power producers.

3. The Case of Syria

The primary energy intensity per GDP in Syria had been improved from 0.697 toe/1000 US$ in 1994, to 0.595 toe/1000 US$ in 1999[1]; however it is still higher than the world average. During the period 1994-1999, the primary energy consumption had been increased from 12,304 ktoe to about 13,372 ktoe[1]. During the same period, the ratio of oil consumption to production had been increased from 37.8 percent to 44.1 percent.

The previous ESCWA study [9] had shown that the potential of energy efficiency improvement in the Syrian industry ranges from 20 percent to 60 percent of the total plant consumption, especially for the following industries: fertilizers, metals, textiles and cement industry. Thus more attention has to be given to the rational use of energy in all sectors including industry.

(a) The pattern of energy consumption in Syria

The main sources of primary energy in Syria are: crude oil (70.6%), natural gas (25%) and hydro (4.3%). About 78 percent of the natural gas consumption is used for electricity generation and the rest is used in manufacturing, mining and petroleum industries.

Figure V shows the distribution of petroleum products (including natural gas) and electricity on economic sectors in 1999[10]. The transport sector is the largest consumer of petroleum products (32%), followed by the residential and commercial sector (30%), the industrial sector (26%), the agriculture (9.4%) and other sectors (2.6%). Concerning electricity consumption, the residential sector comes in the first place (39%) followed by the industrial sector (29%) and all other sectors, including agriculture, (32%).

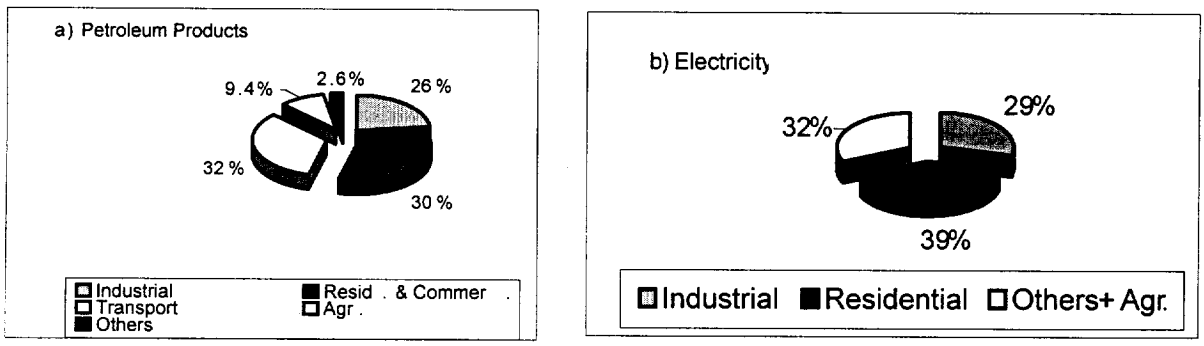

Figure V. The distribution of final energy consumption in Syria

(b) The industrial sector in Syria

The main bulk of the manufacturing industries in Syria belongs to the public sector, and are normally classified into six industries:

- *Cement industries*, belong to the General Organization of Cement and include the following industries: cement, porcelain, plumping tools, and building materials;

- *Textiles industry,* belong to the General Organization for Textile Industries, and include: cotton yarn, spinning and weaving, dyeing, synthetic silk, wool, linen, nylon and socks, underwear and garments industries;
- *Food industries,* belong to the General Organization for Food Industry, and include: dairy, biscuits and chocolates, oil and soap, milk, vegetables and fruits conserves, bakery, water and soft drinks industries;
- *Chemical industries,* belong to the General Organization for Chemical Industries, and include the following industries: fertilizers, chemicals, paints, rubber and plastic products, tanning, cleaning products, paper, glass, tires and leather products;
- *Sugar industries,* belong to the General Organization for Sugar and includes the manufacturing of sugar and yeast;
- *Engineering Industries,* belong to the General Organization for Engineering Industries and include: aluminum industry, iron and steel, cables, matches and wood, tractors industry, batteries, and electronics industries.

(c) *The pattern of energy consumption in the Syrian industry*

Based on the data provided by the Energy Planning and Conservation Centre, belonging to the Ministry Of Electricity in Syria, the main indicators of Syrian industry, including production capacity and consumption, are shown in table 8. The table shows the average specific energy consumption (SEC) for each industrial branch. The total electrical energy consumed in the public sector in 1999 was 1395 GWh, distributed between sub-sectors as shown in Figure VI-a..The distribution of petroleum products, excluding natural gas as feedstock, is shown in Figure VI-b.

TABLE 8. THE MAIN INDICATORS AND ENERGY CONSUMPTION (1999) IN SYRIAN INDUSTRY (PUBLIC SECTOR)

Industry	Production (tons)	Energy Consumption				Total (toe)	Overall SEC (*) (toe/ton)
		Electricity (GWh)	Petroleum Products				
			Fuel Oil (ton)	Diesel (ton)	Natural Gas (1000 m^3)		
Cement	4,837,399	733.596	443,318	14,316	83,638	582,296	0.120
Textiles	59,087	253.769	28,938	6,388	0	56,758	0.96
Food	261,165	44.046	12,402	11,504	0	28,105	0.108
Chemicals	995,578	184.932	57,148	10,239	319,858	361,737	0.363
Sugar	182,623	78.733	82,863	2,803	0	90,301	0.495
Engineering	16,638	99.809	2,078	12,714	0	24,155	1.452

Source: Energy Planning and Conservation Centre, Ministry of Electricity, Syria.
(*) SEC = Specific energy consumption.

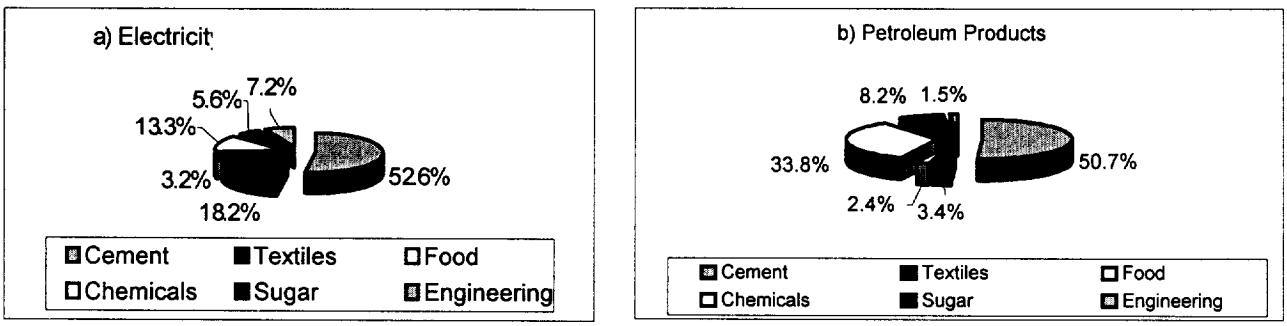

Figure VI. The distribution of energy consumption by industrial sub-sectors (1999)

(d) The potential CHP in Syrian industry

Excluding hydro power, Syria has a total power plants of installed capacity of 5,130 MW[1] in 1999, classified as follows: 3000 MW steam, 1530 MW gas and 600 MW combined cycle. The generated electricity during this year was 21, 366 GWh. Steam power plants generated about 57 percent of this energy and consumed approximately 2378.6 kton of heavy fuel oil, 5.12 kton of diesel oil, and 245.65 million m^3 of natural gas[10]. The specific energy consumption of steam power plants ranges from 0.226 to 0.344 kgoe per kWh. In 1999, the maximum demand in Syria was 3,891 MW, and the total end-use electricity consumption was 22,096 GWh[1]. Electricity consumption is increasing at an average rate of 5.8 percent per year.

In Syria, combined heat and power is implemented only in sugar industries with a total capacity around 32 MW. The systems are used only 100 days per year. Syria has a large potential in other industries where the need of power and thermal energy are particularly acute. The targeted industries in Syria, for which are most convenient for CHP facilities are: food, chemicals, textiles, cement and engineering. The ageing of industrial boilers, providing process steam to these industries is opening up new opportunities to implement CHP technologies. A rough estimation of the CHP potential in Syrian industry is shown in Table 9 and Figure VII. The estimation is made only for the major consumers in the public-sector based on the consumption figures provided by the Energy Planning and Conservatio Centre.

TABLE 9. ESTIMATED CHP POTENTIAL IN SYRIAN INDUSTRY

Industry	CHP Potential (MW)	%	Module Sizes
Cement	93	47	1 - 10 MW
Food	10	5	0.3 - 5 MW
Textiles	34	17	0.3 – 5 MW
Chemicals	44	22	0.3 – 10 MW
Engineering	17	9	0.5 – 10 MW
Total	**198**	**100**	

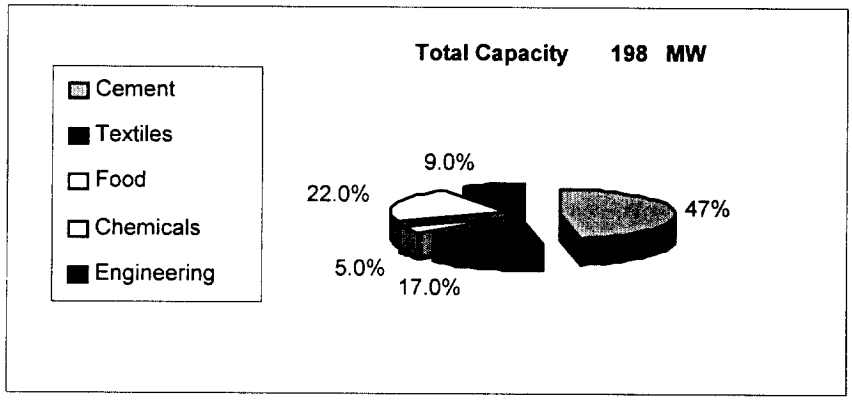

Figure VII. The Estimated CHP Potential in Syrian Industry

Since CHP is site-specific, thus the above estimated figures need to be verified and/or corrected with detailed site investigation. Also, the most convenient option of the CHP systems has to be selected based on site conditions.

(e) *The expected benefits by CHP implementation*

By implementing the potential CHP capacity in Syrian industry, the amount of energy savings may reach about 220 ktoe at the utility side (with distribution losses of 16 percent). Assuming fuel oil is used at the power plant, the amount of associated CO2 will be approximately 684 tons.

Financial analysis has shown that implementation of CHP projects, on the plant side, is not feasible, due to the extremely low tariff and large subsidy to energy prices.

(f) *Conclusions and recommendations*

In view of the above, it can be concluded that the major barriers identified for the CHP in Syrian industry are:

(i) Energy prices represent the most significant economic barriers, since companies in the industrial sector receive a large subsidy;

(ii) The benefits of CHP applications are most widely known, and current regulations do not recognize these benefits;

(iii) Inadequate demonstration experience for CHP technologies and project development models for different and potential industry sectors.

It is recommended to reconsider energy prices offered to industrial facilities and stimulate the awareness of CHP benefits. The UNDP/GEF Project, sponsored by the Ministry of Electricity, can play an important role for the promotion of energy efficiency improvement, including CHP in Syrian industry.

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