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Mediterranean and National Strategies for Sustainable Development
Energy Efficiency and Renewable Energy

Israel National Study
Working Document

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Introduction

Israel's current energy situation reflects its unique combination of European living standards with the rapid growth in fossil-based energy demand typical of developing countries. The State of Israel has undergone rapid economic development during the past 10-15 years, and has attained the standard of living typical of many countries in western and southern Europe. Israel's overall GDP is approximately $120 billion, and its GDP per-capita is approximately $18 thousand, similar to that of Spain and Greece.[1] Israel's population density and its location at the edge of the desert make it especially vulnerable to climate change; 60% of the population of 7 million resides along the narrow coastal strip along the Mediterranean. In contrast to many European counties, Israel has become more dependent on imported fossil fuels over time, and its energy intensity has not decreased. Moreover, although Israel's electricity demand has been steadily increasing, Israel has no electrical interconnections with neighboring countries, and must depend on its extremely low reserves to meet demand during peak hours.

Given this combination of rapid energy demand growth and energy dependency, Israel should be at the forefront of renewable energy (RE) and rationale use of energy (RUE) development. Nevertheless, while Israel continues to be a leader in RE and RUE technology development, it lags significantly behind most developed European countries in adopting these technologies for domestic usage. This report will demonstrate the historical and projected policies and strategies in these fields.

A. Current and forecasted energy demand

While experiencing relatively high economic growth rates, Israel has not followed the trend toward declining energy intensity and greater energy efficiency characterizing most of Europe. For example, Israel's per-capita energy usage increased by 44% since 1990, while the EU average increased by only 15%. Israel's final energy consumption in 2005 was 13.2 Mtoe, of which 8.6 was petroleum products and 3.8 Mtoe was electricity; the remainder was largely natural gas and heat & steam[2].

However, three recent trends in energy demand may be encouraging: (a) the stabilizing of fuel consumption for electricity generation, which rose only 0.1 Mtoe in 2005 to 11.6 Mtoe; (b) the decline in fuel oil sales from 3.6 to 3.26 Mtoe, due mainly to the increase in natural gas consumption by electricity generators;[3] and (c) the consistent decline in the

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[1] World Bank data on Israel, http://devdata.worldbank.org/external/CPProfile.asp?SelectedCountry=ISR&CCODE=ISR&CNAME=Israel&PTYPE=CP

[2] Israel Central Bureau of Statistics www.cbs.gov.il, Table 21.1.

[3] Israel Ministry of National Infrastructures. http://www.mni.gov.il/NR/rdonlyres/35F88D05-58BB-43FF-A22E-A62C2A9B43C7/0/20032006צריכה.xls.

energy ratio since 2002, reaching 50.5 in 2005, the lowest level in 10 years. Overall, final energy consumption rose in 2005 by only 0.85%, from 13.04 to 13.15 Mtoe.

Table 1 indicates the final consumption composition for 2004 and 2005.

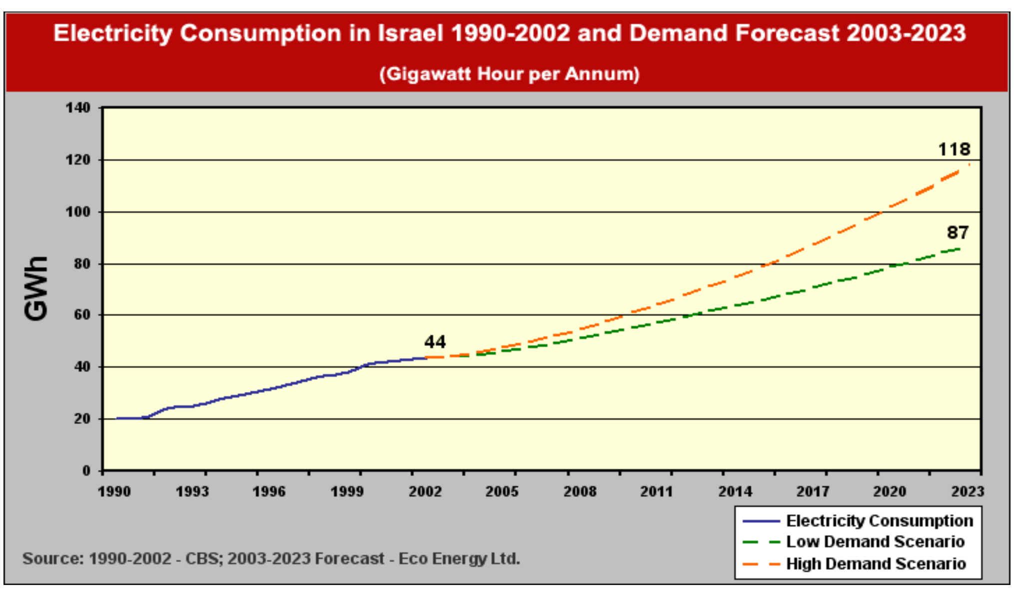
Final consumption of energy products

	2004 (Thousands of t.o.e.)	2005 (Thousands of t.o.e.)	Percentage change 2005 compared with 2004
Electricity	3,679	3,779	2.72
Petroleum products	8,609	8,607	-0.02
Primary Products	752	765	1.80
Total final consumption	**13,040**	**13,151**	**0.85**

Source: Israel Central Bureau of Statistics Energy in Israel 2005

Currently, Israel's total electricity cost is about $4 billion annually, constituting over 1% of Israel's GDP. With the current generation supply mix consisting exclusively of fossil generation, residential and commercial customers, who consume about 55% of all electricity produced, are responsible for approximately 30% of all CO_2 emissions. Industrial customers, who consume about 29% of all electricity, are responsible for only 15% of all CO_2 emissions. The slightly higher share of emissions attributable to non-industrial customers reflects their higher contribution to electricity system peaks, requiring peaking diesel and oil-fired generators. Israel's electricity consumption was nearly 3.8 Mtoe in 2005, an increase of 2.7% over 2004.

The diagram below illustrates Israel's historical and projected demands for electricity, and can be summarized as follows:



As the above diagram indicates, Israel's electricity consumption has doubled during the past 10 years, and is expected to nearly double by 2023 – even in the low-demand scenario. **Given the long lead times required for constructing new electricity generation in Israel, it is very possible that there will be frequent supply shortages unless RE and RUE receive significant attention.** Moreover, demand growth by residential and commercial customers is expected to outpace that of industrial customers, thereby accelerating peak demand growth and increasing the probability of outages during critical peak hours.[4]

B. Current and forecasted energy supply

Israel's energy ratio (primary energy supply per dollar of GDP including taxes) increased by 24% from 1990 to 2004, while the EU average declined by 10%. Despite the relative slowdown in Israel's economy since the mid-1990s and the projected moderate rate of long-term economic growth, primary energy supply is expected to reach 48 Mtoe by 2025 (from today's 21). Table 2 indicates Israel's primary energy supply vs. its GDP from 1990 to 2005.

Table 2: Energy intensity: 1990 - 2005

Year	Base: 1995=100	Intensity	Base 1995 =100	NIS (billion)	Base: 1995=100.0	(Mtoe)
1990	95.4	55.3	74.4	199.6	70.9	11,036.0
1991	90.9	52.7	78.9	211.8	71.7	11,159.6
1992	96.4	55.9	84.5	226.9	81.5	12,689.6
1993	98.8	57.3	87.7	235.5	86.7	13,490.8
1994	98.6	57.2	93.9	252.0	92.7	14,423.3
1995	100.0	52.2	100.0	298.3	100.0	15,564.3
1996	99.4	51.9	105.6	315.0	105.0	16,342.2
1997	98.9	51.6	108.6	323.9	107.4	16,713.6
1998	102.5	53.5	113.1	337.4	115.9	18,038.4
1999	102.8	53.6	116.4	347.3	119.7	18,626.6
2000	99.0	51.7	126.6	377.5	125.3	19,499.2
2001	99.3	51.8	125.7	375.1	124.9	19,435.2
2002	103.4	53.9	124.6	371.6	128.8	20,039.8
2003	101.7	53.1	126.4	377.2	128.6	20,015.2
2004	100.5	52.4	132.5	395.3	133.2	20,728.2
2005	96.8	50.5	139.5	416.0	135.0	21,004.9

Source: Israel Central Bureau of Statistics 2005

Israel's energy sector is based on imported fuels, especially oil. Israel's primary energy consumption in 2005 was 21.0 million tons of oil equivalent (Mtoe), approximately 93% of which was supplied by imported fuels: 56% (11.8 Mtoe) of which was petroleum

[4] Israel Energy Master Plan and discussions with PUA staff.

products, and 37% (7.6 Mtoe) coal used primarily for power generation. In fact, Israel's energy dependency is among the highest in the world, with energy production totaling only about 1.7 Mtoe annually while its net imports exceed 19 Mtoe[5].The remaining 7% (1.5 Mtoe) of primary energy consumption was natural gas, using Israel's recently discovered offshore natural gas reserves.[6] Israel is utilizing its own offshore natural gas reserves (~35 billion cubic meter – BCM), the vast majority of which is under contract with the Israel Electric Corporation (IEC) for its natural gas-fired generating stations. To meet the demand for natural gas of the power and industrial sectors it will be necessary to import natural import gas from other sources, primarily from Egypt, thereby increasing Israel's energy dependence again.

Electricity generation is primarily coal-fired, with approximately 4,800 MW producing approximately 35 million MWh annually, or approximately 75% of Israel's electricity generation. Overall, 10.9 Mtoe of primary energy was used to produce 48 billion KWh of electricity in 2005, mainly in three steam turbines power stations located on the Mediterranean coast (2 coal power plants and one dual-fuel capable - heavy fuel oil and natural gas). Israel Electric Corporation has been actively retrofitting its oil-fired generators to use natural gas, and most of its new electricity generation for the next several years will use natural gas as its primary fuel.

The following table summarizes the fuels used for electricity generation since 1995.

Type of primary fuel consumed by power plants*
Thousand tons

Power Plant	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Haifa	547	448	439	421	494	488	441	402	431	369	344
Reading	612	579	539	592	646	571	477	371	448	407	392
Eshkol	1,141	996	1,035	1,173	1,195	1,257	1,047	888	882	309	116
Orot Rabin (Fuel Oil)	40	-	-	-	-	-	-	-	-	-	-
Private Producers	-	-	-	9	24	29	19	24	21	22	22
Fuel Oil, Total	2,340	2,023	2,013	2,195	2,359	2,345	1,984	1,685	1,782	1,108	873
Orot Rabin	3,864	5,332	6,316	6,758	6,996	6,944	6,684	6,611	6,814	6,815	6,857
Rutenberg	2,703	2,476	2,324	2,526	2,267	3,363	4,882	5,591	5,796	5,902	5,837
Coal, Total	6,567	7,808	8,640	9,284	9,263	10,307	11,566	12,202	12,610	12,717	12,694
Gas (Eshkol C & D)	-	-	-	-	-	-	-	-	-	823	1,127
Jet Engines, Total	37	10	6	13	6	7	5	15	6	3	14
Heavy Duty, Total	292	120	113	212	457	379	149	307	114	88	257
Combined Cycle, Total	-	-	-	-	-	181	81	82	293	234	316
Gas Oil, Total	329	130	119	225	463	567	235	404	413	325	587

* Fuel used for energy production only.

Source: Israel Electric Corporation 2005 Statistical Report

Table xx and Figure xx indicate historical trends for Israel's total primary energy supply from 1980 to 2005 and from 1971 to 2005, respectively.

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[5] Israel Central Bureau of Statistics and International Energy Agency.

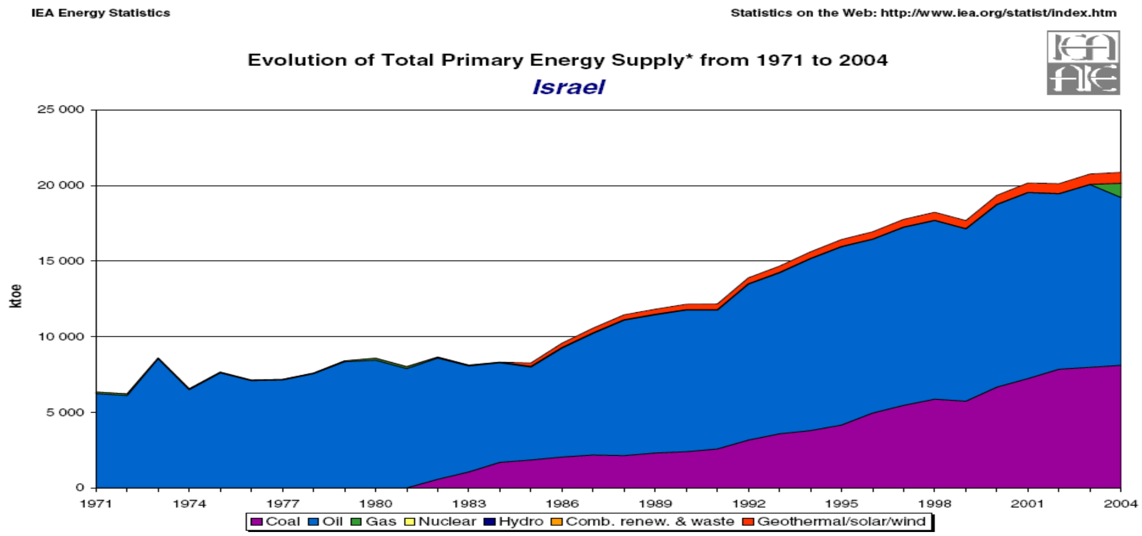
[6] Israel Central Bureau of Statistics, http://www1.cbs.gov.il/reader/new_energy/new_enr_bhar_sidrot_e.html?opzii_sidrot=2&nachalo=nach1

Table xx: Historical trends for Israel's total primary energy supply: 1980-2005

Period	Total Primary Energy	Transformation to Secondary Energy	Primary Energy Supply Grand Total
1980	5,427.3	2,478.6	7,905.9
1985	5,619.2	2,875.2	8,494.3
1990	7,236.0	3,800.0	11,036.0
1995	10,608.6	4,955.4	15,564.3
2000	12,808.2	6,690.8	19,499.2
2002	13,039.0	7,000.7	20,039.8
2003	13,217.6	6,797.8	20,015.2
2004	13,039.7	7,688.5	20,728.2
2005	13,151.1	7,853.6	21,004.9

Source: Israel Central Bureau of Statistics 2005 Energy Report

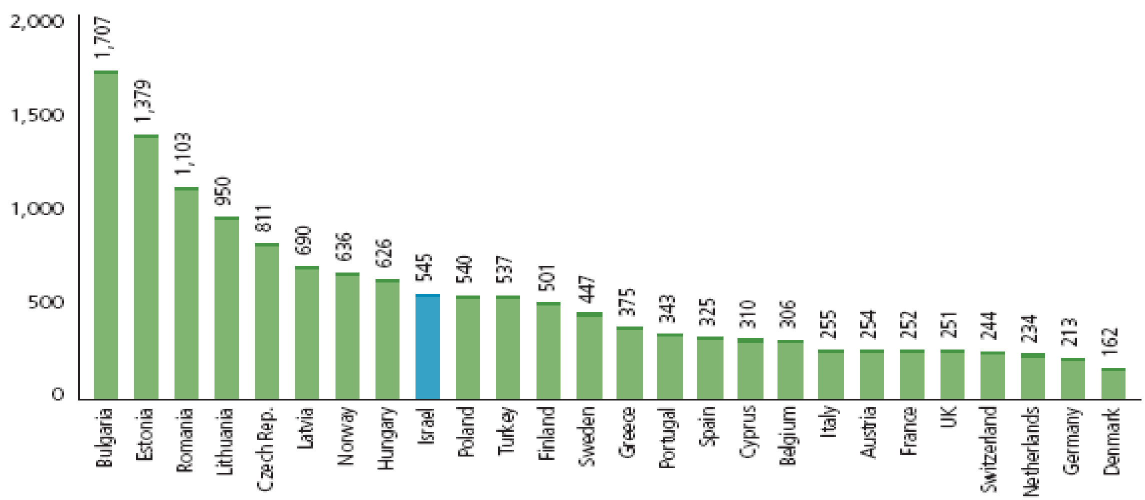
Figure xx: **Evolution of Total Primary Energy Supply 1971 – 2004**



Source: International Energy Agency

Figure xx shows the electricity consumption per GDP ratio in Israel compared to a selection of European countries

Figure xx: Israel electricity consumption per US$1000 of GDP



Source: Statistics and Prospects for the European Electricity Sector, 33rd edition, Eurelectric, Brussels, 2005 (booklet & excel file)
1 2003 data

Table xx shows the trends of electricity usage by customer class since 1995. (Note that all customer classes are eligible for the Time-of-Use (T.O.U.) tariff, and all customers consuming more than 60,000 kWh annually are required to be billed according to that tariff).

Table xx: Annual Electricity Consumption by Sector: 2001-2005

Tariff Groups	Million KWH					Percent				
	2001	2002	2003	2004	2005	2001	2002	2003	2004	2005
Residential	12,307.5	12,734.7	13,347.7	13,482.5	13,637.3	31.8	31.9	32.0	31.4	30.8
Public & Commercial	3,212.8	3,324.3	3,331.1	3,295.9	2,969.1	8.3	8.3	8.0	7.7	6.7
Agricultural	118.3	120.3	115.2	105.5	90.7	0.3	0.3	0.3	0.2	0.2
Industrial	454.6	461.3	432.8	387.4	354.0	1.2	1.2	1.0	0.9	0.8
Water Pumping	110.1	100.4	82.8	73.1	59.7	0.3	0.3	0.2	0.2	0.1
Bulk	2,311.9	2,300.1	2,455.0	2,598.5	2,862.8	6.0	5.8	5.9	6.1	6.5
T.O.U. Tariff	20,150.2	20,878.8	21,956.0	22,989.8	24,335.2	52.1	52.2	52.6	53.5	54.9
Total	38,665.4	39,919.9	41,720.6	42,932.6	44,308.8	100.0	100.0	100.0	100.0	100.0

Source: Israel Electric Corporation 2005 Statistical Report

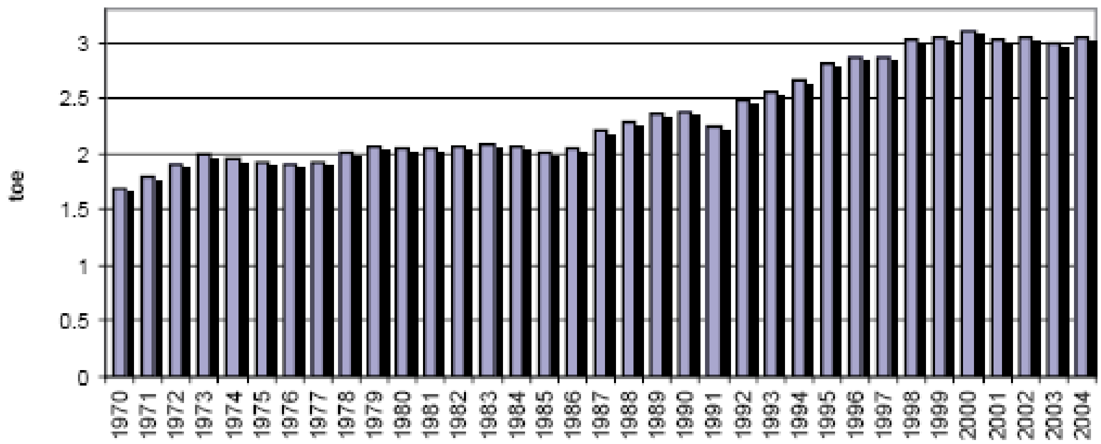
Table xx indicates the annual average price per kWh expressed in US cents per kWh (at year-end US dollar-shekel exchange rates). When combined with the consumption data above, it is apparent that overall electricity demand is not very responsive to price. In fact, the only clear evidence of price elasticity is displayed by customers recently switched to Time-of-Use tariffs; these customers have shifted portions of their consumption to non-peak hours.

Table xx: Annual average electricity price (in US cents per kWh)

Year	Residential	Public & Commercial	Agricultural	Industrial	Water Pumping	Bulk	Total Consumption
1995	8.5	8.2	7.0	6.8	6.1	6.5	7.6
1996	8.4	8.0	6.9	6.8	5.9	6.4	7.5
1997	8.3	8.1	7.1	6.8	6.1	6.5	7.5
1998	7.1	6.9	6.1	5.8	5.6	5.6	6.4
1999	7.6	7.3	6.4	6.2	5.9	5.9	6.9
2000	8.0	7.8	6.9	6.5	6.3	6.3	7.3
2001	7.3	7.0	6.1	5.9	5.7	5.7	6.6
2002	7.8	7.5	6.5	6.2	5.9	5.9	7.1
2003	9.1	8.6	7.4	6.9	6.7	6.7	8.1
2004	9.8	9.3	7.9	7.5	7.3	7.3	8.7
2005	9.8	9.3	8.1	7.7	7.4	7.4	8.8

Table xx presents the trend of per-capita energy supply since 1970. Note that per-capita supply has stabilized since 1998. However, energy supply requirements are growing due to rapid demographic growth.

Energy supply per capita in Israel (in tons oil equivalent)



Source: Israel Ministry for Environmental Protection

TABLE xx.- ISRAEL'S ENERGY BALANCE 2005
Thousands of t.o.e. (tons of oil equivalent)

	Coal	Petroleum products	Natural gas	Hydro and solar Energy	Electric	Grand total
1. Indigenous production			1,496.5	741.2		2,269.5
2. Imports	7,718.0	5,307.8				23,446.6
3. Thereof: refinery feedstocks		-1,614.5				0.0
4. Exports (a)		-3,822.3			-143.2	-3,965.5
5. Marine bunkers		-273.1				-273.1
6. Stock changes (b)	93.4	-59.0				-139.4
7. Statistical differences (c)	-178.2	59.3	0.0	0.0	-13.7	-333.8
8. Primary energy supply (1 through 7)	**7,633.2**	**-423.1**	**1,496.5**	**741.2**	**-156.9**	**21,004.9**

TABLE xx.- ISRAEL'S ENERGY BALANCE 2004

Thousands of t.o.e. (tons of oil equivalent)

	Coal	Petroleum products	Natural gas	Hydro and solar energy	Electricity	Grand total
1. Indigenous production			1,087.6	741.7		1,862.0
2. Imports	7,788.5	5,419.6				22,705.4
3. Thereof: refinery feedstocks		-1,200.5				0.0
4. Exports (a)		-3,684.0			-125.6	-3,809.6
5. Marine bunkers		-223.5				-223.5
6. Stock changes (b)	-48.2	187.3				-202.5
7. Statistical differences (c)	70.3	158.4	-0.3	0.0	-14.8	396.2
8. Primary energy supply	**7,810.6**	**641.7**	**1,087.3**	**741.7**	**-140.4**	**20,728.2**

Table xx: Primary energy supply and total final consumption-forecast through 2025

Year	Primary energy supply - total per capita (toe)	Energy - total final consumption per capita (toe)	Primary energy supply - total (Mtoe)	Energy - total final consumption (Mtoe)
1970	1.7	1.2	5,033	3,495
1975	1.9	1.3	6,635	4,579
1980	2	1.4	7,906	5,427
1985	2	1.3	8,494	5,619
1990	2.4	1.6	11,036	7,236
1995	2.8	1.9	15,564	10,609
2000	3.1	2	19,499	12,808
2005	3	1.9	21,005	13,151
Projections through 2025				
2010	3.0	1.8	22,445	13,723
2015	3.0	1.8	23,983	14,319
2020	2.9	1.7	25,627	14,941
2025	2.9	1.7	27,384	15,590

Source: Israel Central Bureau of Statistics

C. Greenhouse gas (GHG) emissions: current and forecasted

Israel's overall CO_2 emissions are approximately 67 million tons annually, amounting to 9.7 tons per person[7]. Although this figure has declined by about 1% per year, Israel's population continues to increase by about 2% annually (higher than nearly any other developed country), and its total greenhouse gas emissions level has been increasing by about 1% annually since 1990. At current trends, annual CO_2 emissions will reach nearly 83 million tons by 2025. Therefore Israel faces significant challenges in lowering its CO_2 emissions, while meeting the energy needs of a growing population in a rapidly developing country.

Table xx: Total emissions: 2000-2005 with projections through 2025

Year	Total emissions (1000 ton)	CO_2 emissions (1000 ton)	Population (in 000)	CO_2 emissions per capita (in tons)
2000	2,010,088	64,104	6,289	10.19
2001	1,892,822	64,353	6,439	10.00
2002	1,785,661	65,652	6,570	10.00
2003	1,772,015	66,352	6,690	9.92
2004	1,685,900	66,901	6,809	9.83
2005 (est)	1,613,419	67,458	6,929	9.74
Projections through 2025				
2010		70,988	7,634	9.30
2015		74,702	8,410	8.88
2020		78,611	9,266	8.48
2025		82,724	10,209	8.10

Source: Israel Central Bureau of Statistics Energy in Israel 2005

D. The scope of RE in Israel

Since its pioneering efforts to develop rooftop solar water heating, Israel has done little to develop a renewable energy industry that can substantially reduce that energy dependency. Like most of its eastern Mediterranean neighbors, Israel has among the highest solar radiation rates in the world, yet its solar industry has largely consisted of developing technologies, rather than manufactured goods, for export. While Israel has

[7] Israel Central Bureau of Statistics. www.cbs.gov.il.

over 1.3 million solar water heaters producing the equivalent of over 4% of Israel's electricity consumption as a result of mandatory solar water heating installations, it has only 886 kW of photovoltaic installations. In fact, the Ministry of National Infrastructures (MNI) estimates that, without significant government involvement, solar penetration will continue to lag behind most European countries through 2025. However, without the initial government incentives, it is unlikely that solar PV and thermal systems, with facilities costs exceeding $4,000 per peak kW and few suppliers, will reach the necessary scale to be competitive with fossil fuels.

Besides solar, Israel's renewables potential is limited. Biomass potential is about 8.6 Mtoe, primarily from municipal waste. Israel's wind potential is also rather low, with maximum capacity around 600 MW (or about 1.75 billion kWh), and faces the additional difficulties of location and grid interconnection.[8]

In 2004, the MNI published a set of policies and procedures to promote renewables development. The Israel Public Utilities Authority – Electricity (PUA) has since developed tariffs, licensing procedures, and codes of conduct for renewable electricity generators. Renewable electricity includes solar, wind, biomass, and all hydroelectric facilities except for pumped storage)[9]. To date, renewable developers' response to these government initiatives has been slow, and less than 100 MW of renewable generators have received conditional licenses[10]. In addition a 100-MW solar thermal generating station in the Negev (to be profiled below in greater detail) may receive a license in the near future.

Nevertheless, the lack of renewables in Israel's energy portfolio is noteworthy; Israel's entire electricity generation mix in 2005 consisted of coal (75%), natural gas (11%), with the remainder consisting of oil, gasoil, and jet fuel (14%). Moreover, Israel's statistics on primary energy supply include no mention of renewables, indicating that renewables' share of primary energy supply is less than 0.1%, far less than the 2% to which the Government has committed since 2003.

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[8] Presentation by Dan Raviv of RMST and Israel National Report on Climate Change.
[9] Israel Ministry of National Infrastructures, http://www.mni.gov.il/mni/he-il/Energy/Electricity/ElectricitySustainability/ElectricityRenewables.htm
[10] Israel Public Utilities Authority – Electricity: www.pua.gov.il.

E. The scope of RUE in Israel

Government standards for energy efficiency have been in place since 1989 when the Energy Resources Law was passed by the Knesset (Israel's Parliament). These standards include energy labeling for domestic products and inspections for larger commercial and industrial facilities. Although enforcement of these standards remains spotty due to lack of resources, energy efficiency as a strategic energy resource is just beginning to develop. The Israel Energy Master Plan and subsequent work indicate the potential for energy conservation of 20% overall. Subsequent work by the Ministry of National Infrastructures suggests potential savings approaching 35% in all sectors – domestic, commercial, industrial, and transportation.[11] The MNI has begun the process of licensing energy service companies (ESCOs) to develop this RUE potential. As of September 2006 there were 16 ESCOs registered with the MNI, operating under performance contracts with standards set by Econoler, a major worldwide energy service provider assisting the MNI.

F. Barriers to RE and RUE development

There are a number of reasons that RE and RUE have not made more inroads into Israel's energy sector, including the following:

(a) The Ministry of National Infrastructures, which has primary responsibility for energy policy, has not developed comprehensive implementation plans for RE and RUE. It has also not taken opportunities to coordinate RE and RUE with other Ministries that have mandates to promote RE and RUE. This inaction has impeded progress in establishing the necessary governmental coordination and budgeting for sustainable energy policy.

(b) The Israel Electric Corporation, due to its dominant role in electricity supply and fuel acquisition, has a strong bias toward maintaining and increasing dependence on traditional labor-intensive generation sources, especially coal. Despite recent initiatives to use cleaner coal and the notable shift to natural gas, IEC's fuel choices have increased risks to the environment and raised Israel's level of energy dependency. Moreover, IEC has stymied PV growth by creating formidable procedural roadblocks for PV to obtain the required authorizations to interconnect with IEC's grid.

(c) Low renewable tariff incentives that reflect only marginal environmental externality costs, as opposed to incentives in other countries that compensate renewables for portions of their fixed costs as well. .

(d) The extremely low levels of public investment in research and development on RE and RUE. Much of the research and training in RE is funded by universities such as Ben-Gurion University in Beersheba and the Weizmann Institute in Rechovot. Most remaining R&D has been self-financed (for firms who have been successful abroad) or partially financed through small financing ventures through the

[11] MNI presentation at Prime Minister's Renewable and Alternative Energy Conference, November 2006

Infrastructure and Environment Ministries. RUE investment is largely self-financed as well, as RUE training programs and technology improvements have largely been the initiative of Israel's electrical contracting and engineering organizations. Government funding to supplement these efforts has been inadequate.

(e) The lack of public awareness of climate change issues in Israel, which lags behind that of most European countries. Although opinion polls of Israelis indicate that an overwhelming majority believe that the Government does not do enough to address the environment (89%), and that nearly two-thirds identify global warming as a serious environmental issue (65%), actual practice indicates that less than 50% of Israelis have taken steps to reduce their energy consumption,[12] believing that the Government should take the initiative to developing the necessary action plans. Initiatives by organizations such as the Israel Union for Environmental Defense ("IUED") and Greenpeace, as well as increased focus by the mainstream press on RE and RUE topics have only begun to address this issue.

These factors explain why Israel has long ceased to be a leader in RE and RUE domestically. They may also explain why, despite Israel's proven capability in RE research and development, RE technology exports have been in the tens of millions of dollars, a small share of Israel's overall annual exports in excess of $20 billion.[13,14] Many promising RE and RUE developments have remained at the research stage because of the lack of resources and policy coordination necessary simply to make the initial assessment of their commercial viability.

Therefore, it is critical that Israel improves its policymaking with regard to RE and RUE, despite an array of barriers including slow progress on policy, strong vested interest groups, and lack of public awareness. Such improvements must occur in the following areas:

1. Ensuring compliance with higher efficiency standards mandated for new equipment.

2. Converting voluntary standards for energy-efficient construction into requirements. This includes coordination between the Ministries for Environmental Protection, Housing & Construction, and Finance to develop mandatory "green" building standards.

3. Improving the current time-of-use electricity tariffs to create stronger incentives for reduced usage during peak hours.

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[12] Pratt Survey of Environmental Sensitivity in Israel – survey for the Heschel Institute
[13] Israel Export Institute,. http://www.export.gov.il/Eng/_Uploads/4303Renewable.pdf
[14]Israel Ministry of Finance ,http://www.mfa.gov.il/MFA/MFAArchive/2000_2009/2002/5/High-Tech%20Opportunities%20in%20Israel

4. Promoting entry of energy service companies (ESCOs), including expedited licensing processes.

5. Improving the efficiency of street lighting for local and intercity roads

The question for Israel is whether the small steps taken thus far will be sufficient to create an environmentally responsible, efficient, independent energy economy, while at the same time addressing growth rates that exceed those of Europe and North America.

PART II: Rational Energy Use (RUE) - Renewable Energies (RE): policies, tools, progress, resulting effects, case studies

The starting points for RE and RUE policy in Israel are the UN Framework Convention on Climate Change and the Kyoto Protocol. Israel ratified the UN Framework Convention on Climate Change in September 1996, and set the groundwork for its activities following the Kyoto Protocol signing. Through its Interministerial Committee on Climate Change, Israel prepared a national inventory of emissions and removal of GHGs, and has reported regularly on mitigation options and action plans to the United Nations, the most notable being:

(a). The integration of natural gas that should reduce Israel's CO_2 emissions by 11.5 million tons annually by 2015.

(b). Budgeting for "green building" development that would reduce energy consumption by 2.5 Mtoe.[15]

The Kyoto Protocol has been the main compliance standard for Israeli regulation and compliance since 1998, when Israel became a signatory. In February 2001, the Government issued an official decision[16] setting GHG targets and funding mechanisms pursuant to its Kyoto obligations as a signatory. Israel ratified the Kyoto Protocol in February 2004, to become effective in February 2005, and was classified as a non-Annex 1 country under the Climate Change Convention. To date, Israel has not adopted a position regarding post-Kyoto environmental standards to become effective in 2012, although the Ministry of Environmental Protection has recently issued tenders for assistance in addressing this post-Kyoto period, including assessing the merits of continuing Israel's Kyoto status as a "developing country" rather than a developed one.[17]

Soon after ratification, Israel created a Designated National Area ("DNA") to determine whether its Clean Development Mechanism ("CDM") initiative, developed in response to Kyoto ratification, complied with Kyoto's sustainable development criteria. The DNA

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[15] Israel National Report on Climate Change, http://www.sviva.gov.il/Enviroment/Static/Binaries/index_pirsumim/p0110en_1.pdf

[16] Government of Israel Decision 2913(13).

[17] Israel Ministry of Environmental Defense www.sviva.gov.il

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consists of a variety of members, including Government ministries, the Israel Electric Corporation ("IEC") and non-governmental organizations.

In May 2003, the Government of Israel announced a strategic plan for sustainable development consistent with the Plan of Implementation accepted at the World Summit on Sustainable Development in 2002. Each Ministry is required to draft its own plan that sets forth tasks action plans, measurable goals, and target dates for achieving those goals within a predetermined budget. The overall strategic plan relates to the period from 2003 to 2020, and is updated every three years. While the Ministry of National Infrastructures has the greatest responsibility for RE and RUE development under the strategic plan, other Ministries assume major roles in developing energy efficiency, "green building" standards and legislation, and marketing RE and RUE. To date, the Ministries have largely met their obligations under the strategic plan, including updating their sustainable development strategies under the strategic plan, in 2004 and 2006.[18] The MNI is a glaring exception, however, having failed to meet obligations stipulated in the Strategic Plan, including: (a) to integrate solar energy in new construction, to have 2% of electricity production from renewable energy sources by 2007, and to stimulate the RE research and development necessary to meet future renewable energy targets.

2.1 RUE and RE Policies

2.1.1. Rational energy use policies

Most of the MNI initiatives in RUE have occurred since 2004, following the completion of the Energy Master Plan.[19] RUE is an integral part of the Master Plan commissioned and mostly accepted by the MNI, and has been implemented slowly over the past 3 years. The Master Plan addressed RUE in the context of energy conservation policy, defining it as "steps taken by the Government in order to achieve: maximum savings in primary energy usage; production and consumption efficiencies; and intelligent use of renewable energy from a societal, environmental, and market perspective. The Plan identified potential energy savings of more than 20%, which would have far-reaching effects on electricity system investment needs, economic growth, and environmental protection. Currently, the lack of timely information available to energy consumers and the exclusion of environmental externality costs in energy pricing have significantly restricted actual savings below the 20% level. To address this shortfall, the Plan made 3 major recommendations regarding RUE:

(a) Thorough information gathering regarding international experience;

(b) Developing rigorous methods of cost-benefit analysis for RUE reflecting social costs;

(c) Prioritization of RUE activities as a matter of policy.

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[18] Israel Ministry for Environmental Protection (2006). "The Path toward Sustainable Development in Israel" http://www.sviva.gov.il/Enviroment/Static/Binaries/index_pirsumim/p0394_1.pdf

[19] The energy master plan was not officially adopted by the Government.

To date, the evaluation of RUE from a societal welfare perspective (including all environmental costs) is not integral to the Government's energy policy, and much of the energy efficiency efforts are targeted toward high-profile initiatives that can be implemented easily (e.g. large government offices and manufacturing companies).

The MNI has focused primarily on developing energy efficiency standards for appliances, mechanisms for enforcing those standards, providing information regarding energy efficiency for the general public and mandating energy audits for large commercial and industrial consumers. In recent years, the rapid penetration of air-conditioning has been the primary driver of the growth in peak demand; air-conditioning load (over 250 thousand sold annually) now accounts for about 45% of the annual electric peak load.[20]. Since 2005, Israel has adopted new standards prohibiting the import of air conditioning with COP levels below 3 and with R22 coolants, in order to improve the efficiency of the air conditioning stock and reduce Freon gas release into the atmosphere.

RUE at the national level is only in the initial stages, and there remains a distinct lack of information and training for electricity consumers, for whom the economic case for demand-side efficiency has not yet been made. Moreover, despite the potential of over 100 million shekels' worth of savings in HVAC and refrigeration alone, RUE has not caught up with standards set in current law which have yet to be fully enforced. The Government itself may have started to recognize its obligation to provide RUE leadership, implementing its May 2003 decision requiring each ministry to provide a sustainable development plan.

Most significantly, the connection between GHG and residential energy usage has not been emphasized sufficiently, despite the fact that residential electricity consumers contribute nearly one-sixth of Israel's annual CO_2 emissions.[21] Similarly, IEC has consistently fought demand-side measures as being opposed to its interests in deploying its workforce to construct new stations. However, with electricity generation comprising nearly 50% of Israel's energy requirements (with only 30% for transportation, and the remaining 20% for industrial and residential purposes), and electricity industry restructuring's increasing the financial risks associated with additional coal station investments, encouraging RUE may be in IEC's interests as well.

Since 2004, the MNI has advanced the concept of energy service companies ("ESCOs") to promote energy efficiency, beginning with commercial and industrial energy users. During these initial stages, the MNI has begun the approval process for ESCOs, developed performance contracting mechanisms, and earmarked funds for micro-projects (up to NIS 100,000), while engaging international experts to develop its in-house expertise on ESCOs. Apparently, the rising cost of energy in the past several years is creating increased awareness of potential areas of energy savings, even for smaller to mid-sized companies. This awareness is reflected in the increasing frequency of energy efficiency articles in business and trade publications, and the anecdotal evidence of an

[20] Climaton journal, November -December 2004 www.climaton.co.il.
[21] Israel National Report on Climate Change.

increase in non-energy companies' participation in energy-related conferences and exhibitions. Potentially spurring some ESCO growth has been the PUA's imposition of time-of-use electricity rates on electricity customers with annual energy consumption above 60,000 kWh has affected these customers' consumption patterns – possibly prompting them to hire energy saving consulting to identify ways to reduce and shift consumption, and thus reducing their electricity bills. Since, initial government-sponsored ESCO projects in Israel receive payments linked to the performance of the solutions they implement, they have a strong incentive to make the engineering and financial decisions to make those consumption changes happen.

In response to this ESCO growth, the MNI is developing additional proposals for tax incentives and favorable loan conditions for all approved energy efficiency measures, regardless of whether they are implemented through an ESCO. Despite this advance, there is little overarching policy guidance from the MNI for the growing number of energy service professionals working with or for ESCOs. For example, licensed ESCOs, by focusing on energy savings in air conditioning and energy-intensive industrial equipment have reduced their customers' demand for energy by up to 30%. Perhaps more significantly, between 45% and 75% of these customers' overall electric bills reflect air-conditioning usage, usually occurring when Israel's electricity system is most stressed. The greatest success has been achieved for manufacturers with high energy requirements, which, by altering their manufacturing processes, have also reduced their emissions levels.

The Government has also joined with MED-ENER to identify opportunities for energy-efficient construction, and to develop awareness and commercial viability of new RUE projects.[22] . Recently, one such project funded in part by the Ministry for Environmental Protection, received MED-ENER's highest award for a "green" building project in the Arab village of Sakhnin. The Government considers this project to be of special importance in moving Israel toward the EU market requirement that at least 12% of conventional energy supply (including energy efficiency as a resource) be from alternative energy sources. Another recent example from the private sector is Intel's new building in its Haifa development center. This building is Intel's – and Israel's - first to be recognized as a "green" building through its LEED certification (Leadership in Energy and Environmental Design).

As of September 2006 there were 16 ESCOs registered with the MNI, operating under performance contracts with standards. One problem that ESCOs have faced is the fact that the ESCO concept is alien to the Israeli banking community, which views even projects with very bankable results as being much riskier than they actually are (MNI website December 12, 2006 conference on ESCOs). Nevertheless, ESCO development has created greater awareness of the need (and business case) for RUE, particularly by the high-tech and government sectors. New construction of high-tech office complexes, with its emphasis on glass exteriors and insufficient attention to energy-efficient HVAC

[22] Ministry of National Infrastructures website www.mni.gov.il

design has in fact contributed to greater peak electricity consumption than many existing buildings. Moreover, in response to a fourfold increase in electricity use since the 1980s, and the claimed potential savings that may exceed 20%, the Knesset has passed legislation obligating public bodies to reduce electricity consumption.

In addition to ESCO development, the MNI is authorized to offer incentives for purchasing more energy efficient appliances, especially in the case of market failures preventing such purchases, and to work with other Ministries to identify such opportunities (Energy Master Plan, "Energy Conservation Policy, May 2004"). To date, such efforts have been very limited, due to the combination of related factors, including:

(1) The Government's insufficient appreciation of energy efficiency for national policy;

(2) Insufficient – and declining - funding;

(3) Lack of centralized responsibility for energy efficiency; and

(4) General reticence toward market interference.

Regarding local RUE initiatives, the MNI has not developed specific projects, but has worked with local authorities on projects such as increasing the penetration of photovoltaic systems in public buildings. It is unclear whether the Ministry will eventually develop local partnerships for RUE, as the Environment Ministry has done for its initiatives.

Although the MNI's Energy Master Plan calls for an independent Energy Efficiency Authority to oversee energy efficiency, this area remains another small, underfunded division of the MNI that has received annual allocations below NIS 3 million out of a total national budget exceeding NIS 400 billion. If given a higher priority than the current Resources Division of the MNI, this Authority would be responsible for enforcing efficiency standards and integrating cogeneration, as well as integrating demand-side resources into electricity system planning. In contrast, the Israel Standards Institute has begun to set and enforce more stringent energy efficiency standards, especially for HVAC; this effort, while still not sufficient, is spurring developments in air-conditioning technology by Israel's major manufacturers such as Electra, Tadiran, and Trane.

In February 2005, the Knesset (Israel's Parliament) passed an amendment to the Law of Municipal Government Supervision" requiring each local jurisdiction to form an environmental commission to "initiate and develop action plans regarding the environment and to ensuring sustainable development and growth". As of late 2006, approximately 80 of Israel's 150 municipalities have set up these commissions (53% of all municipalities) and another 15 are in the development process. Although there has been considerable interest in these commissions, and a substantial majority (nearly 75%) are satisfied with the performance of these commissions, many participants have noted that they lack the information required to carry out the Law's mandate. These participants have recommended training sessions to be held every few months, some of which began in December 2006.[23] Nevertheless, these commissions have been responsible for actions taken against Israel Electric Corporation's ("IEC's") generating plants and for working with the Ministry and IUED to encourage "green schools" in their communities – Hadera being a prominent example of such a commission.[24]

The PUA has also promoted RUE, by means of expanding the time-of-use rate program, including mandating time-of-use rates for customers with annual consumption over 60,000 kWh. Time-of-use rates in Israel have contributed to load shifting to off-peak hours, thereby reducing the probability of blackouts and allowing for more efficient dispatch of generators. Currently, although only 1.7% of IEC customers are billed at time-of-use rates, these customers constitute 55% of IEC load, and, without time-of-use rates, would contribute significantly to daily peak loads[25]. The PUA has begun investigating the viability of critical-peak pricing, following the lead of successful programs in the US. Preliminary data from these programs indicate that critical peak pricing is significantly more effective than interruptible credit program and the time-of-use rates (both of which are offered by the PUA), in terms of meeting both customer preferences and system needs in maintaining reliability.

As part of its RUE initiatives, the MNI issued a decision regarding co-generation in 2002 reflecting the Government's goal of encouraging co-generation due to its high efficiency and low fuel consumption, while maintaining the efficiency of the current overall electricity generation system. The MNI has recognized cogeneration's benefits to Israel's energy sector, including its minimal land requirements and peak-shaving capability, while also recognizing the problems of non-dispatchability that cogeneration creates for the system operator. MNI staff estimates that the potential for cogeneration is about 3,000 MW of which about 2,000 MW is in industry.

In 2004, the MNI issued rules for grid-connected cogenerators wishing to sell electricity to the grid. Cogenerators connected to the high-voltage distribution system can sell all of their electricity to the grid, while those connected to the transmission system can sell, during peak and shoulder periods, up to 70% of their output to the grid for 12 years or the greater of 35 MW or 50% of their installed capacity for 18 years. The tariff set by the PUA compensates the cogenerators for normatively-determined capacity and fixed O&M costs, and varies inversely with the number of hours during which the cogenerators supplies capacity and energy to the IEC grid. Nevertheless, it may be necessary to offer other incentives, such as participation in CDM markets, to make cogeneration a more attractive investment in Israel.[26]

Cogeneration's benefits to Israel may be limited nevertheless, due to the lack of very large manufacturing facilities and relatively low heating requirements. Moreover, the

[23] Neaman Institute survey on Municipal Environmental Committees, September 2006 report to the Ministry for Environmental Protection; Climaton, December 2006, p. 31
[24] www.igudhadera.co.il
[25] Israel Public Utilities Authority presentation May2006.
[26] Combined Heat & Power systems report, Neaman Institute, July 2006.

expansion of cogeneration in Israel depends greatly on the availability of inexpensive natural gas production and delivery during the coming years; reliance on diesel or oil for cogeneration creates environmental and potentially even larger price risks.

2.1.2. Renewable energy (RE) development policies

In 2002, the Government of Israel set a target of at least 2% of all electricity to be supplied by renewable energy by 2007; this target rises to 5% by 2016. Reaching this target requires the construction of large solar and wind plants, as well as a mixture of small hydro, biomass, and PV systems). Currently, although there are individual programs aimed at promoting RE, there is no overarching national strategy to achieve the Government-set RE targets.

The Energy Master Plan commissioned by the MNI analyzes alternatives for RE, and makes recommendations for strategies to achieve specific RE objectives. However, rather than developing strategies, the Government has initiated individual programs with a few goals in mind. Some examples of programs include: incentive mechanisms for renewable electricity generation and co-generation, and stricter appliance efficiency standards, which are consistent with broadly defined goals such as improving Israel's balance of payments, improving public health, and promoting domestic achievements in renewables development.

The Government's RE priority is solar energy, and the MNI has set an initial goal for solar thermal energy of 100 MW at an estimated cost of $225-$250 million, as a pilot project that should grow over time. Despite this emphasis on solar development as a policy matter, however, the Government has budgeted little for solar R&D; PV-related R&D spending was only NIS 688,000 in 2004 with an additional NIS 200,000 from non-governmental public funding.[27] In addition, the Israel Ministry for Environmental Protection has recently become involved in promoting promising Israel-based renewables technologies.

In 2004, Israel, through the Environment Ministry established a Designated National Authority (DNA) for the Clean Development Mechanism. In May 2006, the Government and companies specializing in CDM projects sponsored a conference on the CDM and emissions trading as means of financing greenhouse gas reduction projects. Since Israel is classified as a non-Annex I developing country under the Kyoto Protocol, entrepreneurs who implement emissions reduction projects in Israel will be able to sell their carbon emissions credits to developed countries. Greenhouse gas emissions in Israel currently exceed 80 million tons per year, with 60% of the emissions generated by the energy sector. The electricity sector alone is responsible for over 35 million tons of GHG emissions.

The Ministry of Environmental Protection has promoted Israel's unique advantages of being a developing country with the expertise in clean technologies and professional

[27] National Survey Report of PV Power Applications in Israel 2004, May 2005 (report for the International Energy Agency under contract from the MNI).

investment community of a developed country; this expertise is essential for developing and identifying projects to offset emissions in Kyoto-classified developed countries.

The PUA has developed initiatives for incentivizing RE, through ratemaking and licensing procedures. Tariffs during the next decade are expected to cover over $1.5 billion in environmental investments by IEC alone, comprised of $1.4 billion in pollution reduction, and $0.1 billion in addressing hazardous waste cleanup at generator sites.[28]

The PUA is seeking to work with the Environment Ministry to set principles for long-term reduction of generator-caused pollution, including developing incentives for oil-fired generators that take steps to reduce pollution. The PUA has also tried to promote net metering for renewables (see below), but has received objections to this initiative for a variety of tax-related and operations-related reasons.

In January 2007, the PUA issued draft licenses for small renewable generators selling directly to the IEC grid, which will comprise most of the generation licenses to be issued through mid-2007. These licenses set forth in broad terms the mutual obligations of the generator and IEC, but do not address the specific effects of intermittent, non-dispatchable generation on IEC's system operations. Such issues will be addressed in the broader context of electricity industry restructuring which is currently taking place.

2.2 Instruments and measures to be taken in favor of RUE and RE

2.2.1 Tools and measures in favor of rational energy use

The two primary policy actions for promoting RUE are:

(1) The expansion of mandatory time-of-use to all electricity customers using at least 60,000 kWh per year; and

(2) The development of the ESCO mechanism, which has created significant energy savings in the large commercial and industrial sectors, including large healthcare facilities.

It remains the case that official development assistance is small, isolated, and with no long-term structuring capacity. The major area of improvement has been the improved coordination of renewables policy among all governmental parties involved in renewables generation from a policy perspective, with some linkage to the Ministry of Trade, Manufacturing and Industry and the Export Institute. Moreover, the area of energy efficiency has largely been a joint effort of the Environment Ministry, MNI, and the MNI's energy efficiency consultant Econoler, which has tailored the ESCO concept and the performance contract mechanism to Israel's circumstances.

[28] Israel Public Utilities Authority.

2.2.2 Tools and measures in favor of renewable energy

The main economic incentive measures for RE are the renewables premium developed by the Israel Public Utilities Authority for non-IEC renewable electricity generator sales (except for some biogas) to the Israel Electric Corporation and the related feed-in tariff and licensing arrangements for solar thermal generation. In 2004, the PUA developed renewables premium to generation license holders producing electricity using renewable resources. The renewables premium reflect the costs of the avoided CO2, NOx, SO2 and particulate emissions due to the renewable generator's replacing fossil-fuel generators during each time-of-use period.

The premium are based on the level of emissions in grams per kWh as determined periodically by the Environment Ministry, and is adjusted over time in response to Ministry revisions and changes in the CPI and the currency basket of the Bank of Israel. These premia are added to the recognized production costs paid by IEC to IPPs, and vary with the time-of-use blocks, reflecting the pollution properties of the fuels that would have been used for electricity generation if they had not been displaced by the renewable fuel. That is, the costs of acquiring the renewable energy are costs recognized in IEC rates.

The approved premium are in effect for the lesser of:

(1) 15 years from the renewable generator's construction date; and

(2) The duration of the renewable generator's license.

Although the premium are relatively small, ranging from 1.55 cents per kWh during shoulder hours to 2.45 cents per kWh during off-peak hours (due to the predominance of coal generation), the renewables premium have been an integral factor in obtaining financing for small renewables such as wind, small hydro, and biomass. Renewable generation owned by IEC is ineligible for the renewables premium, since the PUA already reflects these costs in designing IEC's tariffs.[29]

In August 2006, the PUA developed tariffs for solar thermal generators of 100 MW or greater (with and without fossil-fuel backup) and generators with installed capacities between 20 MW and 100 MW. These tariffs reflect the normative (representative) costs of a solar thermal facility similar to those located in Southern California manufactured by Israel-based Luz (the predecessor of Solel Solar Systems Inc.), and do not include the renewables premium for which other renewable electricity generators are eligible.

These normative costs are recognized in IEC's tariffs, since IEC is obligated to purchase the entire output of these generators. These tariffs do not assume any project financing support from outside sources, even from Government agencies. Nevertheless, the tariffs reflect normative values to be representative for the first 20 years of a solar thermal plant's operations, and lower values for later years, representing both efficiency improvements over time and the full repayment of long-term debt obligations. The

[29] PUA Session 145, Decision 3 of July 13, 2004.

current tariffs for solar thermal facilities have been in place since September 2006, but it is uncertain when the facilities themselves will be fully operational, due to substantial delays in the land acquisition and licensing processes.[30]

2.3 Energy Efficiency Evolution - decoupling

Decoupling, or the separation of a direct increasing relationship between economic activities and energy consumption, has occurred at the national level in Israel. Energy intensity, the primary indicator of decoupling, has declined since 2002 from 53.9 Mtoe per NIS million GDP to 50.5.

There has been no government policy aimed explicitly at reducing energy intensity, although Israel's transition to a value-added service economy and the declining role of heavy industry in the economy may help to explain the decrease. Moreover, it is possible (though barely detectable at this point) that the higher efficiency of power plants substituting natural gas for oil (and in the case of onsite generation, gasoil or diesel) may be contributing to this decoupling as well.

It is unclear, however, whether changes in the electricity and natural gas delivery systems have contributed to lower energy intensity; the natural gas transmission system is new and the electricity transmission and distribution system have maintained loss rates comparable with the better electric systems in the US and Western Europe.[31]

The resolution of controversies between IEC workers and the Government regarding new coal generation may determine the rate of future decoupling, as coal's higher heat rates may undo some of the energy intensity improvements realized since 2002. Nevertheless, Israel is following the trend of energy intensities already set by most EU member countries.

2.4 Renewable Energy evolution

In 2002, the Government of Israel set a target of at least 2% of all electricity to be supplied by renewable energy by 2007; this target rises to 5% by 2016. Reaching this target requires the construction of large solar and wind plants, as well as a mixture of small biomass, and PV systems. The PUA is responsible for issuing licenses, setting tariffs and codes of conduct and overseeing IEC's conduct relative to renewable generators.

In February 2004, the PUA set a premium for renewable suppliers based on the prices of the emissions avoided by substituting renewables for fossil units. That is, renewable generators are paid IEC's normative production costs plus the premium. As of 2006, all renewable generation except solar thermal is eligible for the premium, including renewable generation that is not selling to the grid or to private customers. The current premium ranges from 1.5 cents during off-peak hours to 2.5 cents during peak hours. As

[30] PUA Decision No. 177 (August 16, 2006 decision), www.pua.gov.il.
[31] See, for example, the 2005 IEC Statistical Report.

of October 2006, the PUA has offered the premium to 7 generators, with total installed capacity of 13 MW, comprised of 6 MW of wind, 6 MW of hydro, and 1 MW of biogas. However, this amount is expected to rise quickly, as nearly 150 MW of wind generation may receive conditional licenses.

Tariffs for solar thermal generation are differentiated by size, reflecting the scale economies inherent in solar technology; solar thermal units with installed capacities under 100 MW receive a higher tariff than units with installed capacities of 100 MW or more. The tariffs are also differentiated by time periods for which they are effective – the first 20 years and the next 10 years. In accordance with Government decisions, solar thermal units may retain that classification for fossil-fuel backup capacity up to 30% of the solar unit's installed capacity, and will be compensated according to the relevant fuel prices. The tariff for units with less than 100 MW capacity and units with at least 100 MW capacity are currently 20.7 cents and 16.5 cents per kWh, respectively. The PUA expects that at least 200 MW of additional solar thermal capacity will be developed during the coming years.

Investment in RE and RUE has been minimal, compared to conventional energies, with most investment being directed to the solar sector, both thermal and photovoltaic. The Israel Electric Corporation and the Israeli government have provided some financial assistance for projects that have demonstrated potential benefit to the electricity system. Until very recently, however, the investment and particularly the venture capital community has not financed these developments due largely to their long lead times to exits and the lack of opportunity to pilot-test their technologies locally. Consequently, successful firms such as Ormat (geothermal) and Solel (solar thermal) have relied heavily on power contracts and incentives abroad in order to develop their technologies in Israel.

This phenomenon is beginning to change, however, as firms such as Israel Cleantech Ventures and Terra Venture Partners have begun to fund renewables technologies that have a sustainable business concept. In January 2007, Israel Cleantech Ventures completed its first closing of $15-25 million mainly from US investors; about 35% of this fund is targeted toward renewable energy and technologies improving electricity generation efficiency.[32] Currently, Israel Cleantech Ventures alone has over 200 Israeli firms in its database, most of which are early-stage startups.

Worldwide, the primary growth activity for renewables has been in the solar sector, which has increased rapidly in recent years. In 2005, solar generation increased by 44%, reflected in revenue increases of 50% and nearly 150% in profits. Solar generation is expected to increase six fold in the next 5 years. Israel continues to develop leading-edge solar technology in companies such as Solel and Millennium Electric, and at university settings including the Blaustein Institute on the Sde Boker campus of Ben-Gurion University and the Weizmann Institute.

At the university centers, the main focus areas have been in materials studies, modeling solar devices and systems, energy conversion and storage, and concentrator photovoltaic.

[32] Israel Cleantech Ventures and Globes announcements www.globes.co.il.

The most prominent developments at these centers have been the Weizmann Institute's solar tower for concentrating solar energy, and the solar dish facility at the Blaustein Institute. The Institute's main research emphasis has been on improving solar thermal and PV efficiency for commercial purposes while the Weizmann Institute in Rechovot has focused on solar technology as a base for other currently research-oriented processes such as hydrogen fuel storage and transportation. The Blaustein Institute is presently developing concentrating PV systems that may be able to reduce the cost of PV to $800 per kWp due to their energy-collection efficiency and scale economies due to their multiple commercial applications.[33]

Within the corporate sector, leading-edge companies such as Solel (profiled below), SolarPower, and Millennium have made significant progress in solar thermal and PV development.

DiSP has focused almost exclusively on developing concentrating PV systems for distributed power systems, with potential for providing both electricity and heat as a CHP unit (taking advantage of the act that 70%-90% of solar energy in most units escapes as heat rather than producing electricity Source: DiSP presentation at Nov 2006 conference).

SolarPower has developed PV for a variety of applications in communications, "self-reliant" communities such as moshavim, and agriculture, thereby exploiting PV's unique ability to meet load reliably at specific locations at lower cost than the incumbent utility. SolarPower has been planning PV expansion to larger areas, mainly Netanya-area industrial parks and facilities.

Finally, Millennium Electric has used its PV/T solar cell array for monitoring traffic and billing on the Cross-Israel Highway toll road, on grid-connected school systems, and signage. IEC is working with Millennium on implementing a 29-home grid-connected "Solar Village" demonstration project in the Negev, to assess its impact on the local grid and the required interconnections and metering. Millennium's primary activities, however, are concentrated mainly in Europe and Southeast Asia, where it has collaborated with solar thermal and PV developers to construct 10-20 MW solar plants.[34]

It should be noted, however, that while IEC's investment in the project exceeds $1 million, the total funding for photovoltaics from the MNI in 2004 was only NIS 688,000 ($160,000).[35]

In fact, since 80% of Israel's households use their solar water heating system (the largest such penetration in the world), suggests that PV should be readily accepted as well if prices declined sufficiently. Currently, most PV systems in Israel, with module prices averaging $5.50/peak-watt and marketed through a few specialty stores, are not cost-effective, mainly due to the lack of government incentives sufficiently promoting PV for

[33]Israel Export Institute, December 30, 2006
www.export.gov.il/Eng/_Articles/Article.asp?ArticleID=5201&CategoryID=354 and Jerusalem Post November 13, 2006.
[34] Millennium website: http://www.millenniumsolar.com.
[35] Millennium Solar presentation at 2005 Energin Conference.

it to achieve scale economies common in locations such as Northern Europe with far less solar intensity. To remedy this, the private sector has proposed a plan similar to Germany's for 50 thousand rooftop PV units, which would produce about 1% of current electricity and would avoid 1 million tons of greenhouse gases.[36] . Until that time, most PV facilities will serve only environmental educational purposes.

As of June 2006, 886 kWp of PV power have been installed in Israel, with 353 of that total installed in 2004 alone. Of the 886 kWp, 653 are off grid domestic, 210 are off-grid non-domestic; only 23 kWp are grid-connected. There are several projects and demonstrations of grid-connected PV systems, all of which are privately financed, and all of which are education-related demonstration and field-test programs.[37]

The Israel Electric Corporation (IEC), although not integrating RE into its fuel mix, has reduced its environmental footprint over the past 10 years through the substitution of fossil fuels with lower emissions. SO2 emissions per kWh dropped from 5.7 grams per kWh in 1995 to 2.6 in 2004, mainly due to the substitution of 0.5% and 1.0% sulfur coal replacing coal with higher sulfur content, but also due to the substitution of natural gas for crude oil. Similarly, NOx emissions declined from 3.0 grams per kWh in 1995 to 2.0 in 2004, and particulates dropped from 0.28 grams per kWh to 0.09, mainly due to improved fuel burning technology and the introduction of natural gas. IEC has also taken steps to minimize the water pollution - and overall water needs-.of electricity generation, including the use of brackish water for cooling whenever feasible, and acquiring advanced fuel storage systems to minimize the possibility of groundwater pollution.[38]

In addition to solar, there is some potential for up to 600 MW of wind energy in Israel, although only 150-200 MW are included in the MNI-approved electricity plan. Currently, both IEC and private producers are either planning over 80 MW of wind facilities, exclusively in northern Israel. Although wind facilities developers have encountered few of the objections to wind power encountered by their counterparts in the US and Europe, there are few areas in Israel with the combination of topography and wind speed to make wind a viable option, despite its per-kWh cost being less than half of the cost of solar thermal and its being ideally suited to the PUA's renewables premium mechanism. The most prominent wind facility to date has been the 6-MW Golan Heights wind farm, producing approximately 12,000 MWh per year.[39] In addition, the PUA has issued conditional licenses to other non-IEC wind facilities intending to sell their electricity to the IEC grid.

A promising area for solar energy development, especially for regional development, is solar/desalination integration, by which solar energy produces electricity used by

[36] SolarPower presentation at 2005 Energy Conference in Tel Aviv Israel.
[37] IEA Cooperative Programme on Photovoltaic Power Systems, National Survey Report of PV Power Applications in Israel 2004), May 2005.
[38] IEC Environmental Report 2004.
[39] Baruch, R. and Ben-Dov, E. (2002). "The use of wind energy for electricity generation or 0% polluting electricity" (Hebrew).

desalination facilities. Since the solar facility's operations are limited to daytime hours while the desalination system operates continuously, such integration requires either large heat storage capacity or fossil-fuel backup – both of which significantly reduce these facilities' economic viability. To address these issues, Israeli firms such as Solel and IDE Technologies have developed technologies to improve solar radiation collection and to use the solar thermal energy to distill water directly via evaporation without generating electricity first.[40] For facilities requiring electricity generation, however, the issue of fossil-fuel backup is significant, particularly with regard to future natural gas availability.

In addition to the technology issues, solar/desalination integration in Israel has faced two additional obstacles: (1) a lack of sufficient inexpensive land along the Mediterranean coastline and (2) lengthy licensing processes. Despite these obstacles, this integration has progressed, albeit slowly. The most prominent example of this integration is the cogeneration and desalination plant in Ashkelon, which is one of the largest in the world, and which is projected to produce over 100 MCM of water annually. The power plant's capacity will be approximately 80 MW, 56 MW of which will be used to power the desalination plant. To date, the cogeneration facility has received a conditional generation license from the PUA, but does not yet supply the desalination facility, which continues to receive electricity from IEC. This facility has become a model of compliance with high environmental standards, setting a benchmark for future facilities throughout the Mediterranean region.[41]

The Government of Israel is aware of the possibilities for regional development of solar energy projects, especially between Egypt's Sinai Peninsula, the Jordanian deserts, and Israel, thereby taking advantage of scale economies and information sharing, both of which are critical for solar development. This regional cooperation could occur through tax breaks and subsidized loans for companies – and universities – that are willing to engage in this regional development.

It should be noted that these economic benefit estimates do not entirely reflect business competitiveness and international trade benefits. To the extent that RE and RUE reduce operating costs and create additional revenue streams (e.g., emissions permit trading), the above estimates understate the true value of RE and RUE.

2.4.1 Rational use of energy:

With regard to RUE, achieving energy savings of 20% can result in an annual cost savings of some $2 billion (Eco Energy estimate). These cost savings do not include the costs avoided by the Israel Electric Company by reducing peak-hour consumption on the generation, transmission, and distribution systems. However, the incentives provided for RUE are limited to favorable performance contract provisions to spur ESCO growth, expanded use of time-of-use rates, and net metering proposals (albeit at an initial stage).

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[40] Sagie, D., Feinerman, E. and Aharoni, E. (2001). "Potential of solar desalination in Israel and in its close vicinity", *Desalination* 139**,** 21-33.

[41] Einav, R. and Lokiec, F. (2003). "Environmental aspects of a desalination plant in Ashkelon", *Desalination* 156, 79-85.

The PUA has also proposed a net metering mechanism for customers connected to the low-voltage distribution network, and is primarily intended for photovoltaic and small wind systems. These customers are required to have time-of-use metering and all net metering settlement will be priced at the relevant time-of-use rate for low-voltage distribution customers with a discount reflecting avoided pollution costs. The PUA proposal allows residential customers to use either PV or small wind turbines, while other customers may use any renewable energy to be considered eligible net metering customers. IEC, in turn, would be responsible for accounting for the electricity generated to and consumed from the grid, and the relevant billing tariff, as well as ensuring that these generators meet the technical standards required for grid interconnection. The PUA proposal also allows for some flexibility with regard to emissions trading mechanisms, by which either IEC or the customers would be eligible traders.

Some potential tools for expanding RUE include:

(1) Greater education levels, beginning at the elementary school level, including greater use of mass media, with an emphasis on how personal energy decisions affect broader society. The education should also include improved energy efficiency labeling on appliances and on retail exhibits. Moreover, education efforts should give the successful ESCOs an opportunity to develop cooperative ventures to publicize their achievements; currently, most of this publicity reaches only the small community of energy professionals and interested policymakers.

One possible education vehicle proposed by researchers at the Technion in Haifa is to have "Energy Star"-type ratings for buildings that have received thorough energy audits; the standards for these ratings would be the responsibility of the Israel Standards Institute. The reasons for a given rating would be explained at the layperson's level, emphasizing both environmental and economic benefits of RUE. Offices and large public buildings may be the logical initial audience for such education efforts, due to their higher energy bills and generally energy-inefficient design (e.g., excess use of reflective glass in office complexes and lack of ambient light).

However, the residential and small commercial demands for air-conditioning and lighting should be approached soon afterwards, due to their more rapid demand growth and greater suitability for mass-market educational material.

(2) Mandatory demand-side management programs for all fuels, based on a "societal test" (net present value of the demand-side measure to society, including environmental costs), and directed primarily to inefficiencies resulting from market failures. Funding for such programs would come from fuel and electricity surcharges, as well as targeted tax breaks. The programs would be centrally administered by one entity (preferably an independent authority or an "efficiency utility" regulated by that authority).

For example, air-conditioning, which is responsible for nearly half of Israel's summer peak loads, can be significantly more efficient when the financial incentives for purchasing higher COP units – many of which are manufactured domestically- make such purchases economically viable. Combined with more "aggressive" interruptible/curtailable and real-time pricing programs introduced by the PUA, these programs' valuations would increase – and their payback horizons would decrease - significantly. In this way, consumers' incentives and society's incentives for energy efficiency would be aligned.

(3) Non-bypassable public benefits charge on all electricity sales, in order to ensure adequate funding for RUE initiatives, including partial funding of efficient air conditioning systems, whose initial costs and long payback periods make such purchases unattractive to most residential and commercial customers.[42]

2.4.2 Recommendations for developing RE in Israel

The following are recommended actions for developing RE in Israel, most of which require much more active government involvement:

1) A "carrot-and-stick" approach to developing RE, consisting of a combination of improved feed-in tariffs and enforceable emissions standards. The recent development of feed-in tariffs for grid-connected solar thermal units reflecting the units' capital and fixed O&M costs should be expanded to other renewable technologies that are not yet cost-competitive with fossil fuel generation, and should be only the beginning of incentive mechanisms offered by the Government. Although the current premium for renewable energy reflect the marginal external cost of the non-renewable energy displaced, they do not allow the renewable generator a sufficient return on its fixed investment and O&M costs. The solar thermal tariffs follow the model of the successful feed-in tariff programs in Europe, which have been responsible for rapid adoption of renewable generation and for R&D investment in new technologies. Such feed-in tariffs would also signal to the investment community abroad that Israel believes in the level of its domestically developed RE technology.

   An example of enforceable standards would be Emissions Performance Standards (EPS), which would complement and strengthen the appliance efficiency standards that the MNI has developed for nearly 20 years. EPS would require any new generation to emit less than a given amount of CO_2 per MWh as a condition for receiving and keeping its license. EPS should be considered a temporary measure, however, until permanent load-based GHG emissions standards become feasible.

[42] Dr. M. Hirsch et al. (2004). "A Survey of Air Conditioning in Israel – Potential savings and policies to allow its realization", report for the Samuel Neaman Institute and Ministry of the Environment.

Such a measure is proposed for California, for which emissions below the EPS cap of 500 kg of CO_2 per MWh are achievable by a variety of technologies including "clean coal".[43] EPS would require each unit to demonstrate its own emissions levels, without reliance on CDM or other emissions trading mechanisms. EPS thus functions as a binding standard reflecting Israel's future GHG obligations, allowing only new generation complying with those standards to be part of Israel's energy mix, and creating greater certainty, benefiting the electricity generation sector and its capital sources alike.

2) A non-bypassable public benefits charge on all electricity sales, in order to ensure adequate funding for R&D in renewable energy.

3) Regular updates of environmental costs that are reflected in the PUA tariff to account for worldwide changes in emissions values as emissions markets become larger and more liquid.

4) Development of net metering, especially for small renewable generators wanting to sell excess generation to the IEC grid. Net metering allows the generator to (net) sell to the grid at peak hours and to (net) purchase from the grid during the remaining hours. It has been adopted by 40 US states and Canada, and has spurred the growth of small-scale solar photovoltaic systems and wind generation. Such an initiative requires little more than interval metering and appropriate tariffs and interconnection agreements with IEC. Net metering is an agenda item for the PUA, but it has not developed beyond the exploratory stage, to date, mainly due to issues regarding taxation and IEC interconnection.

It may be necessary to set up a separate regulatory authority to implement these recommendations. This authority would introduce and promote them via introducing legislation and creating a broader base for education than is possible through private organizations. Education would also accelerate domestic R&D in energy efficiency, for which the authority can also address the market failures inhibiting its growth. The authority would also have broader powers for supervision and enforcement than is currently possible through a government ministry.

2.5 Existing or expected effects and benefits of RE and RUE

The potential effect of both RE and RUE on Israel's economy is substantial. In a recent study conducted by Eco Energy, assuming 2,000 MW and 500 MW of PV phased in by the year 2025, indicates that solar-generated electricity would reduce greenhouse gas emissions by nearly 4 million tons by 2025, and would increase steady-state (i.e., post construction) employment by nearly 3,200 per year. The overall benefits through 2025, taking into account employment, environment, avoided T&D infrastructure, avoided pollutants, and balance of payment improvements is between $1.8 billion and $2.7

[43] California Public Utilities Commission Decision 07-01-039 dated January 25, 2007. http://www.bracewellgiuliani.com/blog/energylegalblog/uploads/CPUC%20GHG%20Order%201-25-07.pdf

billion, with ongoing post-construction benefits of some $200 million per year.[44] That is, the benefits from developing Israel's solar sector include energy security, environmental improvement and increased economic opportunity in areas with poor job prospects, and which are national priority locations, but which are areas with significant solar exposure.

In a different study performed by an Israeli developer of concentrated PV systems, the foreign currency expenditure saved by developing solar resources will be about $130 billion, or $3.25 billion per year, 33,700 jobs will be created over a 40-year period and another 20 thousand jobs will be created for export, while reducing Israel's fossil fuel dependency to a mere 20%.[45] These results are roughly consistent with Solel's estimate of $1.4 billion dollars from saving 3.5 million tons of fuel with 3,000 MW of solar generation.

The potential benefits of RUE may be substantial as well. Consensus estimates of the potential energy consumption savings in buildings can range from 25-40% through improved insulation, more efficient heating/air-conditioning, maintaining year-round temperatures between 17.5 and 25.5 degrees Celsius, and passive solar energy. At current rates, electricity bill savings would decline by $1.0 to $1.6 billion annually.

In addition to providing more funds for private savings and capital investments, the consumption decrease would enable IEC to avoid costly capital expenditures precisely when its precarious financial condition and imminent restructuring would cause the financial community to view such expenditures as very risky. Therefore, RUE would improve the financial viability and competitiveness of Israel's electricity consumers, while also improving IEC's prospects in advance of restructuring and partial privatization during the coming decade.

PART III - Examples of good practice, case studies

3.1 Derijat – Bedouin village in the Negev – solar PV systems

Derijat is a small Bedouin village in southern Israel and is located about 6 km from the nearest IEC grid. It has depended on its own portable fossil-fueled onsite generators. Until recently, its entire electricity supply was provided by 26 old diesel generators that operated only a few hours each day. Recently, however, the Government provided funding for Derijat to install its own photovoltaic systems to meet its electricity needs; Derijat is now a fully "sustainable" village.

The project was initiated by the MNI, the Negev Development Authority and the Office for Developing the Negev and the Galilee. As an unrecognized community, it was not connected to the water, electricity, or other systems. The village hired Haifa-based engineering firm Interdan to install and manage the multipurpose 21-MW solar electricity system project that provides power to the entire 850-person village.

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[44] Source: EcoEnergy study for Greenpeace "Utilization of Solar Power in Israel – Economic and Social Impacts

[45] Analysis by Dov Raviv of RMST, www.rmst.co.il.

The contract includes a 4-year maintenance contract and allows Interdan to remove the system from customers misusing the system[46]. The energy is collected by 8 solar PV panels on the rooftops and stored in a DC battery system which converts it to AC, and has a storage capability of 4 days without direct sunlight (a rare occurrence in the Negev).

The system, however, cannot support air conditioners and heaters that would quickly consume the stored energy, so generators are still used at night. The system has been installed in 20 of the 100 households thus far, as well as the local school, mosque and streetlights.[47]

The first stage of this project cost approximately $800 thousand, and the payback period for the project, accounting for fuel savings by not using the diesel generators, is expected to be about 3 years, assuming current diesel costs of NIS 4 per liter (i.e., NIS 1 per kWh).

3.2 Solel - developer of solar thermal systems

Solel is the largest developer of solar thermal technology for centralized power generation. Its predecessor, Luz, set up the world's largest solar thermal facility (SEGS) in southern California, but fell victim to low oil prices and lack of government commitment to incentives that would make such facilities more economically viable. However, the recent surge in oil prices and the rapidly increasing demand for proven renewable energy sources has transformed Solel from a small R&D company with annual revenues under $5 million to a major worldwide player with projected revenues exceeding $100 million in 2007.

This growth has fuelled additional development, especially in heat collection, which may decrease the per-kWh cost of the technology from over 15 cents to nearly 6 cents by 2011, making Solel's technology competitive in many oil-based and natural gas-based electricity systems (e.g., Spain and the southwestern US) without factoring in government subsidies and avoided environmental costs. The SEGS generators have reduced fuel imports in the US by 11 million tons and reduced CO2 emissions by 24 million tons, in addition to creating economic opportunity in a remote section of southern California.

Solel uses the solar-trough method which involved glass parabolic collectors that track the sun's movements throughout the day. The collectors concentrate sunlight onto steel pipes that contain a heat transfer fluid. That fluid is pumped through heat exchangers to generate steam, which powers the turbine that creates electricity. The technology is applicable for both central-station power plants and distributed generation on commercial and industrial sites.

In Israel, Solel has received a special tariff from the PUA and is in the final stages of receiving a license for a 100-MW plant in the Negev desert that would be the first central solar thermal electricity generator in Israel. This facility would be able to meet the peak demands of approximately 200 thousand Israeli residential customers. The major factor

[46] Photon International, February 2006
[47] http://www.israel21c.com , February 12, 2006, and presentation by Eddie Bet HaZevdi of MNI)

hindering the licensing process has been land acquisition for the rows of collectors required.

Solel has been able to convince many within the Israeli government of the economic, environmental, and energy security benefits of developing solar thermal as an indigenous renewable generating technology. Solel has set a goal of meeting 10% of Israel's electricity demand through its technology by 2020.[48]

Nevertheless, the difference between Solel's development outside Israel and its relative stagnation domestically points to the need for government involvement and citizen awareness of the benefits of solar technology. Solel's success in the southwestern US and southern Europe has been a result of government policy requiring utilities to purchase renewable generation and favorable tax and licensing provisions. Solel's slow progress in Israel has been a result of a combination of political factors such as ambiguity in the licensing responsibilities assigned to the Ministry and the PUA, and renewables policies that have not been followed, as well as opposition from IEC.

Solel's ability to combine its own advocacy with various environmental groups and sympathetic officials at the MNI and PUA (who have been responsible for developing policies, tariffs and draft licenses) may have finally made the breakthrough for development, at long last, of a significant solar sector in Israel.

[48] Solel website www.solel.com

Glossary:

ESCO – energy service company

HVAC – heating, ventilation, and air-conditioning

IEC – Israel Electric Corporation (99.8% owned by the Government of Israel)

MNI – Israel Ministry of National Infrastructures

PUA – Israel Public Utilities Authority – Electricity

PV – photovoltaic

Toe – tons of oil equivalent (Mtoe = thousands of tons of oil equivalent)