Carnegie Mellon University

Department of History
Baker Hall 240
5000 Forbes Avenue
Pittsburgh, Pennsylvania 15213-3890
(412) 268-2880

April 19, 2012

To whom it may concern,

This is to certify that on April 19, 2012 Rebecca Yasner submitted an Honors Thesis entitled "Maximizing Renewable Electricity in Israel: Energy Security, Environmental Impact, and Economic Development" to the History Department. This thesis has been judged to be acceptable for the purposes of fulfilling the requirements to graduate with college honors.

Sincerely,

Dr. Laurie Eisenberg
Thesis Advisor

Dr. Caroline Acker
Head, History Department

Dr. Jay Devine
Dean, Dietrich College of Humanities
and Social Sciences

PERMISSION REGARDING DIETRICH COLLEGE SENIOR HONORS THESIS

[signature]
Student's Signature

3/27/12
Date

Rebecca Yasner
Student's Name, Printed

Maximizing Renewable Electricity in Israel: Energy Security, Environmental Impact, and Economic Development
Thesis Title and Semester Completed
Spring, 2012

Maximizing Renewable Electricity in Israel:

Energy Security, Environmental Impact,

and Economic Development

By

Rebecca A. Yasner

SENIOR HONORS THESIS

Presented to the Faculty of the Dietrich College of Humanities and Social Sciences in Partial Fulfillment of the Requirements for Graduation with Dietrich College Research Honors

CARNEGIE MELLON UNIVERSITY

April 30, 2012

Acknowledgements

I would like to thank my thesis advisor Professor Lauie Eisenberg of the History Department at Carnegie Mellon University for her guidance and enthusiasm. Professor Eisenberg's eye for detail and knowledge of the Middle East were invaluable throughout the entire writing process. I would also like to thank Elie Fuhrman for his help on many calculations in this paper and for his continued support. This paper would not have been possible the encouragement, support, and love of family and friends.

Notes from the Author

This project was partially supported by a Small Undergraduate Research Grant (SURG) from the Undergraduate Research Office at Carnegie Mellon University. This thesis represents the views of the author and not those of Carnegie Mellon University.

Abstract

The search for energy security and growing concerns over global environmental degradation, juxtaposed against the promise of economic development, have led to increased worldwide attention to the implementation of renewable electricity technologies. For the State of Israel, located amidst a hostile neighborhood of oil-supplying countries, the need for energy security is paramount. In addition, Israel's global obligation to reduce negative environmental impacts has become a major focus of public policy. Moreover, favorable forecasts of economic growth in the Clean Technology industry in Israel are now the driving force behind sustainable innovation. It is in Israel's best interests to make the implementation of renewable electricity in Israel a high priority through public policy initiatives as well as through industry development. The February 2010 Plan for the Integration of Renewable Energy Sources into the Israeli Electricity Sector (PIRES) by Israel's Ministry of Energy and Water Resources, while well intentioned, falls short of putting Israel on track for large-scale, integrated deployment of renewable electricity technologies. The centerpiece of this study is the author's modifications to this document, Yasner-PIRES (Y-PIRES), which will not only lead Israel to much needed electricity security, but will also help to reduce harmful environmental pollution and will provide extensive economic development through a more comprehensive implementation of renewable power into Israel's electricity mix.

List of Abbreviations

IDF	Israeli Defense Forces
IEC	Israel Electric Corporation
IPP	Independent Power Providers
MEWR	Ministry of Energy and Water Resources
PUA-E	Public Utility Authority-Electricity
PIRES	Policy on the Integration of Renewable Energy Sources into the Israeli Electricity Sector
Y-PIRES	Yasner-Modified Policy on the Integration of Renewable Energy Sources into the Israeli Electricity Sector

Table of Contents

Introduction

The search for energy security and growing concerns over global environmental degradation, juxtaposed against the promise of economic development, have led to increased worldwide attention to the implementation of renewable electricity technologies. For the State of Israel, located amidst a hostile neighborhood of oil-supplying countries, the need for energy security is paramount. In addition, Israel's global obligation to reduce negative environmental impacts has become a major focus of public policy. Moreover, favorable forecasts of economic growth in the Clean Technology industry in Israel are now the driving force behind sustainable innovation. It is in Israel's best interests to make the implementation of renewable electricity in Israel a high priority through public policy initiatives as well as through industry development. The February 2010 Plan for the Integration of Renewable Energy Sources into the Israeli Electricity Sector (PIRES) by Israel's Ministry of Energy and Water Resources, while well intentioned, falls short of putting Israel on track for large-scale, integrated deployment of renewable electricity technologies. . The centerpiece of this study is the author's modifications to this document, Yasner-PIRES (Y-PIRES), which will not only lead Israel to much needed electricity security, but will also help to reduce harmful environmental pollution and will provide extensive economic development through a more comprehensive implementation of renewable power into Israel's electricity mix.

Israel's standing as a newly developed nation with high population density, Western standards of living, a high birth rate and ever-increasing immigration, puts it in a unique place to act as a model for integrating renewable electricity for many different types of nations.[1] As an "electricity island" which shares no electricity connections with its neighbors, Israel has the added challenge of proceeding virtually alone in its endeavor to include renewable electricity into its grid. In addition, Israel's current electricity demand continues to inch dangerously close its total generating capacity (see Appendix A1), a scenario that could potentially lead to hazardous rolling blackouts and inconsistent electricity. Thus, it is in Israel's own best interest to pursue policies that encourage alternative, domestic, electricity fuel sources.

Renewable electricity is electricity generated by renewable fuel sources such as wind, solar, hydro, biomass, and geothermal power. Although some consider it to be a renewable source of electricity, this study does not believe nuclear-generated electricity currently qualifies as renewable as the yet-unsolved issues with the safe disposal of nuclear waste prohibit it from being so. Conventional fuel sources such as coal, natural gas, and petroleum-based products are not renewable due to the fact that there is a finite amount of each resource within nature on the time scale in which human industry and economy use fossil fuels.

Electricity security is the ability to generate and distribute all of a country's electricity domestically without relying on fuel imports. Economic development refers to increases in both the per capita Gross Domestic Product (GDP) of a country as well as to decreases in the unemployment rate and the GINI Index. Environmental impact includes all negative effects of human activity on air, land, and water resources.

In order to achieve electricity security Israel must place a large scale, long-term emphasis on including domestic renewable electricity into the current electricity mix. This emphasis, in the form of public policy, industry involvement, and private investment will put Israel on the path toward total electricity security. Currently, Israel relies primarily on fossil fuels to generate electricity, in the form of coal, natural gas, and oil, the vast majority of which are imported.[2] By focusing on implementing domestically abundant renewable electricity sources such as solar and wind power, and by increasing the technological ability to harness that power, coupled with the use of domestic natural gas fields, Israel has the opportunity to not only reduce its electricity dependence but to become completely electricity independent.

A multifaceted approach to the implementation of renewable electricity would also drastically reduce Israel's environmental impacts on precious air, land, and water resources. Greenhouse Gas (GHG) emissions from electricity generation in Israel, which include Carbon Dioxide (CO_2), Methane, Nitrogen Oxides, and Sulfur Oxides, account for over 50% of Israel's total GHG emissions.[3] Conventional electricity generation also causes land pollution from coal ash and oil spills, and from water pollution due to dumped seawater that is used to cool power plants. Were Israel to heavily incorporate renewable electricity generation into its electricity mix, these impacts could be drastically reduced, even when taking into account the environmental disturbances caused by renewable electricity generation itself. Today, Israel has the opportunity to not only secure control over its own electricity, but to also reduce the environmental degradation of conventional electricity generation.

In addition to achieving electricity independence and reducing environmental harm, a focus on increasing renewable electricity resources would lead to economic development throughout Israel in the form of increased per capita GDP and decreased unemployment and wealth disparities on the GINI Index. By creating a market both for technological innovation as well as for labor, a policy and industry emphasis on renewable electricity generation would lead to more jobs across the entire population within Israel in addition to increases in GDP and overall quality of life.

While the February 2010 PIRES plan is a step in the right direction for the Ministry of Energy and Water Resources, it falls short of instigating meaningful changes in the way in which Israel generates electricity. The notes and additions to the PIRES document, Yasner-PIRES (Y-PIRES), seek to better develop the renewable electricity technology sector in Israel by incorporating the Israel Electric Corporation (IEC) and the

Israeli Defense Forces (IDF) into decision making and planning, by emphasizing economic incentives, by stressing a laterally organized system of electricity generation, and by shifting the nature of the IEC from a utility provider to a service provider. These changes will enable the target capacity of renewables to double from 10% to 20% of total electricity generation by 2020, and will lead to greater electricity security, fewer negative environmental impacts, and increased economic growth.

Background

Understanding the history of electricity in Israel is paramount to grasping the full implications and opportunities of a government and industry-led emphasis on renewable electricity. Jewish immigrants to British Palestine beginning in 1880 laid the foundations for the modern State of Israel. After World War I, the League of Nations granted Britain a Mandate in Palestine. Although it did not become independent until 1948, Jewish activity in Mandate Palestine laid the groundwork for Israel's infrastructure and institutions.

Throughout its history, Israel has fought numerous wars, absorbed millions of immigrants, and produced countless innovations across varying disciplines. As Israel quickly developed from an agrarian society in the 1920's to an industrial society in the 1970's and 80's, electricity generation grew along with increasing standards of living and rising incomes. Although Israel has peace treaties with two of its neighbors, Jordan and Egypt, it shares no direct electric distribution connections with any of the countries that border it. This "electricity island" phenomenon that Israel currently experiences is due in part to the cold peaces (Egypt, Jordan) and formal states of war (Saudi Arabia, Syria, Lebanon) between it and its neighbors.

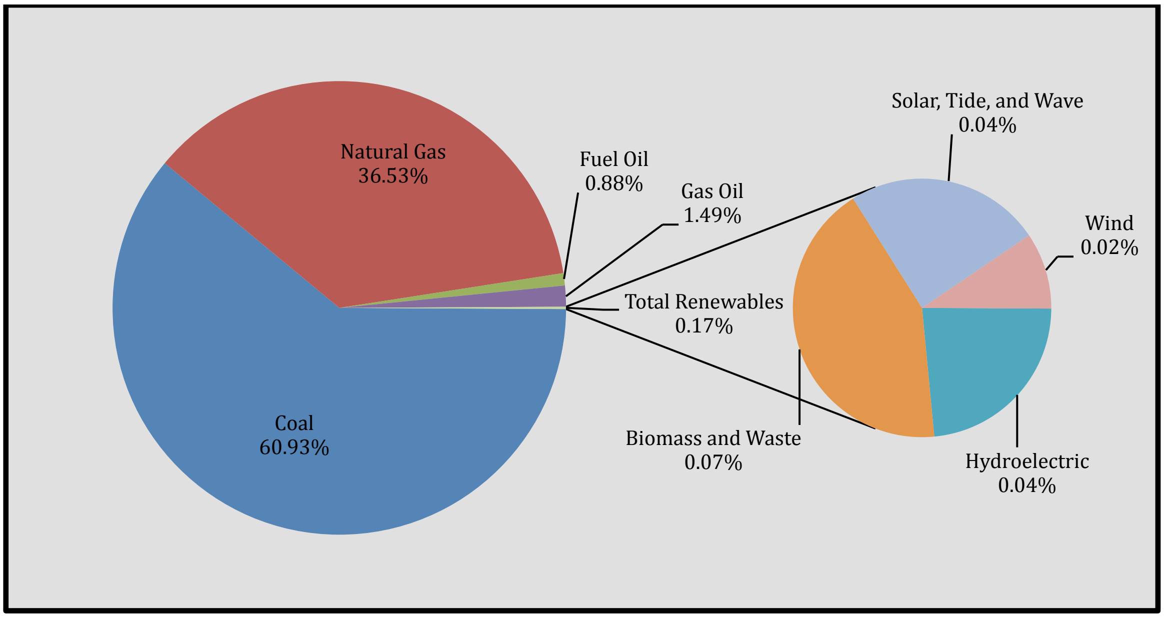
Pinchas Rutenberg brought the first electricity generation to pre-state Israel. A Ukrainian Jew born in 1879 and an engineer by training, Rutenberg served as the

Russian Chief of Police after the fall of the Czar before the Bolshevik Revolution.[4] An ardent Zionist, Rutenberg immigrated to Israel, then British Mandated Palestine, in 1919.[5] In 1923 the British Mandatory Government granted Rutenberg and his newly founded Palestine Electric Corporation (PEC) the rights to build a hydroelectric power plant at the intersection of the Jordan and Yarmouk Rivers.[6] Although the promise of economic development drove Rutenberg's decision to build the hydroelectric plant, it is worth noting that the first large-scale electricity generational the time in Israel (only 60 mWh, a small amount by today's standards) was from a completely renewable fuel source, hydroelectricity (although the PEC did use non-renewable fuel sources such as diesel and oil to generate electricity in power plants in Jaffa, Tiberias, and Haifa in order to build the hydroelectric station).[7]

Rutenberg completed his hydroelectric plant, Naharayim, in 1927. He continued to expand the PEC and in 1935 built a steam-powered electricity plant in Haifa, followed by another steam-powered plant in Tel Aviv in 1938.[8] This pre-statehood electricity infrastructure became the foundation of the newly formed state when Israel declared independence in 1948. In intervening years the PEC continued to expand its generating capacity, building the first large-scale oil-fired generators in Ashdod in 1958.[9] It was not until 1961 that the PEC changed its name to the Israel Electric Corporation Limited.[10] Today the Israel Electric Corporation serves as Israel's national utility provider, supplying 99.7% of Israel's approximately 7 million[11] citizens with electricity.[12] As shown in consisting of hydroelectric, wind, biomass and waste, and solar, tide, and wave power.

Figure 1, the IEC's main fuel sources are coal and natural gas in addition to gas oil and fuel oil. Renewable electricity sources make up a miniscule 0.17% of Israel's total electricity generation, consisting of hydroelectric, wind, biomass and waste, and solar, tide, and wave power.

Figure 1 Electricity Generation in Israel by Fuel Type 2010



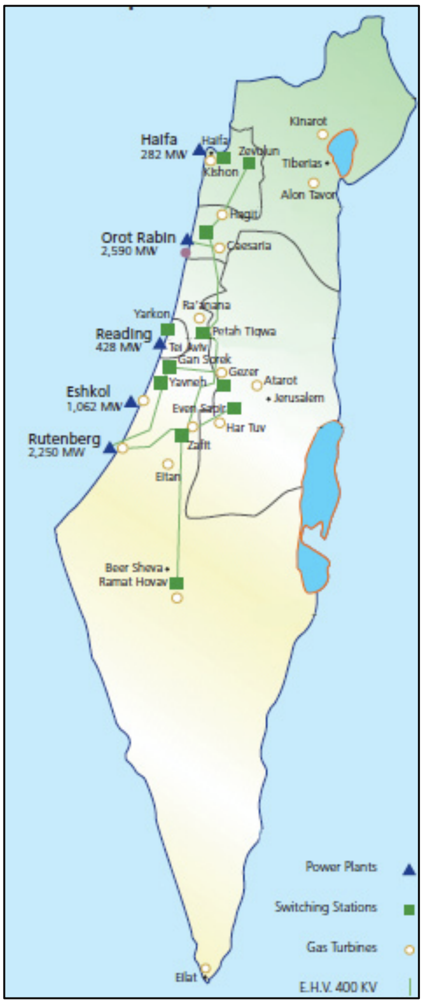
Source 1: "Statistical Report" Israel Electric Corporation, 2010. International Energy Statistics (US EIA) http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=6&pid=alltypes&aid=12&cid=IS,&syid=2010&eyid=2010&unit=BKWH

The Public Utility Authority-Electricity (PUA-E) and the Ministry of Energy and Water Resources (MEWR) regulate the IEC. The PUA-E provides licenses, upholds standards, and enforces tariffs on the generation and distribution of all electricity, generated primarily by the IEC, in Israel.[13] The MEWR, formerly the Ministry of National Infrastructures, was established in July 1996. In addition to supervising the electricity industry, the MEWR oversees Israel's natural resources including water, oil, and natural gas. As a government ministry, the MEWR passes legislation in the form of laws and regulations on electricity generation and distribution in Israel.

Although Pinchas Rutenberg did not have to contend with issues of energy security and environmental degradation, both the PUA-E and the MEWR have begun to see these issues as of critical importance within the scope of Israel's electricity generation in the 21st century. In the volatile and unstable region in which Israel exists today, with few regional allies, it is surprising that Israel is not further along the road to electricity security. The manifestation of this understanding in the form of meaningful policy reform concerning a change in electricity fuel sources by the IEC, however, is not yet apparent in neither practice nor legislation.

Electricity Security

Figure 2 Israel Electricity Grid 2010



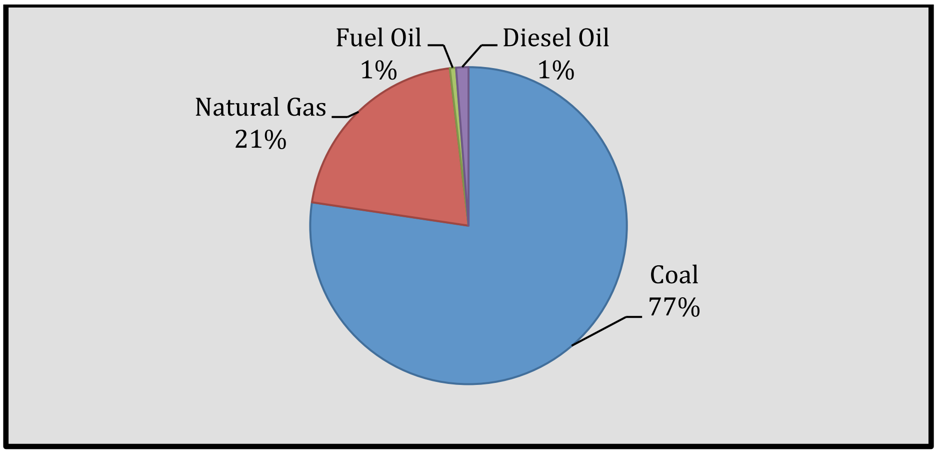
Source 2: "Statistical Report". Israel Electric Corporation, 2010.

Israel currently imports the vast majority of its fuel for electricity generation. While at times of peace and global cooperation this practice may be sustainable, relying on other countries for the ability to generate electricity is extremely risky and fraught with dire consequences. Fluctuations in global commodity prices as well as issues of international relations could very easily lead to a dark, vulnerable Israel. Without electricity generation the Israeli economic structure, private utilities, and industry would cease to function. Perhaps most importantly, Israel would lose its ability to mobilize its Defense Forces in the case of an outside attack. Thus, the need to develop domestic sources of fuel for electricity generation is extremely important for Israel's security. While the recently discovered natural gas fields along the coastline, the "Noa" reservoir in 1999, the "Mary" field in 2000, the "Tamar" and "Dalit" reservoirs in 2009, and the "Leviathan" field in 2010 (see Appendix A2)[14] could serve as a substitute in part for imported fuel sources, the most sustainable option is for Israel to incorporate renewable electricity fuel sources such as solar, wind, and biomass, into its electricity mix, with natural gas as its base load fuel source.[15]

The Israel Electric Corporation owns and operates 20 power plant sites including two coal-fired stations, five gas and oil fired stations, six combined cycle stations, and seven gas turbine stations (see

Figure 3 and Appendix A2).[16] The IEC imports most of these fuels, with the notable exception of natural gas supplied by the Noa and Mary reservoirs. In 2010, the IEC generated approximately 61% of electricity from coal, 36.6% from natural gas, 1.5% from diesel oil, and 0.6% from fuel oil. That year, the IEC spent over 50% of its total budget on fuel purchases (see Figure 3 and Appendix A4).[17] This reliance on imports for electricity generation is the main cause of Israel's electricity insecurity. By pouring its budget into the international fossil fuel market the IEC exposes itself not only to possibly depleted resources and price fluctuations but perhaps most importantly to the uncertainty of Israel's foreign relations with supplying countries.

Figure 3 Total IEC Fuel Purchases 2010



Source 3: IEC Website, "Fuels" http://www.iec.co.il/EN/IR/Pages/Fuels.aspx

Fossil fuels such as coal, oil, and natural gas, the very foundation of Israel's electricity generation, are naturally occurring materials that formed over 300 million years ago through the layering of decomposed plant and animal material. The decomposition of organic materials over millions of years in differing environments caused the distinctions among the different types of fossil fuel. For example, oil originated under layers of ancient seas and rocks, while layers of decomposed trees and land organisms created coal.[18] As organic material decomposes its energy content, or the amount of energy stored in and thus able to be released, increases.[19] This, in addition to features such as easy transportability and combustion, is the reason why most developed and developing countries use fossil fuels as the basis of their industries and economies. Conventional electricity generation is the process by which fossil fuels are combusted, or burned, to heat water to create steam. This steam is then channeled through a series of turbines connected to generators. The movement of the steam causes the generators to turn, thereby generating electricity.

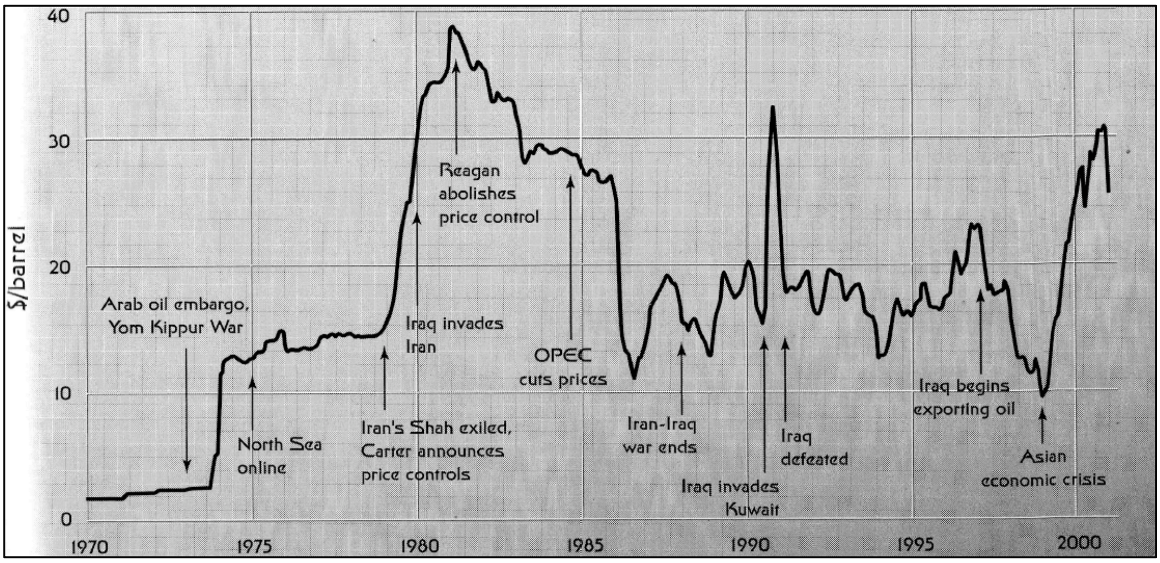
The main problem with depending upon these natural resources for fuel, however, is that Israel, along with the vast majority of countries, is using these resources much faster than they can renew themselves. By relying primarily on fossil fuels for electricity generation, Israel places itself in a precarious position once the earth's fossil fuel resources are inevitably depleted or become prohibitively expensive to extract. Israel's non-renewable, and thus unsustainable, reliance on fossil fuels heavily compromises its electricity security and ability to function as a state.

In addition to the non-renewable nature of fossil fuels, price fluctuations add another element of insecurity for Israel. Price increases of petroleum products impact Israel's ability to import oil in addition to its ability to purchase other fossil fuels such as natural gas and coal from connected markets. Historical analysis shows that increases in global oil prices affect not only the purchase of oil itself but also the ability of an oil poor country, such as Israel, to function industrially as well as economically and socially. As oil prices increase, a chain reaction of increased transportation, construction, electricity, and food costs, to name a few, have the potential to bring the economy to a grinding halt.

For Israel and its political allies, this insecurity most visibly presented itself in the 1973 OPEC Oil Crisis. In response to the United State's support for Israel in the 1973 Yom Kippur War, the Organization of Petroleum Exporting Countries (OPEC), comprised primarily of Middle East nations including Saudi Arabia, Iraq, and Iran, placed an embargo on all oil exports to the U.S. Within six months global oil prices quadrupled, leaping from $3 a barrel to $11.65 a barrel.[20] Oil shortages stymied economic growth and also impacted private citizens as gasoline consumers waited in long lines to fill up their cars in gas station across the U.S.[21] In Israel steep oil prices caused consumers to install solar water heaters to save energy and lower costs.[22]

Since the 1973 OPEC embargo, global oil prices have continued to rise with varying speeds depending on both international political and economic influences (see Figure 4), culminating to date in the highest recorded price, $147 per barrel, in 2008.[23] While only about 2.4% of Israel's electricity is generated by diesel and fuel oil, global price fluctuations of oil impact all industries and economies within Israel due to the fact that Israel's economy and industry, much like those of most developed nations, are almost entirely based on the consumption and purchase of petroleum products.

Figure 4 Global Oil Price Fluctuations 1970-2000



Source 4: Smil, Vaclav. *Energy at the Crossroads: Global Perspectives and Uncertainties.* Cambridge, Mass.: MIT Press, 2003. 151.

Israel's electricity security is also threatened by the very real possibility of weakened international relations with fossil fuel supplying countries. Similar to the 1973 OPEC oil embargo, countries or groups of countries that sell fossil fuels to Israel could simply decide to stop shipments due to either international pressure to marginalize Israel or due to a particular country's falling out with Israel.

This issue most notably presents itself in the peace treaty between Egypt and Israel in 1979. Annex III of the Treaty of Peace between the two parties requires that Egypt engage in "normal commercial sales of oil" to Israel on the "same basis and terms as apply to other" purchasing parties.[24] A memorandum between the United States and Israel further strengthened this stipulation by making the US responsible for supplying Israel with oil if supplying countries decide to halt shipments (see Appendix A5).

In 2005, Israel and Egypt signed a memorandum of understanding for natural gas imports from Egypt into Israel. The IEC and Eastern Mediterranean Gas & Oil (EMG), a joint venture between the IEC and Egyptian companies, signed the official purchase agreement. In May of 2008, Egypt began supplying the IEC with natural gas through a submarine pipeline constructed from El Arish, Egypt to Ashkelon, Israel in 2006. The IEC planned to rely on this constant supply of natural gas from Egypt as its primary source of natural gas until domestic sources, specifically from the "Tamar" field, were ready for large-scale production in 2013.[25]

Israel's reliance on the natural gas contract with Egypt is a glaring example of its' dire electricity insecurity. After Egyptian Prime Minister Sadat's assassination in 1981, Prime Minister Hosni Mubarak scrupulously maintained all of Egypt's treaty and contractual obligations with regard to Israel and energy agreement. However, since the mass protests during the "Arab Spring" forced Mubarak from power in February of 2011, militants have attacked the natural gas pipeline that supplies Israel 12 times due to lessened security and fervent public anti-Israel sentiment which the interim military government encourages. Each explosion of the pipeline halts the transfer of natural gas to Israel forcing the IEC to purchase and combust more expensive and less environmentally friendly fuels such as diesel oil and fuel oil.[26] The Israeli Public Utility

Authority-Electricity announced in March 2012 that electricity rates will increase a staggering 9% in April of that same year due to natural gas shortages and the IEC's need to buy diesel and fuel oil (see Appendix A6).[27] In addition, only one domestic natural gas supplier remains, Tethys Sea from the "Mary-B" field, which will run out between 2012 and 2014.[28] The IEC's earliest projection for the opening of the next domestic field is 2013, when the Tamar reservoir, estimated to last roughly 30 year, becomes operational. As the reliability of Egyptian natural gas fades, the IEC has begun to realize that it must plan to use alternatives to natural gas. In an "Immediate Report" published on January 26, 2012 the IEC outlines a plan of action, with assistance from the Ministry of Finance, to solve Israel's natural gas shortage.[29] In addition to price increases to consumers from the IEC, the Ministry of Finance also plans to give the IEC tax breaks on diesel oil, thereby further relying on foreign sources of fuel for electricity production. By attempting to solve a corollary of the problem, the need for fuel, instead of the true issue, electricity insecurity, the IEC and the Ministry of Finance simply shift the risk of shortages, price fluctuations, and shaky foreign relations to another resource from another country. Instead, the Ministry of Finance together with the MEWR and the PUA-E should incentivize renewable electricity generation via both the IEC and the IDF as well as through Independent Power Providers (IPP's) across Israel.

Isolated attacks on Egypt's natural gas pipeline, however, may be the least of Israel's worries considering the nature of Egypt's newly elected government. As of January 9, 2012 the Freedom and Justice Party, the Muslim Brotherhood's political party, gained control of 45% of seats in Egypt's lower parliament house and the more extreme Islamist "Salafi" parties gained another 25% of lower parliament seats.[30] While the Muslim Brotherhood has yet to issue a formal statement concerning its intentions for upholding or disregarding Egypt's peace treaty and subsequent agreements with Israel, leaders of the organization have publically voiced their own opinions on the matter.

Some Brotherhood spokesmen have said that while they are not happy with the agreements with Israel, the new Egyptian government would uphold all previous international obligations. When asked if the new Egyptian government would uphold past treaties with Israel, Amr Darrag, a senior official of the Freedom and Justice Party explained,

> According to the international law, we have to respect all treaties and agreements of previous governments… [H]owever, the other sides of these agreements have to realize that it's not a one-sided game and the Egyptian people, through the parliament, will have to monitor that.[31]

Others, such as Rashad Bayoumi, Deputy Chairman of the Muslim Brotherhood, stated in an interview with *Al Hayat* in January 2012,

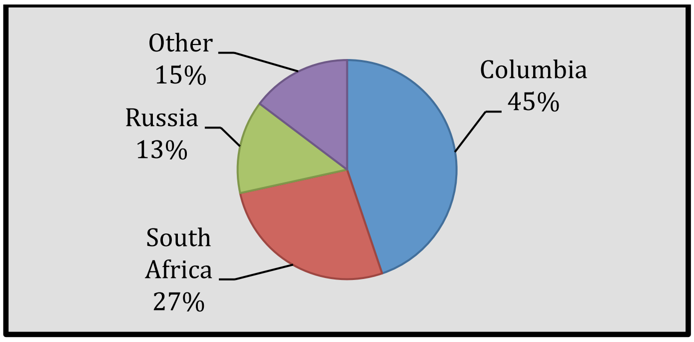
> We do not recognize Israel at all. It is a raping, occupying, criminal enemy entity. I shall never tolerate for myself to sit with a criminal and we shall not deal with Israel under any circumstances…The peace treaty absolutely does not obligate me and the people will give their opinion about this.[32]

Numerous other Brotherhood leaders have echoed Bayoumi's statements on the future relations between Egypt and Israel. Were these opinions to become Egyptian foreign policy, Israel would face detrimental electricity shortages, the cost for which the IEC and the Israeli public have already experienced after the recent pipeline explosions.

Israel currently imports about 30% of its oil from the Baku-Tbilisi-Ceyhan (BTC) Pipeline via Azerbaijan, making it the second largest importer of oil from that country (see Appendix A7).[33] An unlikely ally of Israel, Azerbaijan is a majority-Muslim country. Although there exist no formal recognition or ties between the countries in the form of embassies, foreign ambassadors, and official treaties, Israel and Azerbaijan share strategic and trade incentives to continue a strong relationship.[34] In return for oil imports Israel exports cellphone and military technology, a trade that is valued at approximately $3.6 billion per year.[35] However, a series of diplomatic missteps beginning in May of 2010 led to a rapid deterioration of ties between Israel and Turkey, another ally of Azerbaijan, which may put a strain on Azerbaijan's continued good ties with Israel. In addition, should conflict erupt between Iran and Israel, any Israeli strike that endangered the large Azeri minority in Iran could complicate Israeli-Azerbaijani ties.[36] It is interesting to note that while Israel and Iran are at odds today, the two countries once enjoyed rich diplomatic relations including economic, cultural, and political ties, until the Iranian Revolution of 1979. While favorable relationships between countries may seem unbreakable at the time, internal politics and global events can completely change the international relations game, a very risky one to play with a country's electricity generating abilities.

Risk of fuel shortages, price fluctuations, and international relations debacles of global oil markets greatly impact Israel's electricity industry, albeit, indirectly. Issues arising from coal imports, however, directly impact the IEC's ability to generate the majority of its electricity. Although Israel has no domestic sources of coal, it ranks 7th globally on dependence on coal for electricity (see Appendix A8).[37] In 2011, Israel imported 77% of coal for electricity generation from Columbia, 27% from South Africa, 13% from Russia, and the remaining 15% from a number of different countries (see Figure 5 and Appendix A9).[38]

Figure 5 Coal Imports to Israel for Electricity Generation 2011



Source 5: Yasner email Correspondence with Ronnie Granot Kohen of the National Coal Supply Corporation, February 27, 2012.

Israel's dependence on foreign coal for most of its electricity generation needs is extremely detrimental to its electricity, and thus overall, security. Although foreign relations today between Israel and Columbia, South Africa, and Russia are stable, historical analysis shows that these connections have the ability to deteriorate quickly.

The majority of Israel's coal originates in Columbia, a country that established relations with Israel in the mid 1950's. Since that time exports from Israel to Columbia have also expanded to include military equipment[39], irrigation systems, and plastics.[40] The current bilateral relationship between Israel and Columbia is strong, as evidenced by a positive meeting between Colombian Foreign Minister Jaime Bermudez and Israeli President Shimon Perez in 2010.[41] However, tensions may rise due to Colombian President Manuel Santos's move to restore ties with Venezuela[42], which cut ties with Israel in 2008 and continues to strengthen its relationship with Iran.[43] Were Venezuelan politics to influence Colombian exports, the IEC would face severe coal shortages which might cause blackouts and increased electricity rates to consumers.

Second to Colombia, Israel relies on South Africa for 27% of its coal for electricity generation. While the two democracies share full diplomatic relations today, Israel denounced apartheid South Africa in the early 1960's[44] and later limited diplomatic ties in 1987.[45] Although South Africa is a democracy and an ally of Israel today, the tide of public opinion can easily change government policy, a move that could endanger Israel's coal supply.

The IEC also relies on Russia for coal imports. Although the USSR was one of the first countries to recognize Israel in 1948, diplomatic relations between the two countries were long marred by the Soviet Union's economic, military and political support for Israel's Arab enemies. Most troubling to Israel today is Russia's strengthened relationship with Iran, a situation that could result in a deterioration of ties between Russia and Israel. Russia's ambassador to NATO Dmitry Rogozin warned that his country would consider an attack on Iran as a threat to Russia's security.[46] A break in Russia-Israel ties would have a detrimental impact on the IEC's ability to import coal to generate electricity.

The importance of electricity security, both in terms of the non-renewable nature of fossil fuels and its global price volatility, as well as uncertainty in international relations, is not a major focus, or focus at all, of the Israel Electric Corporation. "The one and only interest of the Israeli Electricity Company," said Pinchas Rutenberg, founder of the IEC, "is the economic development of the country on the basis of pure economic considerations". The IEC's official website showcases this quote along with a list of "central values" which include "financial strength" and a "high standard of service".[47] While this list of values does include a small plug for "encouraging local industries", the IEC's mission statement and goals do not at all address Israel's dire electricity insecurity (see Appendix A10).

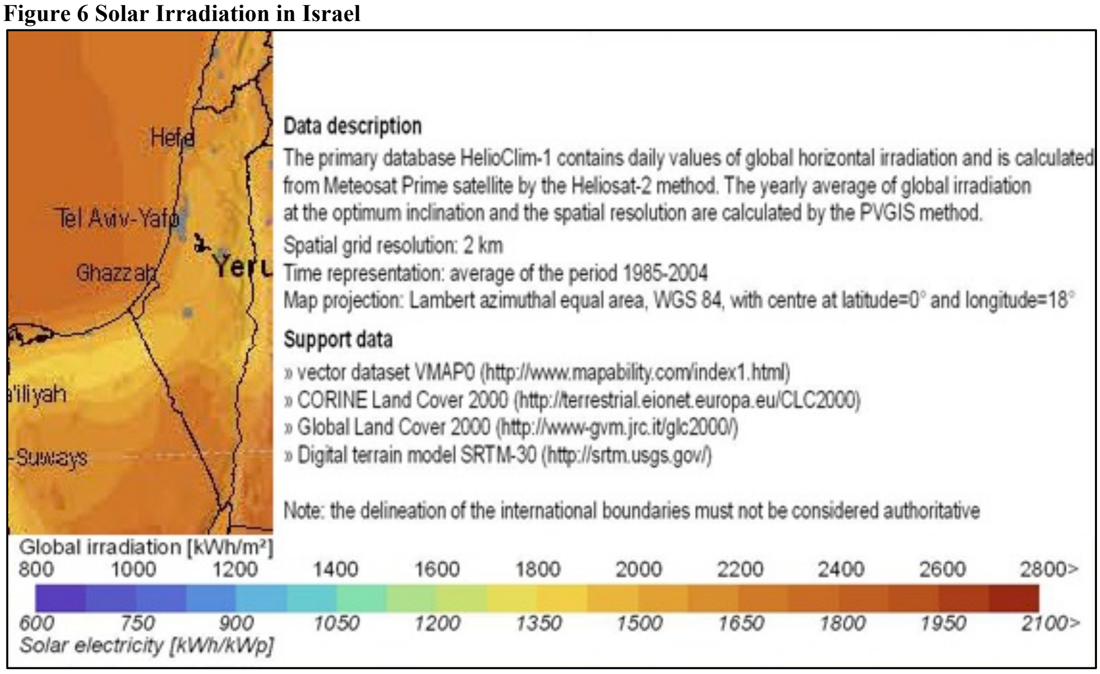
Israel can solve its electricity insecurity by the implementation of domestic renewable fuel sources into its electricity mix. A gradually applied combination of renewable electricity generated from solar, wind, and biomass coupled with a base-load of domestic natural gas with increases in electricity efficiency, can help remedy Israel's electricity insecurity. Today, only 0.17% of Israel's electricity is generated by renewable technologies of which 0.07% is biomass and waste power, 0.04% is solar, tide, and wave energy, 0.04% is hydroelectric power, and 0.02% is wind energy.[48] Each renewable technology operates differently, necessitating an understanding of the individual technologies themselves as well as their potential impact on Israel's electricity security.

The conversion of solar power into electricity includes two main types of technologies, solar photovoltaic (PV) and solar thermal. Solar PV cells, generally made of silicon, convert the sun's energy directly into electricity. The absorption of photons by the silicon cell causes electrons to become excited, thus initiating the flow of electrons, or electricity. Solar PV cells can be arranged on an open plot of land as well as on roofs of existing buildings. Solar thermal technologies use parabolic troughs, usually mirrors with tracking devises, to focus sunlight into a small highly concentrated beam.

This concentrated beam heats water or oil in a central tower to create steam to turn a turbine to generate electricity. Solar thermal technologies generally require large plots of land.

Israel is a prime location for the use of both solar PV and solar thermal technologies (see Figure 6). The southern half of Israel, comprised of both the Negev and Arava deserts, has extremely high solar irradiation and low population density, although large stretches of land are designated for nature reserves and IDF shooting ranges and thus cannot currently house solar technologies.[49] Israel has the potential to increase its electricity security by relying on domestic power from the hot Israeli sun.

Figure 6 Solar Irradiation in Israel



Source 5: "Maps of Radiation for the Mediterranean Basin." Solar Radiation Data (SoDa); Solar Energy Serivces for Professionals, copyright Commission Européenne - Mines ParisTech / Armines 2006.

In its February 2010 Policy on the Integration of Renewable Energy Sources into the Israeli Electricity Sector (PIRES), the Ministry of Energy and Water Resources defined approximately 3% of the Negev region as suitable for solar electricity generation (see Appendix A11 and Appendix D).[50] This plan defines principles for the implementation of renewable electricity fuel sources into Israel's grid based on Government Resolution 4450 ratified on January 29, 2009. PIRES set a target goal that 10% of Israel's electricity must come from renewable sources by the year 2020. Y-

PIRES, however, increases that goal to 20% by 2020 due to the added stipulations of the modified document as well as projected increases in renewable technology development and efficiency. PIRES set a target percentage of 63.4% of renewable electricity for solar electricity generation, in the form of both PV and solar thermal technologies, by 2020 with incremental thresholds beginning in 2014 (see Table 1 in Appendix D). While the percentage of solar electricity generation is the same in both PIRES and Y-PIRES, the target amount of solar generated is double in the modified document.

According to the PIRES plan renewable electricity will be almost entirely generated by private companies and individuals, made possible by economic incentives from PIRES, and will not be generated by the IEC directly. In contrast, Y-PIRES fully incorporates the IEC, the country's largest electricity provider, as well as the IDF, one of the country's largest electricity consumers, into the decision-making and planning process to implement renewable electricity into Israel's electricity grid (see Appendix D).

The first step toward the integration of renewable electricity to the grid came on June 5, 2011 when the Arava Power Company installed Israel's first solar field at Kibbutz Ketura in the Arava (see Appendix A12).[51] While the instillation of this power station is a move in the right direction, Israel is far from achieving its renewable fuel implementation goals for 2014, even when including current PUA-E tenders for solar electricity generation (see Table 9 in Appendix D).

The PIRES plan also outlines thresholds for wind electricity generation, which it forecasts as 29% of total renewable electricity generation capacity in 2020. Wind-power technologies are made up of wind turbines that convert the kinetic energy of wind into mechanical energy to produce an electric current. This mechanical energy spins a gear, which rotates a generator to create electricity. The Mei Eden water company currently owns and operates the sole wind farm in Israel, located in north of Israel in the Golan

Heights.[52] Other locations in Israel, including Jerusalem, Eilat, and Carmiel, have a high potential for successful wind-power electricity generation (see Figure 7).

Figure 7 Wind Potential Map of Israel (wind speeds at ~5-7 m/s at 100m hub heights)

Source 6: Yasner. Map by Israel Foreign Ministry of Affairs http://www.mfa.gov.il/MFA/Facts+About+Israel/Israel+in+Maps/. Data by Odeh, Yousre. "Wind Power Potential in Palestine/Israel; an Investigation Study for the Potential of Wind Power in Palestine/Israel, with Emphasis on the Political Obstacles." Gotland University 2011.

The more Israel invests in and implements wind-electricity generation, the more Israel stands to increase its electricity security by relying on a domestic source of power in lieu of depending on imported fossil fuels. By doubling the projected wind target, the modifications of Y-PIRES put Israel on track to become more electricity secure over the next eight years.

Another source of renewable electricity generation in Israel is biomass. Biomass fuels typically include wood, animal and crop residues, and grain in addition to solid waste such as cardboard and paper. Biomass can be used to generate electricity the same way fossil fuels are used to generate electricity, via combustion. Burning biomass heats water to create steam, which turns a generator, thereby producing electricity.[53] Biomass is considered to be a renewable electricity fuel source if it is combusted in a sustainable manner, such that it could be used indefinitely and in keeping with natural cycles. The PIRES set the target percentage of biomass (including biogass) at 7.6% of total renewable electricity generation by 2020.[54] Israel's location is ideal for biomass electricity generation due to the large supply of biomass fuels from agriculture and forests (Israel is one of only two countries in the world that has a net gain in trees going into the 21st century).[55] Y-PIRES also doubles these projections in bi-yearly intervals beginning in 2015 (see Table 1 in Appendix D).

Yet another option for domestic renewable electricity generation is geothermal power. Geothermal power is energy stored in the earth's core in the form of underground magma, steam, hot rocks, and hot water deposits. If these deposits are near the surface thermal energy can be extracted via drilling to power a conventional steam turbine to generate electricity.[56] The southern edge of the Golan Heights is one such potential site for optimal geothermal electricity generation.[57] Ironically, the PIRES plan does not include geothermal power as a priority for domestic renewable electricity generation, although one of the world's largest geothermal companies, Ormat Technologies Inc., has its main production facilities in Yavne, Israel.[58] Although geothermal power is not included in the Y-PIRES modifications, Y-PIRES emphasizes researching the viability of geothermal electricity generation in Israel (see C.1.e. in Appendix D).

Hydroelectric power is also an option for domestically sourced of renewable electricity. The movement of water generates hydroelectric power via a turbine connected to a generator. Dams, used to create reservoirs of water with high potential energy, increase the efficiency of hydroelectric power plants by insuring a consistent flow of water to turn the turbines.[59] Today, Israel's hydroelectric power is generated by a station in Kibbutz Kfar Hanassi and is sold to the IEC's grid when the Jordan River level is high.[60] Hydroelectric power also does not appear in the PIRES plan, most likely due to the lack of abundant water resources in Israel. While hydroelectric power is not included in the target renewable electricity technologies of Y-PIRES, research and development of high efficiency hydroelectric technologies with lower environmental impacts is a priority.

Some argue that a shift to domestic renewable electricity generation will only serve to move the risk of reliance on fuel imports to dependence on foreign manufacturing, as Israel does not currently house a robust renewable technology manufacturing industry. However, due to Israel's expansive academic and start-up-based Cleantech industry, relations with technology manufacturing supply nations will stand to be mutually beneficial and very secure. Israel, already a powerhouse for technology export in the high-tech industry, could export its Cleantechnologies in exchange for foreign manufacturing. Suntech, the worlds largest producer of solar panels based in China, has already capitalized on this partnership by signing a 10 million NIS (about $2.7 million) deal with Israeli Cleantech firm Enerpoint.[61] In addition, this relationship will not have to continue indefinitely, as does dependence on fuel imports, because once installation is complete renewable electricity technologies usually only need periodic, domestic, maintenance. By relying on Israeli technological expertise and innovation, instead of on the whim of global commodity prices, fuel shortages, and turbulent international relations, Israel has the opportunity to set itself on the path toward greater electricity independence and security with increases in renewable electricity.

The root of Israel electricity security lies in in the Israeli Defense Force's (IDF) ability to mobilize and function seamlessly in case of an attack. By relying on domestically sourced renewable electricity fuels, the IDF would be free from having to operate with the risk of unforeseen blackouts and the need to purchase expensive emergency generators. Renewable electricity fuel sources are inherently diversified in nature, such that an attack on one point of generation would not shut down the entire grid. The same is not true for conventional fossil fuel-based electricity generation, as an attack on a single coal fired power plant would cut the IEC's generation capacity by approximately 30%.[62] In contrast the higher diversification of Israel's electricity grid, via the instillation of solar, wind, and biomass fuel sources, leads to a more secure and reliable flow of electricity crucial for the successful operation of the IDF.

The IDF has already taken upon itself a number of energy-related goals dealing with both the efficient use of electricity as well as the installation of renewable electricity sources on a few of its military bases. IDF ground forces reduced their electricity consumption by 3% in 2008 through education initiatives on energy conservation, resulting in a savings of approximately 11 million NIS, or about $3 million.[63] The IDF Logistics Unit plans to implement solar powered charging stations on the battlefield for infantry soldiers to recharge military equipment and even cell phones.[64] As of November 2011, The School of Ariel Defense at one of the IDF's Air Force bases uses solar PV cells to generate its own electricity.[65] In addition, Israeli company Enlight Renewable Energy Solutions Ltd plans to install solar PV cells on IDF bases.[66] While the IDF is one of the largest organizational structures in the country, the PIRES does not once mention the Israeli Defense Forces or its ability to spearhead a national switch to employing renewable fuel sources. In contrast, Y-PIRES makes this connection a priority, repeatedly citing the opportunity for the IDF to install renewable electricity technologies to aid in its own, and the country's, electricity security.

The PIRES plan provides a structure and timeline for the implementation of renewable electricity fuel sources, but does not fully address the issue of Israel's electricity insecurity vis-à-vis the purchase and consumption of foreign fossil fuels. In order to reduce Israel's reliance on foreign oil, natural gas, and coal, the Israeli government in collaboration with the IEC and the IDF must make the implementation of renewable electricity a high priority in both the long and short term.

A major weakness of the plan, in terms of electricity security, is its lack of focus on changing the fuels used by the IEC. The plan's current thresholds for solar electricity generation only impact increases in electricity consumption and electricity generation by private providers, thus not reducing the IEC's current reliance on foreign imports of fossil fuel. The modifications of Y-PIRES have the ability to greatly reduce the IEC's reliance on foreign fossil fuel imports by incorporating renewable electricity at a larger quantity, 20% of total electricity generation by 2020, through collaboration between the IEC, IDF, MEWR, PUA-E, and IPP's.

Environmental Impact

In addition to increasing Israel's electricity security, the implementation of renewable electricity fuel sources into Israel's electricity grid will also help to reduce harmful environmental impacts of electricity generation as well as reduce the costs associated with restoring environmental degradation. All human activity has the potential to pollute the earth through three main mediums: air, land, and water. While no specific type of electricity generation is completely "clean" and pollution-free, there are different levels of impact on human health and welfare, biodiversity and animal-life, and the environment through air, land, and water pollution ranging anywhere from utterly destructive, to sustainable, to beneficial. Renewable electricity is currently the least environmentally harmful method of generating electricity compared with conventional fossil fuel generation. Israel's drive to become more environmentally conscious stems not only from a desire for cleaner air, land, and water, but also from sound economic reasoning that switching to renewable electricity sources will reduce the need for expensive environmental restoration necessitated by conventional electricity generation. Although the PIRES plan addresses environmental issues such as air pollution, the Y-PIRES modifications double the target percentage of renewable electricity, thereby reducing, twofold, reductions in environmental harm due to electricity generation from fossil fuels.

In order to accurately compare conventional electricity generation to renewable electricity generation in terms of environmental impact it is crucial to maintain a constant scope under which to contrast the two. Life Cycle Analysis (LCA) is a method used by many professionals, including engineers and environmentalists, to compare two types of systems under the same scope.[67] Figure 8 illustrates the processes critical to conducting an LCA of conventional versus renewable electricity generation.

Figure 8 LCA Scope for Renewable and Conventional Electricity Generation

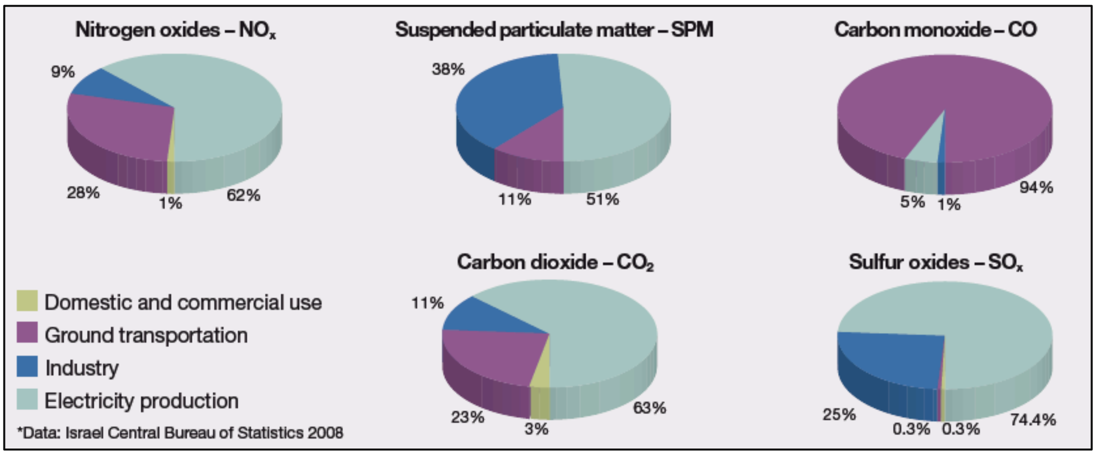
Source 7: Rebecca Yasner

Material/fuel extraction refers to the raw materials used to manufacture renewable technologies such as solar PV cells and wind turbines, while fuel extraction includes processes such as mining for coal and drilling for oil. Transportation includes all shipment of both fuels and materials from their place of origin to where they will be manufactured in addition to air pollution from transportation itself. Manufacturing refers to the process of building renewable technologies as well as conventional power plants while refining is the process that converts natural resources into useful fuels suitable for electricity generation. Generation and combustion both refer to on-site electricity generation. Each segment of this Life Cycle Analysis impacts the environment in different ways and to varying degrees in terms of air, land, and water pollution.

In 2010 the Israel Electric Corporation generated 99.8% of its electricity from conventional combustion generation via coal, natural gas, fuel oil, and diesel oil fuel. Combustion of fossil fuels and fuel transportation are the main source of air pollution from conventional electricity generation. These emissions negatively impact human health and welfare, and animal life, in addition to the earth itself. However, not all conventional fossil fuels have the same environmental impact when combusted. For example, the combustion of natural gas for electricity generation emits approximately 28% less Carbon Dioxide and 98% less Sulfur Dioxide than combustion of coal for electricity generation.[68] Thus, the goal of natural gas as the main base load fuel source will help reduce, although not eliminate, harmful air pollution.

Emissions from fossil fueled power plants have both short and long term affects on human and animal health. Particulate Matter (PM) emitted from coal and oil-fired power plants is associated with cardiovascular and respiratory disease, lung-tissue damage, and premature death. Exposure to sulfur dioxide (SO_2), a pollutant also emitted from coal and oil-fired power plants, can cause respiratory illnesses and exacerbate chronic lung disease, asthma, and bronchitis. Carbon monoxide (CO), an odorless-colorless gas formed by the incomplete-combustion of fossil fuel, can cause shortness of breath and even death at high exposures. Nitric oxide (NO), a gas emitted by coal-fired power plants, oxidizes in the atmosphere to form nitrogen dioxide (NO_2), a compound that can aggravate the human respiratory system and cause bronchitis. Ground-level Ozone, formed from chemical reactions in the atmosphere between nitrogen oxide (NO_x) pollutants and volatile organic compounds (VOC's) or hydrocarbon emissions, lessens lung function and harms lung tissue.[69] Electricity generation in Israel in 2008 accounted for 62% of total NO_x emissions, 51% of total PM emissions, 5% of total CO emissions, 63% of total CO_2 emissions, and 74.4% of total SO_x emissions in Israel (see Figure 9).[70]

Figure 9 Sources of Air Pollution by Sector



Source 8: "Breathing Clean Air." Ministry of Environmental Protection, 2010.

Reducing emissions from electricity generation in Israel, an industry that accounts for over half of total NO_x, CO_2, PM, and SO_x emissions, would have an enormous impact on both improving air quality and on reducing costs associated with maintaining air quality standards. Implementation of the Y-PIRES plan would reduce emissions by about 20%, a number that would increase as installation of renewable electricity technology and their efficiencies grow, compared with only 10% from the PIRES plan (see Appendix B1).

The role of air pollution in damaging human health has long been a topic of debate and public policy in Israel. Since the early 1960's the IEC, together with various government bodies including the Ministry of Health, the Ministry of the Interior, the Ministry of Development, the Ministry of Finance, and the Knesset, have attempted to regulate and reduce harmful air pollution from electricity generation. Due to a multitude of factors, including the government's political makeup, pressure from the IEC and economic constraints, this anti-pollution campaign has moved extremely slowly and falls well behind international standards. For example, although "scrubbers", a technology that reduces SO_2 emissions from coal-fired power plants, were proven to be effective in the 1970's, the technology was never incentivized nor required by the Israeli government until the IEC invested in them in 1989.[71]

Air pollution laws in Israel began as a subtopic of the 1961 Abatement of

Nuisances Law. This law, and its subsequent regulations in1962, banned "unreasonable"[72] emission of "ash, soot, steam, gas and dust created by burning, or by incomplete burning…" [73](see Appendix B2 and B3). Until the early 1990's, the vast majority of Israel's air pollution laws and regulations dealt with pollution from vehicles and industrial sites.[74] In 1992, the government amended the Abatement of Nuisances Regulations to include a section on air quality that defined specific pollutants and acceptable levels of emissions from various sources, including electricity generation (see Appendix B4).[75] The Clean Air Law of 2008 replaced the Abatement of Nuisances Law and Regulation concerning emissions from electricity generation in January of 2011. The goal of this law is to,

> To improve air quality and prevent and reduce air pollution, inter alia, by establishing prohibitions and obligations according to the precautionary principle, in order to protect human life, health and quality of life and to protect the environment including natural resources, ecosystems and biodiversity, for the public and for future generations, while considering their needs.[76]

Included in the law are emission limits and permit requirements, transparency of air quality data, a basis for a national air pollution reduction plan, and strict enforcement penalties.[77] To supplement this law, a policy on Clean Air Regulation Emissions Permits went into force in July of 2010, defining a step-by-step procedure for industries such as the IEC to follow in order to track and regulate emissions (see Appendix B5).[78]

The IEC, due in part to the above regulations in addition to economic considerations, has lowered emissions in spite of increased capacity. For example, the IEC switched to a lower sulfur content coal in July of 2004 and enabled oil-fired power plants to burn natural gas. These changes caused a 59% reduction in SO_x emissions, which also served to reduce the potential for acid rain, and a 64% reduction in PM emissions per unit of electricity from 1998-2007.[79] The IEC has also installed combined cycle units on six of its power plants, and plans to build six more between 2010 and 2013 (see Appendix B6). Combined cycle units increase the efficiency of power plants, and thus the amount of electricity supplied to the grid, by converting the heat exhaust from conventional natural gas turbines (which would normally vent to the atmosphere) into steam to generate electricity.[80]

Although Israel has a history of implementing policies to improve air quality and reduce air pollution, only the PIRES plan begins to address the need to reduce air pollution from electricity generation via installation of renewable electricity technologies. The Y-PIRES modifications further strengthen this endeavor by incorporating input from the IEC, which generates the vast majority air pollution from electricity generation in Israel but is also the best hope for large-scale change. In addition, by empowering the IDF to not only increase efficiency but to control its own electricity sources, Y-PIRES creates an incentive for the IDF to safeguard the surrounding environment that it depends on for power. This connection to the environment through power from sunlight, wind, and biomass will also extend to the general population, both through mandatory conscription to the IDF (where they will have exposure to the IDF's electricity sources) as well as through increased financial incentives for IPP's for renewable electricity throughout Israel. These changes in the Y-PIRES document will lead to cleaner air quality and improved human health.

Many scientists believe that emissions from oil, gas, and coal power plans plants impact global weather patterns via air emissions, a phenomenon commonly referred to as global climate change. The International Panel on Climate Change (IPCC) projects that increases in global greenhouse gas (GHG) emissions such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs) will cause global temperatures to rise.[81] A growth in global temperatures is likely to cause glacial melting, a rise in global sea levels, and increased incidents of extreme weather.[82]

In 2008, IEC electricity generation accounted for about 50% of Israel's total Green House Gas emissions.[83] In order to address and regulate these emissions, Israel joined a number of international campaigns and treaties dealing with environmental impacts and global climate change. Although Israel's contribution to global climate change is small compared to that of other countries, Israel sees a reduction in GHG emissions advantageous for both economic and environmental concerns.

In 1972 Israel sent twelve delegates to the United Nations Conference on the Human Environment, a gathering that led to the creation of the United Nations Environment Programme.[84] Israel also ratified the Montreal Protocol on reducing harmful Ozone and Ozone causing-emissions in 1992.[85] The Kyoto Protocol, ratified by Israel in 2004 as an Annex II country, was the first legally binding international global climate change legislation which called for 50% emissions reductions by Annex I countries of 1990 emissions levels.[86] Israel continues to participate the Clean Development Mechanism (CDM) program, a project developed in tandem with the Kyoto Protocol, which enables low-emission technology collaboration between developed and developing countries.[87] At the United Nations Conference on Climate Change in Copenhagen in 2009 Israel announced its pledge to reduce GHG emissions by 20% by 2020.[88] Israel also continues to work with the Organization for Economic Cooperation and Development (OECD) to develop air pollution regulations.[89]

Renewable electricity sources such as wind, solar, hydro, and geothermal power, in contrast, do not emit any air pollutants directly from generation. Emissions from renewable sources instead stem from raw materials extraction and manufacturing, both of which rely on the combustion of fossil fuels. In comparison to the combustion of fossil fuels for electricity generation, however, air pollution from raw material extraction and manufacturing is negligible (see Appendix B1). In addition, a shift toward renewable electricity sources compounded with the growing trend of environmental consciousness and clean technologies will cause these processes to emit even less than they already do as they become more technologically advanced and environmentally sustainable. Thus, renewable electricity has the potential not only to reduce current emissions levels but also to work toward eliminating harmful emissions entirely. [90]

The Ministry of Environmental Protection, the government body responsible for the implementation and enforcement of air pollution regulations, employs economic incentives and sets standards for the IEC and private electricity generators. While some of these incentives and standards include the implementation of renewable electricity source, it is usually secondary to legislation that attempts to lower emissions without replacing the actual source of those emissions.[91] In other words, the thrust of current policies is one that attempts to solve the air pollution problem by lowering, and not eliminating, air pollution. For example, the Greenhouse Gas Emissions Reduction Plan for The State of Israel, while recognizing that about half of 2010 GHG emissions were from the power sector, does not once mention renewable electricity technologies.[92]
In contrast, an environmental policy focus that placed the implementation of renewable electricity sources at the forefront, such as the Y-PIRES plan, could not only lower air pollution but could remove it entirely.

Land use and pollution issues are extremely important to Israel due to its small size and standing as a landlocked "island." Environmental impacts to land include raw material extraction, such as mining and drilling, the disposal of waste on land, and the use of land for human development. These effects can be harmful to human health as well as detrimental to biodiversity and animal-life. Land-pollution and use often damage whole ecosystems causing a negative chain-reaction of environmental degradation. Human activity on land impacts the environment through loss of biodiversity and endangered species, and natural habitat marginalization.[93] Israel's importation of coal alters the existing landscape, reduces soil nutrients, and demolishes ground vegetation of supplying countries such as Colombia, South Africa, and Russia. Domestic coal combustion leads to soil acidification via ash-waste in addition to large-scale use of high-priority coastal land for coal power plants (see Appendix B7).[94]

A great example of multiple Israeli government agencies working together to solve an environmental problem is the National Coal Ash Board. The Ministry of Energy and Water Resources, together with the Ministry of Environmental Protection, the IEC, the National Coal Supply Company, and the Interior Ministry, formed the National Coal Ash Board (NCAB) in 1993 in order to address growing soil degradation from ash collection at coal-fired power plants.[95] Today the NCAB works to direct ash waste from coal plants to industries that use ash, such as construction and agriculture. Nevertheless, coal ash has the potential to cause environmental harm via ground water pollution, dust, and possible radon emissions.[96]

Renewable electricity generation also impacts land-use and causes land-based pollution. The materials used to create wind turbines, solar PV cells, solar thermal troughs, hydroelectricity turbines, and biomass and geothermal stations are all taken from the environment. The construction of solar PV cells requires the acquisition of raw materials such as silicon. Land pollution caused by the use of renewable sources differs from that of conventional power plants in that the main environmental harm stems not from actual electricity generation but from material extraction, production, and manufacturing.

Solar thermal electricity generation requires large open fields, potentially causing habitat loss to local species. Wind electricity generation, if located near residential areas, can cause may cause noise pollution, or "unwanted and disturbing sound"[97], and land use issues. In addition, many environmental groups in Israel, including the Nature and Parks Authority, oppose wind power installation due to potential avian mortality caused by wind turbines.[98] This threat, however, when compared with other causes of aviation mortality, may not be more harmful to bird populations than other structures such as buildings and windows (see Appendix B8). Hydroelectricity also impacts land by altering the natural flow of rivers and streams, thereby damaging the ecosystem both upstream at the dam and downstream with reduced water flow.

In terms of land pollution, both conventional electricity generation and renewable electricity generation cause environmental harm, albeit on different scales. Renewable technologies must be regulated as rigorously, or even more rigorously, than conventional electricity generation to ensure consistency as well as a high standard for environmental sustainability across all fields. Due to the fact that renewable electricity technologies are developed, at least in part, to be beneficial to the environment, this stringency will be fairly simple to enforce. The PIRES plan estimates that the target projections for renewable electricity technology implantation, 10% by 2020, will take up about 3,380 hectares of land (see Table 1 in Appendix D). Although the Y-PIRES plan doubles the target renewables percentage from 10% to 20% by 2020, the area of vacant land needed does not double. Y-PIRES emphasizes the use of existing infrastructure for appropriate renewable technologies such as solar PV cells and intercity wind turbines to reduce the amount of open land used solely for renewable electricity generation.

Access to clean, non-polluted water is crucial for Israel's survival and success as a nation with very few natural water resources. Water pollution not only causes adverse health affects for humans and animals but also negatively impacts the agricultural sector as well as the natural environment. Electricity generation from conventional power plants causes thermal water pollution as nearby water sources dissipate waste heat from power plants.[99] For Israel, this water source is primarily the Mediterranean Sea. The release of large quantities of heated water back into the sea after being used to cool power plants is very damaging to aquatic life due to the fact that many species are extremely sensitive to temperature changes. Although Israel has quite extensive water protection laws due to water scarcity, in mid 2012 there exist no regulations concerning water used for cooling electric power plants.

Renewable electricity sources primarily impact water via hydroelectric power generation. The installation of hydroelectric power has the potential to affect the function of entire ecosystems by both changing the flow of water and also by creating large unnatural reservoirs. Although hydroelectricity does not directly cause water pollution, loss of habitat and biodiversity, as well as harmful impacts on ecosystems downstream, can occur. Some solar thermal and geothermal power plants may also need water to cool them, much like conventional electricity generation.[100]

Although the PIRES plan mentions the importance of reducing air pollution from electricity generation, the stipulations of the plan fall short of bringing about major improvements in environmental degradation via renewable electricity installation. In contrast, the Y-PIRES plan emphasizes the importance of renewable electricity generation in not only combatting global climate change but also in reducing environmental impacts via water and land pollution. By increasing the scale of deployment the Y-PIRES plan puts into motion a system that will cause less environmental damage over time than the original PIRES plan.

Economic Development

The implementation of renewable electricity power sources into Israel's electricity grid will not only put Israel on the path toward electricity security and reduced environmental impacts, but also on the road to economic development. Today, the IEC has almost complete control over electricity generation in Israel, both in terms of fuel sources as well as in terms of prices and load management. Although the government is currently attempting to incorporate more Independent Power Providers (IPP's) into the grid, there is little push to change the structure and role of the IEC itself and its monopoly over electricity generation. Diversification of Israel's electricity market and a shift towards the laterally organized power production of renewable electricity will lead to the creation of new jobs and markets, an increase in per capita Gross Domestic Product (GDP), and a reduced income gap. In order for Israel to recognize these benefits, government and industry must work together to make the widespread implementation of renewable electricity sources a national priority. Y-PIRES will further economic development caused by renewable electricity installation by doubling the target percent of renewables to 20% by 2020. In addition, the lateral focus of Y-PIRES, and its inclusion of the IEC and IDF, will help further develop Israel's domestic Cleantech sector, thereby further increasing economic expansion.

Israel's standing as an electricity island coupled with rising electricity demand due to high standards of living and population growth can, and will, cause huge peak-demand and load management issues for the IEC if alternative sources for electricity generation are not found. As peak electricity demand inches ever closer to the IEC's total generating capacity, the threat of blackouts (and the economic stagnation that results) grows ever greater.[101] Although not the focus of this study, energy efficiency via the economic tools of price differentiation can greatly increase the IEC's ability to generate and distribute consistent reliable electricity at a safe level above peak capacity. Electricity prices in Israel are artificially low, both in comparison to true generation costs and in contrast to electricity prices in other countries (see Appendix C1). In addition to pursuing a thorough reassessment of PIRES via Y-PIRES, the MEWR, PUA-E, and the IEC should implement a pricing scheme that is both reflective of the true cost of electricity generation and is more beneficial for energy efficiency. This, coupled with a strong emphasis on renewables, can lead to economic growth in the long run.

Three main indicators that track economic growth and decline include per capita GDP, the unemployment rate, and the GINI coefficient. Per capita GDP is the annual monetary value of all domestically produced goods and services per person.[102] The unemployment rate is the number of unemployed individuals divided by the total number of individuals in the workforce.[103] The GINI Index, measured on a scale from zero (perfect equality) to one (perfect inequality), is the measure of income distribution denoting the gap between rich and poor citizens.[104] These three indicators are not only important for domestic data collection on standards of living and a country's stability, but also help determine external legitimacy and foreign relations.

A study from the *International Research Journal of Finance and Economics* entitled "Renewable Electricity Generation and Economic Growth: Panel-Data Analysis for OECD Countries" examined the relationship between renewable electricity installation and economic growth in OECD countries from 1980-2007. Although Israel was not included, the report did find a "long term positive relationship between renewable electricity generation and economic growth" as well as a statistically significant "reciprocal causality" between the two variables.[105] The authors encouraged OECD member governments, a group of which Israel is now a member, to provide tax breaks and financial incentives for increased diversification of renewable electricity sources. Indeed, the underlying reasons as to why the implementation of renewables leads to economic development must be understood both in terms of the electricity market itself as well as in terms of economic tools and indicators, which can then be used to establish a foundation for thoughtful national planning.

Electricity in Israel is currently generated by a state-owned, centralized, hierarchical company tasked with providing, and profiting from, electricity sales in Israel. This type of system, based on the production model of the second Industrial Revolution at the turn of the 20th century, runs both directly and indirectly on fossil fuels such as coal and oil. In his book *The Third Industrial Revolution*, economist Jeremy Rifkin, president of the Foundation of Economic Trends, outlines the current weaknesses of industrial processes, including security risks, economic pitfalls, and environmental costs surrounding reliance on fossil fuels and the antiquated second Industrial Revolution model. He argues in favor of lateral, locally organized sustainable development via a Third Industrial Revolution (TIR), brought about, as were the previous revolutions, through the "convergence" of new communication technology with energy innovation. In the case of the Third Industrial Revolution, Rifkin argues, the Internet serves as the new tool for communication and renewable energy as the energy innovation.[106]

Rifkin outlines five "Pillars of the Third Industrial Revolution" as the means of transitioning from the current industrial model. The first of these pillars is the shift from conventional fossil fuels to renewable sources of energy.[107] Rifkin argues that this move to renewables will lead to a decentralized, open market for local electricity generation, thereby reorganizing the power structure of the industry to benefit local, small-scale businesses and land-owners. The second pillar is the transformation of the "building stock of every continent into micro-power plants to collect renewable energies on site," thereby generating electricity at the point of consumption for increased efficiency and decreased transmission requirements. Third is the development of "hydrogen and other storage technologies in every building and throughout the infrastructure to store intermittent energies." The fourth pillar calls for "using internet technology to transform the power grid of every continent into an energy-sharing intergrid that acts just like the Internet (when millions of buildings are generating a small amount of energy locally, on site, they can sell surplus back to the grid and share electricity with their continental neighbors)". And lastly, the fifth pillar is "transitioning the transport fleet to electric plug-in and fuel cell vehicles that can buy and sell electricity on a smart, continental, interactive power grid."[108] Rifkin argues persuasively that these five pillars, working simultaneously and applied in individual nations and eventually entire regions around the world will serve to usher in the more secure, sustainable, and economically viable infrastructure development of the Third Industrial Revolution.

Israel has an extraordinary opportunity to spearhead this transition Along with the advantages in terms of security and the environment due to the implementation of renewable electricity into Israel's grid, the first step in the shift to the TIR, Israel stands to benefit economically by causing an increase in per capita GDP, a decrease in the unemployment rate, and a drop in the GINI Index. This is due to both the distributed organization of renewable electricity as well as to its nature as an emerging market and new form of infrastructure development. The current hierarchical makeup of the IEC, both in the organization of the company itself, which consists of high-income management and low-income labor, as well as in the structure of the large-scale centralized generation sites of the electricity grid, is utterly unsustainable in a global system in which many developed nations are shifting towards a Third Industrial Revolution.[109]

The inherently diversified nature of renewable electricity sources, in terms of fuel type and geographical location in Israel, will create a wide variety of jobs across multiple fields, education levels, and areas of the country. Although manufacturing of renewable electricity technologies such as solar PV cells and wind turbines will not take place in Israel, job creation from the implementation of renewables will take the form of installation and maintenance in addition to domestic technological innovation (such as Cleantech, discussed below), management of international trade, land and building ownership, grid monitoring, and Independent Power Providers (IPPS). Renewable electricity generation is an increasingly attractive investment, especially in light of a March 2012 agreement to build an underwater electricity connection cable among Israel, Cyprus, and Greece. This cable will connect two electricity islands, Israel and Cyprus, to the European Union via Greece, enabling Israel to become an electricity provider to the (renewable) electricity-hungry EU (which set a target to have 20% renewable energy power by 2020).[110] This mutually beneficial link will not only strengthen Israel's political jockeying power, but will also expand its revenue from a larger electricity market.

Macroeconomic analysis on production factors for developed versus developing countries indicates that the correct combination of capital stock, education and abilities, and residual “A” are what differentiate a highly functional developed nation from a poor developing nation. Residual “A”, the indicator with the most influence on a country's standing as a developed or developing nation, includes a wide variety of factors such as regime type, social norms, and institutions. Most importantly for Israel, residual “A” also includes energy sources, available technologies, and energy innovation.[111] Thus, an emphasis on energy innovation in the form of renewable electricity technologies domestically will enable further development in Israel. A focus on individual renewable electricity providers will also strengthen and encourage local businesses and employment, specifically in low income, high-renewable potential areas such as the Negev Desert and Arava Valley, which include large concentrations of Bedouin Arabs. In addition, as more individuals and companies become small-scale renewable electricity providers, Israel's middle class will be strengthened and the country can look forward to a decrease in the unemployment rate and the GINI Index.

The Y-PIRES modifications expand the speed and depth of this shift by increasing the target percentage of renewables from 10% to 20% by 2020. In addition, the shift of the IEC, arguably the most knowledgeable industry player, from a direct utility provider to a service provider of grid and load management, will most effectively ensure the consistency and reliability of a horizontally organized electricity infrastructure with help from internet technologies.

As the worldwide demand for increasingly scarce and expensive fossil fuels rises, Israel's continued reliance on coal, oil, and diesel/fuel oil will cause economic stagnation and decline. As a quickly developing nation with a high per capita GDP located in a climate conducive to renewable electricity generation, Israel has the opportunity to better equip itself for a future without the need for fossil fuels. The transition from oil to alternative fuel sources such as electricity for transportation has already taken off in Israel with Project BetterPlace, an Israel-based electric vehicle network and service provider, which intends to rely upon renewable power for its charging stations.[112] This conversion of transportation fuel from gas to electric will increase the importance of and demand for sustainable, consistent, and renewable electricity. By shifting to domestic and sustainable renewable electricity sources, Israel stands to increase its per capita GDP through the creation of new markets for renewable technologies within a laterally organized integrated system.

Renewable technology industries, also known as Cleantech, include companies and academic research institutions focused on renewable electricity technologies as well as on sustainably developed innovation for energy efficiency, agriculture, and water use. Israel is an excellent example of a country that has applied its high-tech fervor to Cleantech innovation and venture capital investment as advocated by Dan Senor and Saul Singer, whose book *Start Up Nation* documents Israel's unique approach to entrepreneurialism.[113] Separate from government interaction and policy, "the cleantech economy here hums independently, on market forces and innovation" writes Glen Schwaber, founding partner of Israel Cleantech Ventures.[114] The list of world-renowned award-winning Israeli Cleantech companies and startups is astonishing. In 2011, The Cleantech Group, an industry analyst for Fortune 1000 global corporations, honored eight Israeli-based companies with Cleantech awards.[115] Strategists at the 2011 UN Economics Commission Conference on Promoting Eco-Innovation: Policies and

Opportunities heralded Israel as a "laboratory" for eco-innovation.[116] The Cleantech Innovation Group and the World Wildlife Fund rated Israel second only to Denmark on the 2011 Cleantech Country Innovation Index, and hailed Israel as the "clear winner" in the category of emerging cleantech innovation.[117]

Israeli Cleantech, however, has won more than just international recognition, garnering attention from virtually all-major venture capital (VC) firms for Cleantech investment.[118] Israel-US collaboration leads the way with a number of large-scale investments, such as the $8.5 million budget for the Biational Industrial Research and Development (BIRD) Energy Foundation Program, a joint academic-industry fund for Cleantech.[119] Other Israeli Cleantech companies that collaborate with US firms include Cima Nanotech, Ener-T, Pentalum, Greenlet Technologies, and Halotechnics.[120] Brightsource Energy, an Israeli solar company, brokered the world's largest solar electricity deal, a 1300 MW solar purchase agreement, in California with Southern California Edison.[121] Brightsource raised over $160 million from investors including US VantagePoint Ventures, Google, BP, Morgan Stanley, and JPMorgan Chase.[122] Israel also hosted the 15th Cleantech Exhibition in Tel Aviv that attracted investors and industry leaders from over 85 countries[123] and spawned approximately $75 million worth of business transactions.[124]

Israel's Cleantech industry, however, focuses primarily on exporting renewable technology rather than on incorporating renewable electricity into the IEC's grid. The same Cleantech Innovation Group and the World Wildlife Fund that rated Israel second to Denmark in the Cleantech Country Innovation Index rated Israel 14th for "evidence of commercialized cleantech innovation", citing a "limited domestic market" and "scarcity of local expansion capital" as reasons for the lack of cleantech incorporation into the grid.[125] Industry leaders often see Israel's relatively small grid capacity, in addition to the IEC monopoly over it, as a much less attractive option than the large potential markets and highly lucrative funding abroad.

Y-PIRES increases the appeal of Cleantech installation in Israel by tasking the MEWR with researching foreign incentives and markets for Israeli renewable electricity technologies, so that the Ministry will be equipped to offer similar or better incentives to incorporate home-grown technologies into Israel's electricity grid. Moreover, the increased target of 20% renewables by 2020 opens up potential investment for projects that venture capitalists may otherwise view as too risky. The involvement of the IDFin the Y-PIRES plan will also serve as a propelling economic force in installing renewable technologies.

Conclusion

The Yasner modified version of the Ministry of Energy and Water Resource's renewable electricity plan, Y-PIRES, increases its efficiency and effectiveness in attaining the goal of implementing renewable electricity into Israel's electricity grid. By fully integrating the IEC and the IDF into the planning and execution of the plan, it is possible to increase the target percentage of renewable electricity from 10% to 20% of total generation capacity by 2020. The IEC's industry knowledge, expertise, and infrastructure are crucial to a transition of this magnitude. The IDF, arguably the largest industry in Israel, not only has the impetus to participate in this shift - namely electricity security - but is also perfectly positioned to facilitate such change as a structured industry that influences all aspects of Israeli life. The inclusion of these two industries in the plan, with an added emphasis on the use of existing infrastructure, makes an increase from 10% to 20% renewables by 2020 eminently probable.

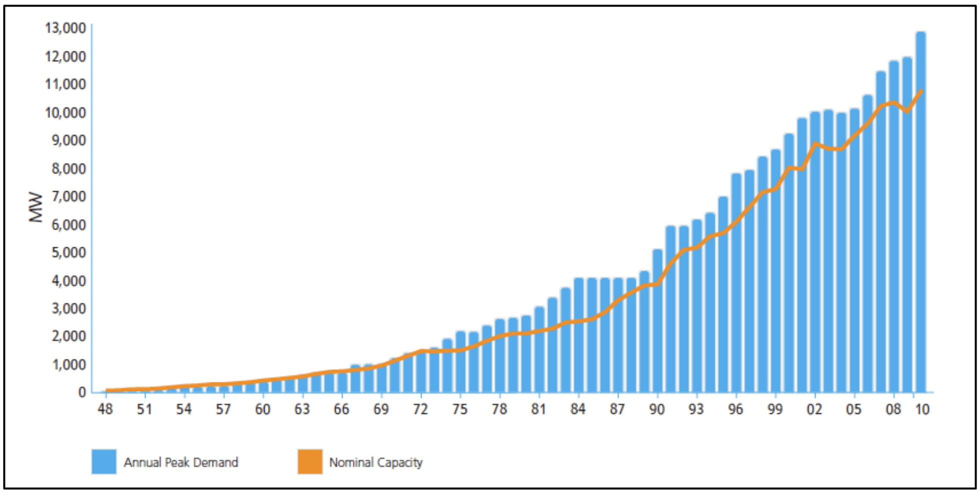
In addition, Y-PIRES calls for sustained large-scale growth of the renewable electricity sector instead of small annual increases after 2014 (see Table 1 in Appendix

D), which will further increase Israel's electricity security and economic development while reducing harmful environmental impacts from reliance on conventional electricity generation. Electricity security will increase as the IDF pursues electricity independence from the national grid via renewable electricity technologies. By creating a laterally organized electricity grid, this improved plan returns the electricity market to the people while insuring its consistency and reliability due to the involvement and cooperation of the industry leader, the IEC. This revised plan fosters continued economic development by shifting from conventional electricity generation to renewable electricity generation at a greater magnitude than the original plan. While upfront costs of renewable technologies may seem steep, the risk of economic collapse due to reliance on foreign fossil fuel imports fraught with international relations issues, fuel shortages, and price fluctuations, is much higher. Rarely does a policy initiative solve three separate issues with one document. In a world that usually demands compromises and trade-offs, the Y-PIRES plan gives Israel the opportunity to do what is both in its best interest for security and economic development in addition to what is best for the environment at large.

Appendix A: Electricity Security Items

1.

Figure 10 IEC Annual Peak Demand vs. Nominal Capacity 1948-2010



Source 9: "Statistical Report" Israel Electric Corporation, 2010.

2.

Figure 11 Natural Gas Infrastructure in Israel

Source 10: Popper, Steven W. *Natural Gas and Israel's Energy Future : Near-Term Decisions from a Strategic Perspective* [in English and Hebrew.]. Santa Monica, CA: RAND, 2009.

3.

Table 1 IEC Electricity Production by Power Plant and Primary Type of Fuel (Million kWh)

Power Plant	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Steam Units:										
Haifa	1,871	1,709	1,838	1,576	1,430	1,739	1,562	1,501	562	127
Reading	2,014	1,581	1,926	1,761	1,703	1,765	2,485	2,812	1,923	2,026
Eshkol	4,448	3,794	3,786	5,598	6,445	5,532	5,587	6,650	4,331	3,800
Orot Rabin	18,854	18,654	19,222	19,256	19,186	19,709	19,595	18,518	18,051	18,409
Rutenberg	14,045	16,418	16,833	17,197	16,942	16,027	17,652	16,869	16,306	15,858
Gas Turbines (Gas)	489	1,085	395	296	910	814	986	1,018	1,114	2,243
Combined Cycle (Gas)	398	520	1,512	1,204	1,651	4,674	5,631	7,027	10,776	13,640
Total	42,119	43,761	45,512	46,888	48,267	50,260	53,498	54,394	53,062	56,102
thereof:										
Gas Units	-	-	-	4,248	5,597	9,085	10,569	14,158	17,298	20,527
Coal Units	32,899	35,072	36,055	36,453	36,127	35,658	37,247	35,387	34,302	34,243
Fuel Oil Units	8,333	7,084	7,550	4,687	3,981	2,880	1,720	1,618	642	492
Gas Oil	887	1,605	1,907	1,500	2,561	2,637	3,962	3,231	820	840

Source 11: "Statistical Report" Israel Electric Corporation, 2010.

4.

Table 2 IEC Expenses 2010

Objective	Expenses (million NIS)	Million USD
Operational budget and fluent maintenance		
Generation system	1580.3	$420.53
Transmission system	280.4	$74.62
Distribution system	1149.3	$305.84
Management and general expenses	606.9	$161.50
R&D and KARAT	7.8	$2.08
Total operational budget	**3,624.7**	**$964.56**
Investments budget		
Generation system	1774	$472.08
Transmission system	505.2	$134.44
Distribution system	1088.1	$289.55
Purchases and other investments	520.8	$138.59
Total investments budget	**3,888.1**	**$1,034.66**
Fuel budget		
Fuel oil	234.7	$62.46
Coal	4573.9	$1,217.15
Gas oil	1137.5	$302.70
Natural gas	2920.1	$777.06
Total fuel budget	**8,866.2**	**$2,359.37**

Source 12: "IEC Annual Budget 2010." Israel Electric Corporation, http://www.iec.co.il/EN/IR/Pages/budget0308-6615.aspx.

Table 3 IEC Fuel Purchases 2010 (millions of tons)

Coal	12.3
Natural Gas	3.3
Diesel Oil	0.2
Fuel Oil	0.1

Source 13: "Fuels." The Israel Electric Corporation, http://www.iec.co.il/EN/IR/Pages/Fuels.aspx.

5. *Memorandum of Agreement between the Governments of the United States of America and Israel – Oil, March 26, 1979*

"The oil supply arrangement of September 1, 1975, between the Governments of the United States and Israel, annexed hereto, remains in effect. A memorandum of agreement shall be agreed upon and concluded to provide an oil supply arrangement for a total of 15 years, including the 5 years provided in the September 1, 1975 arrangement.

The memorandum of agreement, including the commencement of this arrangement and pricing provisions, will be mutually agreed upon by the parties within sixty days following the entry into force of the Treaty of Peace between Egypt and Israel.

It is the intention of the parties that prices paid by Israel for oil provided by the United States hereunder shall be comparable to world market prices current at the time of transfer, and that in any event the United States will be reimbursed by Israel for the costs incurred by the United States in providing oil to Israel hereunder.

Experts provided for in the September 1, 1975 arrangement will meet on request to discuss matters arising under this relationship.

The United States administration undertakes to seek promptly additional statutory authorization that may be necessary for full implementation of this arrangement.

M. Dayan For the Government of Israel

Cyrus R. Vance For the Government of the United States

Annex to the Memorandum of Agreement concerning Oil
ANNEX

Israel will make its own independent arrangements for oil supply to meet its requirements through normal procedures. In the event Israel is unable to secure its needs in this way, the United States Government, upon notification of this fact by the Government of Israel, will act as follows for five years, at the end of which period either side can terminate this arrangement on one-year's notice.

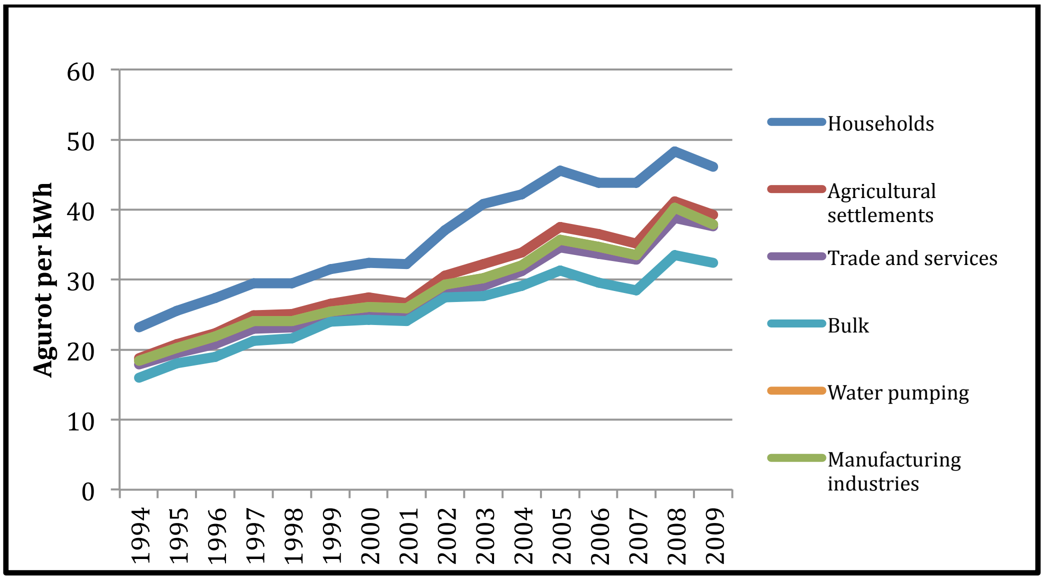
(a) If the oil Israel needs to meet all its normal requirements for domestic consumption is unavailable for purchase in circumstances where no quantitative restrictions exist on the ability of the United States to procure oil to meet its normal requirements, the United States Government will promptly make oil available for purchase by Israel to meet all of the aforementioned normal requirements of Israel. If Israel is unable to secure the necessary means to transport such oil to Israel, the United States Government will make every effort to help Israel secure the necessary means of transport.

(b) If the oil Israel needs to meet all of its normal requirements for domestic consumption is unavailable for purchase in circumstances where quantitative restrictions through embargo or otherwise also prevent the United States from procuring oil to meet its normal requirements, the United States Government will promptly make oil available for purchase by Israel in accordance with the International Energy Agency conservation and allocation formula, as applied by the United States Government, in order to meet Israel's essential requirements. If Israel is unable to secure the necessary means to transport such oil to Israel, the United States Government will make every effort to help Israel secure the necessary means of transport.

Israeli and United States experts will meet annually or more frequently at the request of either party, to review Israel's continuing oil requirement."[126]

6.

Figure 12 Average Price of IEC Electricity by Sector (Agurot per kWh)



Source 14: "Electricity: Average Price of Electricity by Sector." Israel Central Bureau of Statistics. http://www1.cbs.gov.il/energy/

7.

Figure 13 BTC Pipeline

Source 15: "The Baku-Tbilisi-Ceyhan Pipeline: Oil Window to the West." edited by S. Frederick Starr and Svante E. Cornell. Uppsala, Sweden: Central Asia-Caucasus Institute Silk Road Studies Program, 2005.

8.

Table 4 Coal in Electricity Generation (2008, 2009)

South Africa	93%	Kazakhstan	70%	Morocco	55%
Poland	90%	India	69%	Greece	55%
PR China	79%	Israel	63%	USA	45%
Australia	76%	Czech Rep	56%	Germany	44%

Source 16"Coal in Electricity Generation." World Coal Association, http://www.worldcoal.org/resources/coal-statistics/.

9.

Table 5 IEC Coal Imports 2011 (thousand metric tons)

South Africa	3,337
Colombia	5,591
Russia	1,711
Other	1,836
Total	**12,475**

Source 17 Email Correspondence with Ronnie Granot Kohen of the National Coal Supply Corporation. Email, February 27 2012.

10. "Our Central Values Are:

Achievement of high standard of service

Adherence to the contract between the company and it customers, adherence to schedules , provision of professional guidance and advice to our customers and flexibility in response to the public's requirements.

Achievement financial strength

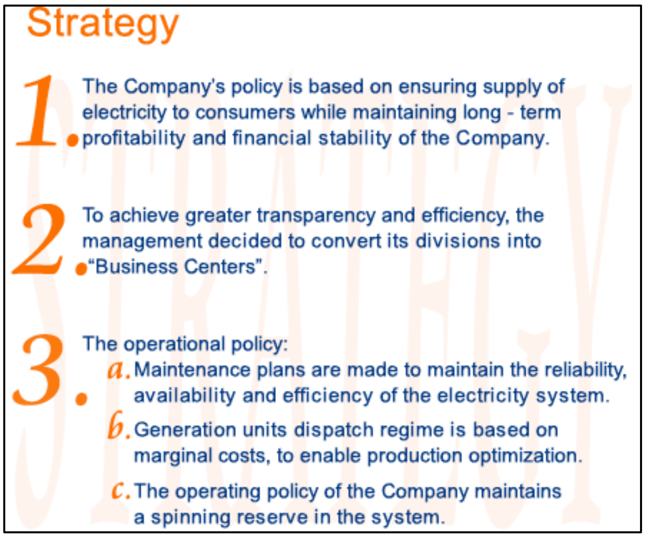
Increase of the sense of competition, increase of the productivity, profitability, introduction of technological improvements, and search for additional market sectors.

Cultivation of human resources

Increase of the professional standard of our workers with constant training and education, motivate our employees, encourage them to take initiative and excel, promote the growth of managers from within the ranks, ensure work conditions and appropriate remuneration, while paying special attention to the social well-being of the worker and his family.

Awareness of national and communal responsibility

Take action for the preservation of the environment, contribute to projects in the community, ensure public safety, support and encourage local industry, realization of the technological advancement and assist in shaping energy policy in the country and in the Middle East."[127]



[128]

11.

Table 6 Calculation for Negev Solar Potential (land)

Israel total land area	21,671 sq km
Negev land area (~ half of total)	10835.5 sq km
Negev land suitable for solar	350 sq km
Percent of Negev suitable for solar	3%

Source 18: Rebecca Yasner, data from: "Policy on the Integration of Renewable Energy Sources into the Israeli Electricity Sector." The State of Israel: Ministry of National Infrastructures (now Ministry of Energy and Water Resources), 2010.

12.

Table 7 Arava Power Company Solar Plant Specifications at Kibbutz Ketura

Field Area	8 hectares
Number of Suntech Solar Panels	18,500
Installed Capacity	4.95 MW
Cost	100 million NIS
Jobs Created	~70

Source 19: "Ketura Sun." Arava Power Company, http://www.aravapower.com/Technical%20Figures

Appendix B: Environmental Impact Items

1.

Table 8 CO2 Emissions from Renewables vs Base Case Scenario

Renewables	CO_2 emitted g CO_2/kWh	Projected Generation in 2020 (twh)	Projected Generation in 2020 (kwh)	Total CO_2 emitted (grams)	Total CO_2 emitted (tons)	Total CO_2 emitted (million tons)
Solar thermal and "large" PV	70	4.5	4500000000	315000000000.00	347231.5277	0.347231527650000
"Small" Solar PV (up to 50 kwh)	70	0.63	630000000	44100000000.00	48612.41387	0.048612413871000
"Medium" PV	70	1.2	1200000000	84000000000.00	92595.07404	0.092595074040000
Wind	4.64	3.7	3700000000	17168000000.00	18924.66942	0.018924669418080
Base case without renewables						
Conventional Electricity Generation (IEC 2007)	800	64.3	64300000000	51440000000000.00	56703459.63	56.7034596264000000
Y-PIRES						
IEC Conventional Electricity Generation (80% of total generation)	800	51.44	51440000000	41152000000000.00	45362767.7	45.3627677011200000
Renewables (20% of total generation + biomass w/o emissions calculated)	(See above)	12.86	12860000000	460268000000.00	507363.685	0.507363684979080
					Percent reduction of emissions with Y-PIRES	**19.10523%**

Source 20: "Policy on the Integration of Renewable Energy Sources into the Israeli Electricity Sector." The State of Israel: Ministry of National Infrastructures (now Ministry of Energy and Water Resources), 2010. Tumbale, Spencer, and Vyshaali Jagadeesan. "Solar V.S Wind Energy." https://sites.google.com/site/anatomyofglobalclimatechangevj/data-and-analysis. Personal Communication with Elnatan Samuel Fuhrman. April 15 2012.

2. **Abatement of Nuisances Law 5721-1961**
   "Prevention of air pollution
   4. (a) A person shall not cause any considerable or unreasonable pollution of the air, from any source whatsoever, if the same disturbs, or is liable to disturb, a person in the vicinity or a passerby.
   (b) Air pollution, for the purposes of this section – pollution by smoke, gas, fumes, dust or the like.
   Rules of implementation
   5. The Minister shall, by regulations, make rules for the implementation of sections
   2-4, and he may, inter alia, define what constitutes considerable or unreasonable

noise, odor or air pollution."[129]

3. **Abatement of Nuisances Regulations 5722-1962**
"1. In these Regulations –
"Smoke" – includes ash, soot, steam, gas and dust created by burning, or by incomplete burning, in an open fire, in a stove or in any burning installation;
"Black smoke" – shade 2 smoke in the "Ringelmann" or "Micro-Ringelmann" smoke measurement chart or dark smoke from it.
2. Emission of black smoke into the public domain or into the domain of others is unreasonable air pollution.
5. A person shall not cause or permit to be caused an emission of black smoke from his premises into the public domain or into the domains of others."[130]

4. **Abatement of Nuisances Regulations (Air Quality) 5752-1992**

Column A

Serial no.	Pollutant	Chemical formula
1.	Ozone	O_3
2.	Sulfur Dioxide	SO_2
3.	1,2 Dichloroethane	CH_2ClCH_2Cl
4.	Dichloromethane	CH_2C1_2
5.	Toluene	C_7H_8
6.	Tetrachloroethylene	C_2C1_4
7.	Trichloroethylene	C_2HC1_3
8.	Hydrogen Sulfide	H_2S
9.	Styrene	C_8H_8
10.	Formaldehyde	CH_20
11.	Carbon Monoxide	CO
12.	Nitrogen Oxides (as NO_2)	NO_x

Column A

Serial no.	Pollutant	Chemical formula
1.	Suspended Particulate Matter	
2.	Respirable Particulate Matter, the diameter of whose particulates is less than 10 micrometers	
3.	Vanadium (in suspended particulate matter)	
4.	Sulfate Salts	SO_4
5.	Phosphate (in Suspended Particulate Matter)	P_2O_5
6.	Lead (in Supended Particulate Matter)	Pb
7.	Cadmium (in Suspended Particulate Matter)	Cd

Serial no.	Pollutant	Chemical formula
1.	Settling Dust	
2.	Phosphate	P_20_5

[131]

5. **Clean Air Regulation Permits 2010**
"**Process survey**: survey of all processes, materials, activities, emission sources and facilities for the reduction of pollutant emissions of pollutants;
Emission survey: survey of pollutants and the rate of their emissions from both point sources and non-point sources (fugitive emissions);
Environmental survey: survey to assess air quality in the vicinity of the emission source, including more distant areas which may be impacted by pollutant emissions. The survey will relate to existing pollutant emissions and future emissions once best available techniques are implemented, in comparison to ambient, reference and target values.

Gap analysis: analysis of gaps in the emission source in comparison to best available techniques as presented in the BREFS, in relation to environmental management policy, energy efficiency, treatment and reduction technologies, procedures and maintenance, handling of failures and emergencies, sampling and monitoring, and reporting.
Selection of best available techniques (BAT): information on BATs proposed in the BREFS which will bring about maximum emissions reduction.
Implementation plan: plan for the implementation of the BAT chosen.
Measures during high air pollution events: information on measures to be taken during a public alert about high air pollution levels."[132]

6.

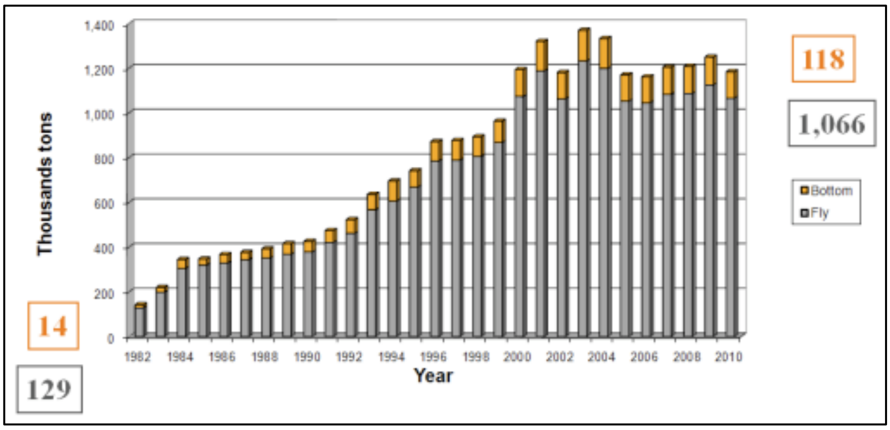
Figure 14 IEC Combined Cycle Current Plants and Future Plans

Current Power Plants with Open/Combined Cycle	Capacity (MW)	Year	Type
Ramat Hovav	1x120	1999	HRSG+ Steam turbine+ Air Cooled Condenser
Hagit (units 7&8)	1x120	2002	HRSG+ Steam turbine+ Air Cooled Condenser
Eshkol	1x370	2003, 2005	2 Shafts configuration - seawater cooled
Alon Tavor	1x370	2004, 2008	2 Shafts configuration - Treated waste water cooled
Gezer (units 3&4)	2x370	2005, 2007. 2006, 2008	1 Shaft configuration - Treated waste water cooled
Hagit (unit 2)	1x370	2007	1 Shaft - Air cooled
Future Power Plants with Open/Combined Cycle	**Capacity (MW)**	**Year**	**Type**
Tzafit (units 3&4)	1x370	2006, 2013	2 Shafts configuration - Air cooled
Haifa (units 3&4)	2x370	2010, 2011	N/A
Hagit (unit 9)	1x370	2010, 2013	2 Shafts- Air cooled
Ramat Hovav (units 8&9)	1x370	2010, 2013	3 Shafts- Air cooled
Eshkol (units 3&4)	3x370	2010, 2013	2 Shafts- Seawater cooled
Alon Tavor (units 5&6)	1x370	2012	2 Shaft - Air cooled"

Source 21: "Combined Cycles- List." Israel Electric Corporation (IEC), http://www.iec.co.il/EN/BusinessDevelopment/Pages/CombinedCyclesList-.aspx

7.

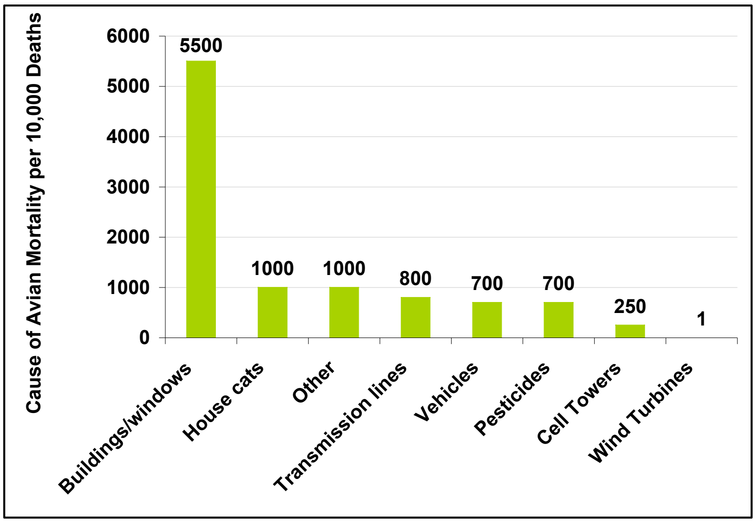
Figure 15 IEC Coal Ash Production



Source 22: "Coal Ash Production." Israeli National Coal Ash Board (NCAB), http://www.coal-ash.co.il/english/info.html

8.

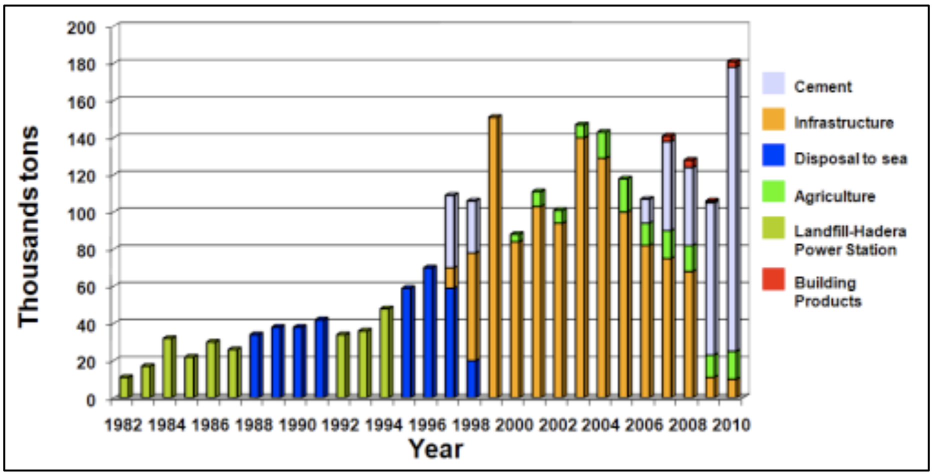
Figure 16 Wind Turbine Avian Mortality



Source 23: Samaras, Costa. "Innovative Technologies Case Study: Wind and Solar Electricity." 2009.

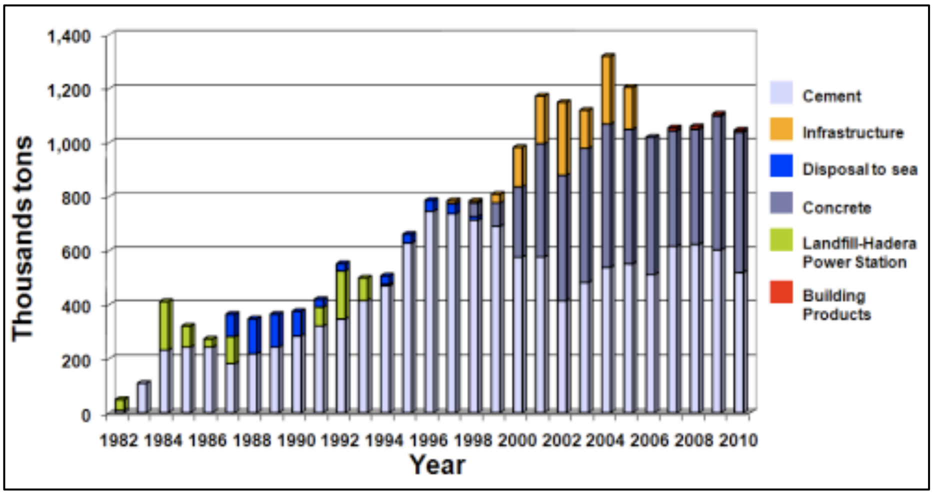
9.

Figure 17 Bottom Ash Uses



Source 24: "Coal Ash Uses." Israeli National Coal Ash Board (NCAB), http://www.coal-ash.co.il/english/info_uses.html.

Figure 18 Fly Ash Uses

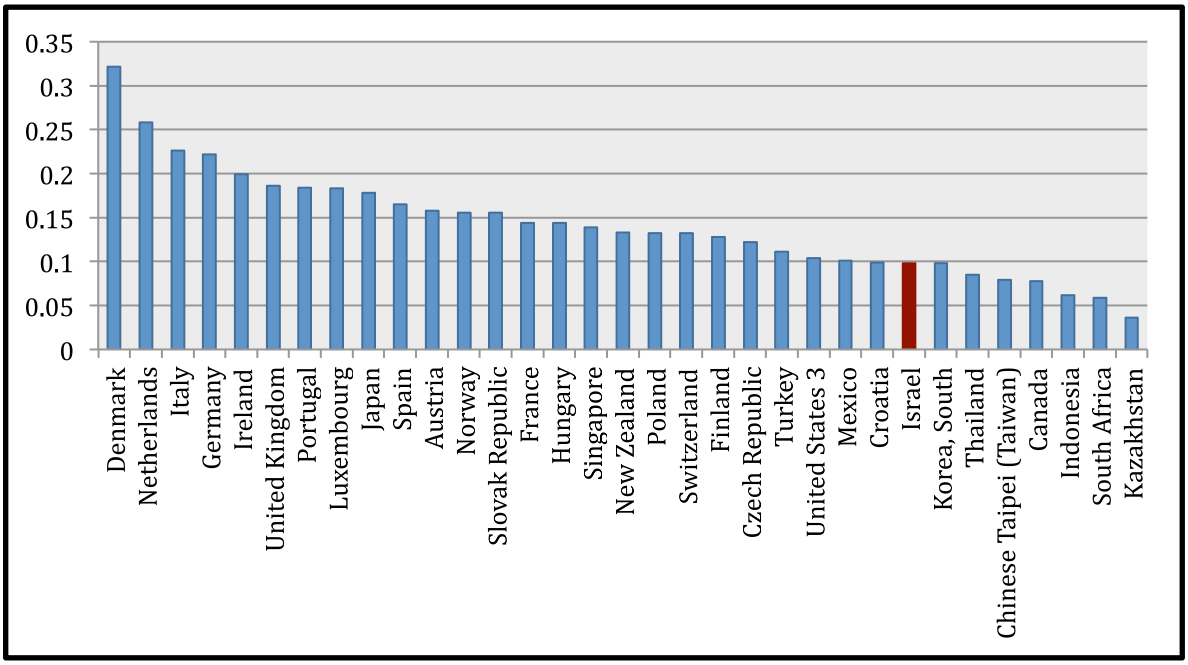


Source 25: "Coal Ash Uses." Israeli National Coal Ash Board (NCAB), http://www.coal-ash.co.il/english/info_uses.html.

Appendix C: Economic Development Items

1.

Table 9 Electricity Prices (USD/kwh)



Source 27: "International Electricity Prices and Fuel Costs." U.S. Department of Energy U.S. Energy Information Administration, [http://www.eia.gov/emeu/international/electricityprice.html.](http://www.eia.gov/emeu/international/electricityprice.html)

Appendix D: Yasner-Modified Policy on the Integration of Renewable Energy Sources into the Israeli Electricity Sector (Y-PIRES)

MINISTRY OF NATIONAL INFRASTRUCTURES

YASNER- MODIFIED POLICY ON THE INTEGRATION OF RENEWABLE ENERGY SOURCES

INTO THE ISRAELI ELECTRICITY SECTOR

February 14, 2010

Deletions and Modifications by Rebecca Yasner

May 2012

A. INTRODUCTION AND SUMMARY OF RECOMMENDATIONS

Objective:

The Ministry's policy is designed to promote intensive development and integration of renewable energy sources in Israel's energy sector. Such efforts are aimed at promoting Israel's energy independence and security, ~~and~~ reinforcing a culture of environmental awareness, and stimulating economic growth. These goals will be achieved by leveraging advancements in Israeli industry and technology, in addition to engaging Israel's main electricity provider, the Israel Electric Corporation (IEC), with one of Israel's largest electricity consumers, the Israeli Defense Forces (IDF). At the same time, these goals will provide sources of income for the public, especially in outlying areas.[i]

The policy is intended to optimally implement Government Resolution No. 4450 (SE/176) concerning the generation of electricity from renewable energy sources.

The aim of this document is to set forth the measures to be taken by the Ministry of National Infrastructures to advance this policy.

Principles guiding the Ministry of National Infrastructures' policy on renewable energy:

- ✓ Creating certainty in the area of renewable energy, and solidifying the electricity generation targets by 2020.
- ✓ Encouraging the deployment of electricity generating installations based on renewable energy in Israel in general, and in the outlying areas of the country in particular.
- ✓ Promoting the renewable energy industry in Israel and encouraging Israeli research and development in the area of renewable energy sources.
- ✓ Increasing Israel's energy security.
- ✓ Encouraging generation of electricity from environmentally friendly technologies.
- ✓ Increasing the generation of electricity from renewable energy sources and minimizing the cost burden on consumers.
- ✓ Generating a dynamic model that will adapt continuously according to the penetration of renewable energy technologies and their techno-economic improvements.
- ✓ Shifting the role of the IEC from a utility provider to a service provider
- ✓ Incorporating the IDF into the planning process such that the IDF has the opportunity to generate its own electricity from renewable sources to further direct electricity security
- ✓ Outlining stipulations for environmental impact statements of renewable electricity technologies for air, land, and water pollution

Government resolutions

The target for generation of electricity from renewable energy sources: Government Resolution No. 4450 (SE/176) of January 29, 2009 set a target for generation of ~~10%~~ 20% of Israel's electricity needs from renewable energy sources by 2020. The same resolution stated that steps must be taken to construct power stations at an annual rate of not less than 250 MW per year, as of 2010.

In that resolution, "renewable energy" is defined as energy derived from the utilization of solar radiation, wind, biogas and biomass or another inexhaustible source that is not fossil fuel.

The energy efficiency[ii] target for 2020: Resolution No. 4450 was preceded by Government Resolution No. 4095, dated September 1, 2008, and by Resolution No. 3261 (SE/69), dated

[i] "Outlying areas" – cities, towns and settlements that are defined as located in national priority areas, in accordance with a resolution by the Government of Israel dated December 13, 2009.

[ii] Energy efficiency" – an all-inclusive term for actions intended to reduce electricity consumption.

January 29, 2009, which decided on a series of energy efficiency measures to reduce electricity consumption by 20% of the electricity consumption forecast for 2020.

The target for generation of electricity from renewable energy sources in 2020, assuming increased energy efficiency:
~~6.43~~ 12.86 terawatt-hour (TWh)

<u>Forecast installed capacity and forecast electricity generation from renewable energy sources</u>

Following are the biennial milestones (forecast installed capacity with renewable energy technologies) set out by the Ministry of National Infrastructures, in order to comply with the electricity generation target of ~~6.4~~ 12.77 TWh from renewable energy sources in 2020. These milestones are based on the demand forecast and on increased efficiency rates by 2020.

Table 1

<u>Forecast installed capacity from renewable energy sources, according to technology (MW installed): milestones for 2014-2020</u>

	2014-2015	2016-2017	2018-2019	2020	Percentage of installed capacity (%)
Energy efficiency target: percentage of the demand forecast (%)	7	12	17	29	
Estimate of demand forecast including energy efficiency (TWh)	60.4	61.5	64.5	64.3	
Wind (MW) [3]	250	~~400~~ **800**	~~600~~ **1200**	~~800~~ **1600**	29
Biogas and biomass (MW)	50	~~100~~ **200**	~~160~~ **320**	~~210~~ **420**	7.6
Thermo-solar or "large" photovoltaic[4] (MW)	700	~~750~~ **1500**	~~1000~~ **2000**	~~1200~~ **2400**	43.5
"Medium" photovoltaic[5] (MW)	350	~~350~~ **700**	~~350~~ **700**	~~350~~ **700**	12.7
Photovoltaic up to 50 kW (MW)	200	~~200~~ **400**	~~200~~ **400**	~~200~~ **400**	7.2
Total installed capacity (MW)	**1550**	~~1800~~ **3600**	~~2310~~ **4620**	~~2760~~ **5520**	
Percentage of generation from renewable energy sources (%)	**5.30%**	**13.00%**	**16.60%**	**20.40%**	100%
Estimate of the land area required according to the installed capacity forecast: ~ 3380 hectares[6]					

Note that the Ministry of National Infrastructures' policy on the integration of renewable energy as part of the development plan for Israel's long-term electricity sector will be reviewed and revised in 2014, in accordance with technological and economic developments and with changes in the demand forecast.

[3] Electricity generation installations using wind energy connected to the distribution and/or transmission grid.
[4] Electricity generation installations connected to the transmission grid.
[5] Electricity generation installations using all types of solar technologies connected to the distribution grid
[6] Estimate of land requirement for wind energy refers to the net land requirement (turbine base only).

Table 2

Forecast of electricity generation from renewable energy sources (TWh)					
	Dec-14	2016-2017	2018-2019	2020	Percent of total generation
Wind (TWh)	0.61	~~0.98~~ **1.96**	~~1.47~~ **2.94**	~~1.96~~ **3.92**	30.04%
Biomass (TWh)	0.33	~~0.66~~ **1.32**	~~1.05~~ **2.1**	~~1.38~~ **2.76**	21.10%
Thermo-solar or "large"photovoltaic[1] (TWh)	1.33	~~1.43~~ **2.86**	~~1.9~~ **3.8**	~~2.28~~ **4.56**	34.87%
"Medium" photovoltaic (TWh)	0.6	~~0.6~~ **1.2**	~~0.6~~ **1.2**	~~0.6~~ **1.2**	9.10%
Photovoltaic up to 50 kW (TWh)	0.32	~~0.32~~ **0.64**	~~0.32~~ **0.64**	~~0.32~~ **0.64**	4.89%
Total actual energy generation (TWh)	**3.19**	~~**3.99**~~ **7.98**	~~**5.34**~~ **10.68**	~~**6.54**~~ **13.08**	100%

Policy highlights

"Identifying and developing electricity generation clusters" – the Ministry of National Infrastructures is taking steps to establish clusters of electricity generation units from renewable energy sources. The Ministry has undertaken preliminary mapping of lands in the Negev area, and accordingly, sites have been identified that are not in military firing zones or nature reserves and/or not incorporated in existing outline plans. Concentrating several factors of production in a continuous cluster will minimize open stretches of land affected and facilitate energy transmission. The Ministry will promote the deployment of electricity generation clusters in collaboration with the Israel Land Administration, the planning authorities and the relevant Government Ministries.

In addition, the Ministry of National Infrastructures will identify existing infrastructure such as commercial buildings and residential areas that can be used as renewable electricity generation sites throughout Israel. The IEC, under direction from the Ministry and the PUA-E, will collaborate with the IDF to install renewable electricity technologies in areas convenient for distribution to IDF bases. The IEC will also collaborate with other large and small electricity consumers to install renewable electricity generating technologies close to or in consumption sites. The IEC will begin its transition from a utility provider of electricity to a service provider of reliable, renewable, electricity distribution by managing the variability of said renewables among producers and consumers via internet technology and smart grid management.

Note: The Ministry of National Infrastructures will emphasize a fully distributed electricity generation system from renewable sources to local IPP's in order to reduce transmission needs by locating generation sites directly on consumption sites such as in residential or commercial areas.

"Generation of electricity using wind energy technologies" – the feasibility of generating electricity from wind energy technologies is relatively high compared to other renewable energy technologies. However, statutory barriers and complex planning procedures stand in the way.

- The Ministry has surveyed "exploration areas" in the Negev for generating electricity from wind energy, based on requests from entrepreneurs for wind regime measurements. The Ministry is working with the Ministry of Defense, the Nature and Parks Authority, and the planning authorities to remove planning and implementation barriers in these areas.
- The Ministry is cooperating with the Israel Land Administration to move ahead with a land tender to erect wind measurement masts.

"Biogas and biomass" – the Ministry considers the **various kinds** of biogas technologies as important in achieving the electricity generation target. Gasification and waste incineration technologies have a clear advantage, even in the short term: high energy efficiency, land use efficiency, savings in transmission costs and recycling of waste.

- The Ministry is working with the Tax Authority to introduce accelerated depreciation of 25% on electricity generation installations at wastewater treatment plants and at sanitary landfills. Applying accelerated depreciation at these installations will encourage their construction in view of the steep deployment costs.
- The Ministry is working with the Ministry of Environmental Protection to promote such installations at sanitary landfills.

"An exclusively Israeli workforce" – electricity producers will be required to employ local Israeli personnel only.

"Amendment to the Encouragement of Capital Investments Law" – offers concessions by virtue of the Law to the renewable energy industry (with no generation component) based on original "**know-how**" in the field, pursuant to the approval of the Chief Scientist in the Ministry of National Infrastructures.[7] The Ministry is also working with the Ministry of Industry, Trade and Labor to extend the benefits under the Law to apply also to installations generating electricity from renewable energy sources.

In addition, a recommendation for tax benefits (reduction of direct taxes – corporate and dividend tax) will be brought before the Ministry of Finance for approval. The benefits will be granted to renewable energy companies that are not exporters, as required by law, and that have added value for Israel (employment, intellectual property and ownership) of 70% or more.

"Tariff" – this is one of the important components in the implementation of Government resolutions promoting the Ministry of National Infrastructures' policy. The tariff serves as a tool for encouraging investors to enter the sector, to introduce technological improvements and to increase the energy efficiency of installations that generate electricity from renewable energy sources. The relevant tariffs for advancing the policy of the Ministry of National Infrastructures will be set by the Public Utility Authority – Electricity. Tariffs up until 2015 will be gradually reduced; tariffs for the remaining period, up to and including 2020, will be published no later than 2014.

In addition, the Ministry, in collaboration with industry and academic leaders in the field, will conduct a study to more fully understand the economic incentives for Israeli Cleantech companies to go abroad with their technologies. The aim of this endeavor is to apply those incentives of technology export to the domestic electricity system such that Israeli Cleantech companies will employ their technologies in Israel in addition to foreign markets.

[7] Encouragement of Capital Investments Law, 5719-1959.

Table 3

Quotas for renewable technologies (MW installed capacity)				
Technology	Description	Type of allocation	Total allocation (MW installed)	Time frame
Thermo-solar or **"large" photovoltaic**	Quota for solar electricity generation installations connected to the transmission grid	Quota	700	Until Dec. 2014
			500	2015-2020
"Medium" photovoltaic	Quota for solar electricity generation installations connected to the distribution grid in industrial zones in outlying areas, by means of Israel Land Administration tenders	Quota	50	Until 2020
	Quota for solar electricity generation installations connected to the distribution grid through the use of technologies such as photovoltaic technology	Existing quota	300	
Photovoltaic up to 50 kW (roofs)	No quota limitation in the outlying areas*.	"Open" quota (roofs)	No limit	Until Dec. 2014
Photovoltaic up to 4kW (roofs)	No quota limitation throughout Israel.		No limit	
Photovoltaic up to 50 kW (roofs)	Quota for deploying installations on roofs of public buildings in general, and educational institutions in particular	Quota (roofs)	30	Until 2020
	Quota for deploying installations (throughout Israel except outlying areas, on public buildings)		50	
Photovoltaic up to 50 kW (roofs)	Quota for residents of Judea and Samaria (according to their proportion of the population) who are prevented from making use of the quotas allocated to date for installations that have this installed capacity, because the Civil Administration has not issued permits allowing them to sell electricity to the grid**		2	
Wind	Quota for installations generating electricity from wind energy, connected to the distribution and transmission grid No quota limitation throughout Israel.	"Open" quota	No limit	Until Dec. 2014
Wind – up to 50 kW	No quota limitation throughout Israel.			
Biogas and biomass	No quota limitation throughout Israel.			
R&D in renewable energy sources	Quota for encouraging Israeli technologies in order to promote R&D projects in Israel, on the recommendation of the Chief Scientist in the Ministry of National Infrastructures	Quota	50	Until 2020

* **Outlying areas:** a map of cities, towns and settlements defined as situated in areas of national priority, under Government Resolution No. 1060 of December 13, 2009, can be viewed on the website of the Prime Minister's Office: www.pmo.gov.il

** It is important that this quota be in accordance with the tariff set by the Public Utility Authority–Electricity, in the regulations of 2008, for installations with that installed capacity.

- **Total discounted additional costs for 2010, as a result of the integration of renewable energy sources from 2010 to 2020, are estimated at $2.06 billion.** ~~**This cost will be reflected in a rise in the electricity tariff for all consumers.**~~ **Studies show that the installation of just solar power generation itself, due to lessened environmental impacts and increased economic benefit, will amount to between $125-$150 million per year.**[8]

  Note: Although the target generating capacity of renewables doubles from 10% to 20% by 2020, the cost over time does not double due to increased efficiency, greater market penetration of renewables by Cleantech companies, involvement of the IEC and the IDF, and the cessation of large upfront costs within the first few years of installation.

- In the estimation of the Ministry of National Infrastructures, the consumer tariff will be raised if technological improvements are not made and/or the deployment costs for renewable energy installations are not reduced. **The cumulative increase in the electricity tariff from 2010 to 2020, as a result of the integration of renewable energy sources, is estimated at 18%. While this price increase may seem steep, electricity prices in Israel, when compared to electricity prices in other countries, are extremely low. Thus, this price increase will not only reflect the more accurate cost of electricity, but will also help increase energy efficiency measures.**

[8] Mor, Amit, Shimon Seroussi, and Malcom Ainspan. "Large Scale Utilization of Solar Energy in Israel-Economic and Social Impacts." 2005.

B. ISRAEL'S ELECTRICITY SECTOR: TRENDS AND CHARACTERISTICS

Israel's total electricity generation capacity in ~~2009~~ 2010 was estimated at approximately ~~11,940~~ 12,987 MW installed.[9] Almost all the electricity in Israel is generated by the Israel Electric Corporation, by power stations using a mix of fuels: coal, natural gas, heavy fuel oil and diesel fuel.

The State of Israel is an "electricity island". There are no imports or exports of electricity between Israel and its neighboring countries. This reality requires that Israel ensure the high availability and reliability of its energy sources, much more so than other countries. The Israel Electric Corporation imports the vast majority of fuels for electricity generation.

B.1. General data[10]

- ✓ In 2008, electricity generation totaled 54.5 TWh.
- ✓ Electricity consumption in 2008 amounted to 50.16 TWh per year.[11]
- ✓ Peak demand in the winter of 2008 stood at 10,200 MW. Electricity reserves in 2008 totaled 4.8% of the nominal capacity (hereinafter: "installed capacity").
- ✓ Over the past decade, Israel's electricity consumption has risen steadily. The electricity consumption growth rate (factoring out the increase in the population) averages at 3.5% a year.
- ✓ The demand forecast for electricity in Israel is high as compared to the corresponding growth in most of the developed countries (OECD countries).
- ✓ In 2009, electricity consumption declined by 2.3%, due to the global economic crisis.
- ✓ In 2010, 61% of electricity generated by the IEC came from coal, 36.6% from natural gas, 1.5% from diesel oil, and 0.6% from fuel oil.[12]

B.1.a. Main reasons for increased electricity consumption beyond population growth levels:

- Rising living standards, along with the falling prices of electrical appliances.
- An upward trend in the use of electricity, along with a downward trend in the use of other energy sources, such as diesel fuel.

In the energy sector, the trend is to strike a balance between wanting to meet the demand for electricity on one hand, and restraining demand by increasing energy efficiency on the other. The measures, directed at electricity consumers, focus on regulating consumption at times of peak use. These measures include public information campaigns, regulatory activity and legislation, and differential pricing according to time of use.

It is important to note that there is a cost for "non-supply of electricity" to the economy. Several estimates of the cost of non-supply of electricity have been made over the years. In August 2007, a report by an external consultant estimating the cost at $25 per kilowatt-hour of non-supply of electricity was submitted to the Ministry.[13] This cost accentuates the need to maintain suitable electricity generation reserves in Israel's electricity sector.

---

[9] "Paving the Way for the Mediterranean Solar Plan: Country Report Israel." Consortium MVVdecon/ENEA/RTE-I/Sonelgaz/Terna, 2011.

[10] Statistical Report for 2008, Israel Electric Corporation.

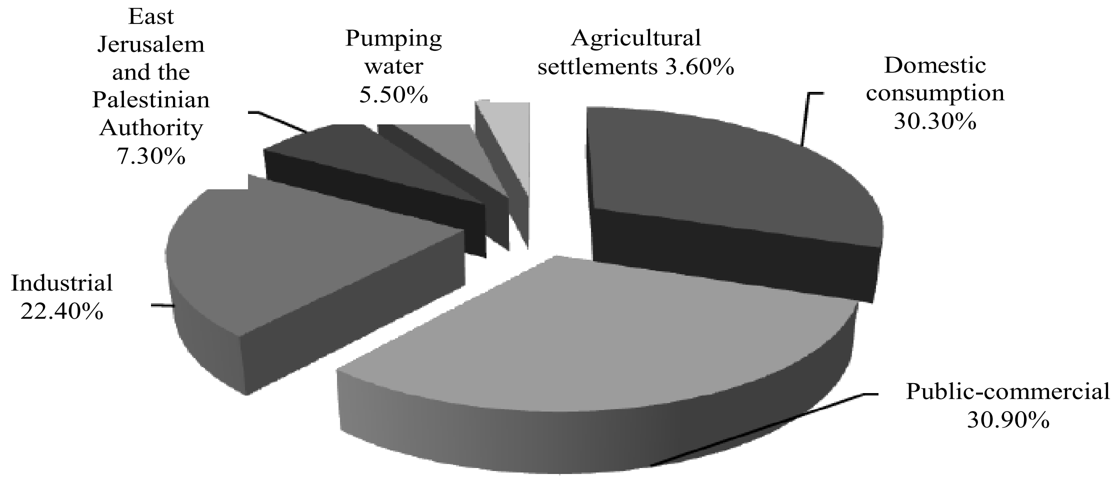
[11] The discrepancy between electricity consumption and electricity generation is partially due to own consumption by electricity generation installations and energy losses during transmission.

[12] "Fuels," The Israel Electric Corporation, http://www.iec.co.il/EN/IR/Pages/Fuels.aspx.

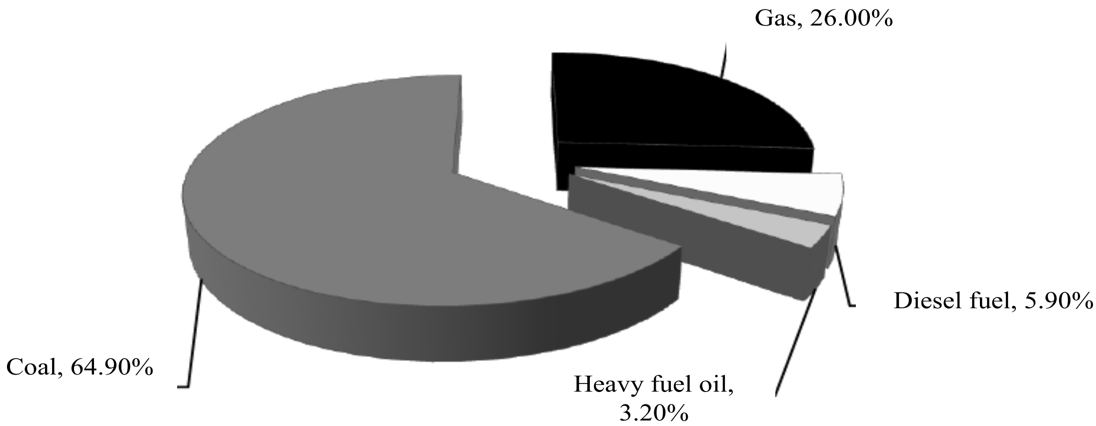
[13] State Comptroller, Annual Report 59B for 2008.

B.1.b. Electricity consumption and fuel mix in 2008

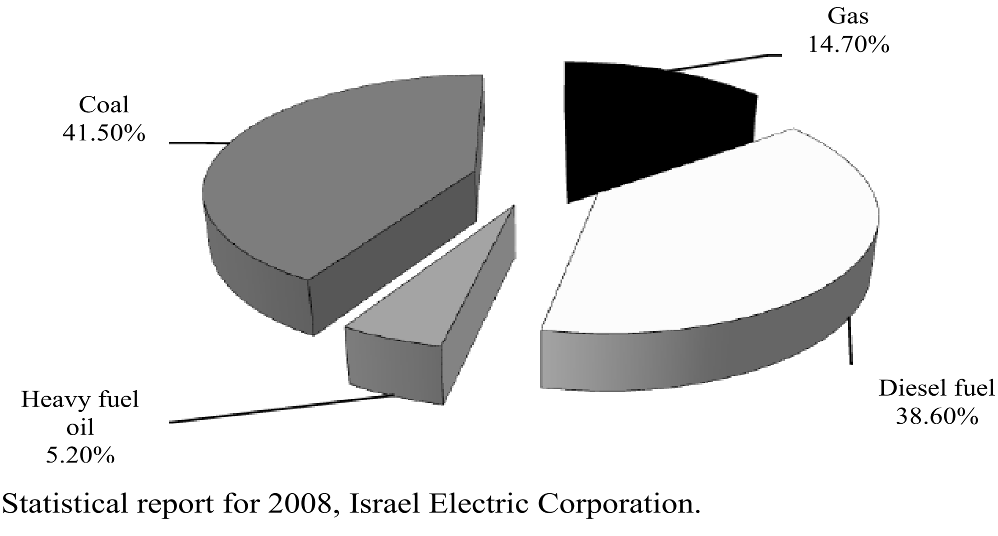
Distribution of electricity consumption by consumer type in 2008



Annual electricity generation by fuel type for 2008



Nominal capacity of the electricity generation system by fuel type in 2008



Source: Statistical report for 2008, Israel Electric Corporation.

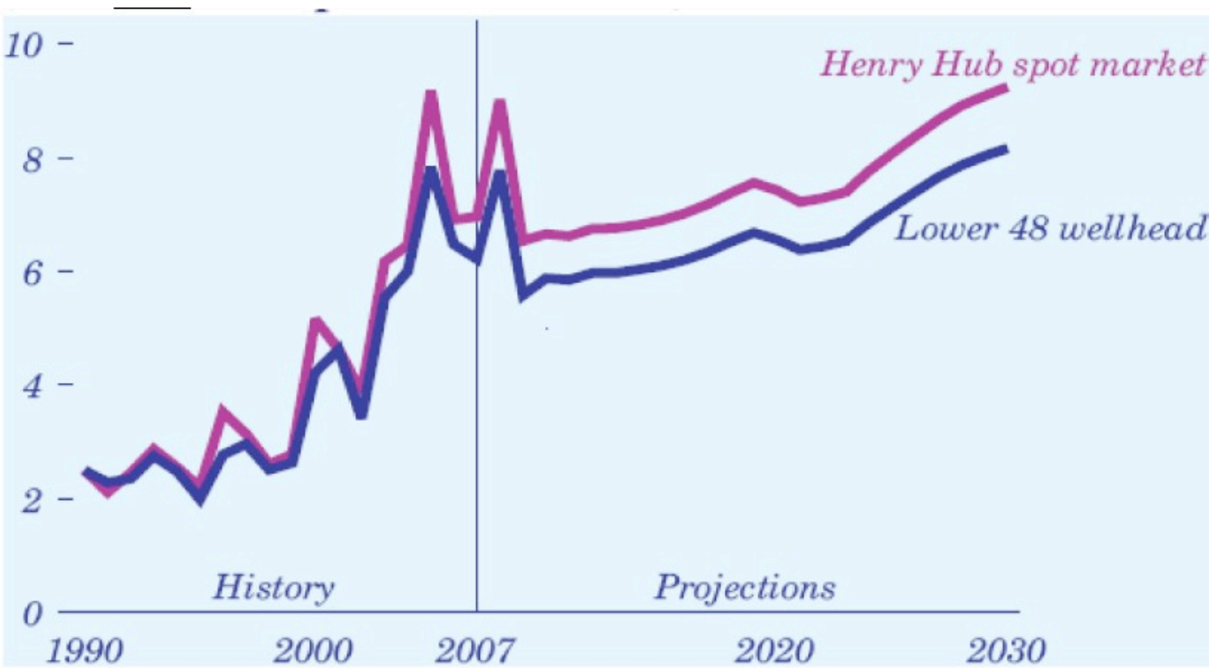
The fuel mix is of decisive importance to Israel's energy security. The more diversified Israel's fuel sources, the less dependent Israel will be on foreign countries and/or on specific fuels. The integration of renewable energy in the fuel "basket" will increase the diversification of sources and strengthen Israel's energy security.

B.1.c. The transition to generating electricity from natural gas

Generating electricity from natural gas is more environmentally friendly than burning coal. Burning coal emits 830g of CO_2 per kilowatt-hour of electricity generated, compared with 600g CO_2 per kilowatt-hour of electricity generated from natural gas. In addition, generating electricity from natural gas emits only 0.1g SO_2 per kilowatt-hour of electricity, compared with 5.2g SO_2 per kilowatt-hour produced by burning coal.

The Ministry encourages increased use of natural gas. At the same time, relying on a single fuel component exposes the energy sector to sharp price fluctuations and increases the energy risk. ~~Moreover, transmission of gas is more susceptible to malfunctions and sabotage than the transportation of coal.~~ While natural gas imports are more susceptible to malfunctions and sabotage, domestic natural gas is a reliable fuel source. The natural gas reserves recently discovered off Israel's coast are projected to last for 40 years.[14] The ability to increase and decrease natural gas combustion for electricity generation pairs perfectly with the need to account for load variability with renewable electricity technologies.

<u>Natural gas contract price projections until 2030 (US$, 2007, per million BTU)</u>



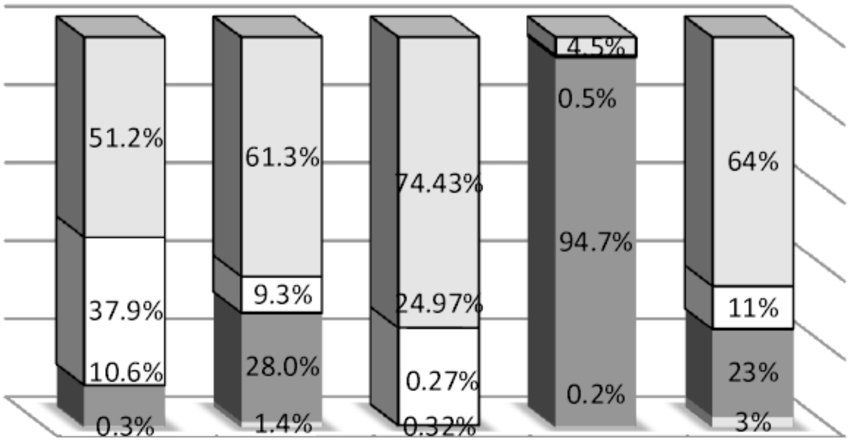
Source: EIA, Energy Outlook 2009

[14] Udasin, Sharon. "Exporting Gas Would Help Economy, Politics." The Jerusalem Post, http://www.jpost.com/Sci-Tech/Article.aspx?ID=262536&R=R1.

B.2. Pollutant emissions

The steady rise in electricity consumption has an environmental cost. Burning fuel to generate electricity with conventional technologies and for the purposes of ground transportation accounts for a considerable proportion of pollutant emissions in Israel. **In 2008,** Greenhouse gas emissions per capita in Israel amounted to 10.69 tons.

<u>Percentage of emissions from fuel combustion, by fuel consumer, 2008</u>



	SPM	NOx	SOx	CO	CO_2
Electricity generation	51.2%	61.3%	74.43%	4.5%	64%
Industry other than electricity generation	37.9%	9.3%	24.97%	0.5%	11%
Ground transportation	10.6%	28.0%	0.27%	94.7%	23%
Domestic and commercial	0.3%	1.4%	0.32%	0.2%	3%

Source: Statistical Abstract for Israel, 2008.

The global trend, in Israel too, is to work towards reducing greenhouse gas emissions. Reducing emissions in the electricity sector and in ground transportation is costly and limited. Nonetheless, as specified below, the Ministry encourages the reduction of greenhouse gas emissions, and environmental considerations play an important role in the decision-making process.

B.2.a. Measures for reducing greenhouse gases and pollutant emissions in the electricity generation in Israel

✓ **Promoting the use of renewable energy:** Israel has been investing resources in reducing greenhouse gas emissions across all sectors of the country's economy. As part of this national effort, the Ministry of National Infrastructures is taking the lead in the area of renewable energy sources in Israel and in promoting their use. In the short term, the contribution of renewable energy sources to the reduction of emissions is limited. Accordingly, investments in renewable energy sources in Israel and worldwide are driven by the vision that future technological improvements in energy storage along with lower future deployment costs for electricity generation systems will lead to greater economic feasibility; and it is this that will bring about the desired reduction in pollutants and greenhouse gas emissions.

- ✓ **Energy efficiency:** reducing the demand for electricity is an efficient way of reducing emissions and is accomplished by various means, including: regulations and standards, such as constraints on the import of energy-hungry appliances; changes in consumption habits, such as installation of energy-saving lighting; and application of advanced management methods for reducing consumption.

- ✓ **Increasing the use of natural gas:** Use of natural gas to generate electricity significantly reduces emissions compared to the use of coal. However, economic and strategic considerations rule out the possibility of basing the fuel mix on natural gas alone.
- ✓ **Technological improvements:** Incorporating advanced means of electricity generation in the development plan for the electricity sector. Installing conventional power stations with higher energy efficiency than that offered by existing technologies (F technology combined-cycle with 56% efficiency). **Examining future "clean coal" technologies, such as IGCC and CCS (Carbon Capture and Storage)**

C. INTEGRATING RENEWABLE ENERGY IN ISRAEL'S ENERGY SECTOR

In setting electricity generation targets, the demand forecast for electricity is a key consideration. In order to formulate a policy that incorporates generation of electricity from renewable energy sources, account must be taken of forecast changes in the energy sector, including the demand forecast, the economic development forecast, the fuel mix, weather scenarios, etc.

The demand forecast for electricity is based on several scenarios. The main variables are weather forecast data, figures on purchases of electrical appliances by the general public, and the economic growth rate. The electricity generation reserve margin for 2014-2015 is expected to be between 1% and 2%, a low margin, highlighting the need to add private electricity producers and renewable energy electricity producers to the equation.

C.1 Main technologies for generating electricity from renewable energy sources

This chapter provides a brief survey of the main electricity generation technologies. Various technologies exist that make use of non-fossil fuels; not all of them, however, are applicable for use in Israel, which does not have abundant sources of water, waves, etc. The main technologies likely to be of practical use to Israel's energy sector are the ones that employ solar, wind and waste energy.

C.1.a. Generating electricity from solar energy sources: photovoltaic cells

- ✓ Photovoltaic cells convert solar energy to electricity.
- ✓ The photovoltaic cell is generally made of a sheet of silicon that separates two electrodes (when the cell is exposed to light, electrons are released between the electrodes, generating an electric current).
- ✓ The efficiency of electricity generation for commercial systems ranges from 12% to 18% of the solar radiation incident on the collectors.
- ✓ The efficiency of photovoltaic cells declines over the years and is adversely affected by cloudiness and heat.
- ✓ The main advantage of this technology is that it utilizes existing infrastructure; the cells can be installed on the roofs of buildings.

C.1.b. Generating electricity from solar energy sources: thermo-solar technology

- ✓ This technology uses "concentrating mirrors" to convert solar energy to heat.
- ✓ The heat is used to generate steam that drives a turbine, which in turn, operates a generator that produces electricity.

Methods for generating electricity using thermo-solar technology:

- ✓ Central receiver – "solar tower". With this technology, the sun's rays are concentrated on a central point at the top of a tower by an array of tracking mirrors with dual-axis control. (Concentrating the sun's rays at the top of the tower generates heat that can exceed 1,000°C. This heat is transferred in a fluid to a heat exchanger and drives a turbine.)
- ✓ Trough – with this technology, a long, concave mirror tracks the sun along one axis and concentrates the radiation onto a pipe containing flowing oil. The oil heats up to about 400°C and then passes through a heat exchanger, where water is converted into steam, to drive a turbine.

C.1.c. Generating electricity from wind energy

Electricity is generated from wind energy by converting kinetic energy in the airflow into mechanical energy. The rotary movement of the turbine rotor is converted into electrical energy by a generator. A single turbine can reach an installed capacity of over 3.5 MW.

C.1.d Generating electricity using hydropower

The movement of water generates hydroelectric power via a turbine connected to a generator. Dams, used to create reservoirs of water with high potential energy, increase the efficiency of hydroelectric power plants by insuring a consistent flow of water to turn the turbines.[15]

Although water shortages and a lack of abundant water resources in Israel limit the capacity of hydroelectric power generation, hydroelectricity currently accounts for more electricity generation than solar power in Israel. While hydroelectric power is not included in the target renewable electricity technologies (see Table 1), research and development of high efficiency-lower environmental impact hydroelectric technologies should be made a priority.

C.1.e Generating electricity using geothermal power

Geothermal power is energy stored in the earth's core in the form of underground magma, steam, hot rocks, and hot water deposits. If these deposits are near the surface thermal energy can be extracted via drilling to power a conventional steam turbine to generate electricity.[16] The southern edge of the Golan Heights is one such potential site for optimal geothermal electricity generation.[17] In order to optimize the implementation of varying renewable electricity technology into Israel's electricity grid, the MEWR, along with the appropriate bodies of the Israeli government, will pursue in depth research on the viability of using geothermal for electricity generation in Israel.

C.1.f. Generating electricity using biogas and biomass technologies

Biogas and biomass are general terms for technologies that use organic materials (including waste) to produce energy.

- ✓ **Waste incineration** – utilization of the energy produced from waste incineration to generate electricity. This technology reduces the quantity of waste for sanitary landfill and neutralizes air and groundwater pollutants. At the same time, waste incineration is liable to create air pollution and ash.
- ✓ **Fermentation** – a process in which organic materials are fermented. In the absence of oxygen and as a result of this process, substances are created that can be used to produce energy.
- ✓ **Gasification** – waste is heated to high temperatures, either in the presence or absence of oxygen. This process generates fuel gas from the waste.

C.1.g. Energy storage

Energy storage devices enable renewable energy sources to be used even at times when they are not sufficient to drive a turbine and/or to be routed for use at times of peak demand. Storage technologies can improve the efficiency of electricity generation installations by more

[15] Rubin and Davidson, *Introduction to engineering and the environment*: 215.
[16] Ibid.
[17] The Israel Project: Israel and Alternative Energy: Innovation and Progress 2011 p31

than 60%. However, the use of storage technologies is likely to increase installation costs and to require larger land areas.

D. ESTIMATED COST OF GENERATING ELECTRICITY USING RENEWABLE ENERGY TECHNOLOGIES

Table 4

(Cost per MW installed)						
	Combined cycle	Photovoltaic up to 50 kW (roofs)	Medium photovoltaic	Thermo-solar	Large wind MW	Biomass (biogas)
Deployment costs in millions of dollars per MW installed (M$)	1.1	4.8	4.2	3.6	2	4.5
Annual operation costs in millions of dollars per MW installed (M$)	0.04	0.152	0.055	0.008	0.022	0.022
Estimated annual generation by technology, in megawatt-hours (MWh)	7709[12]	1600	1700	1900	2455	6570
Estimated installation lifespan (years)	25	20	20	20	20	20
Estimated land area required (hectares)	0.01	1	2.2	1.8	Net: 0.27 Gross: 10	0.17

Source: Electricity Administration, Ministry of National Infrastructures

The above table presents the installation costs according to technology. For example, the deployment cost of a thermo-solar installation is approximately $3.6 million per MW installed. The annual operating cost is approximately $8,000 per MW installed. In addition, each installed MW of thermo-solar technology is expected to generate 1,900 MWh per year.

The table shows that the installation costs and the land area requirements of electricity generation installations that use renewable technologies are much higher than those of conventional electricity generation installations.

Although the baseline cost of conventional technologies is lower, it is the policy of the Ministry of National Infrastructures to promote renewable energy and to consolidate its standing in Israel's energy sector. This is based on the assumption that renewable energy sources are likely to benefit, in the medium and long term, from major technological advancements accompanied by declining installation costs. In addition, fossil fuel prices and the environmental cost of using fossil fuel in the generation of electricity are likely to enhance the economic merits of using renewable energy technologies.

D.1. External costs of electricity generation with conventional technologies

In generating electricity, air pollutants and greenhouse gases are emitted into the atmosphere as by-products of fossil fuel combustion. The principal pollutants are: sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter (PM) and greenhouse gases – primarily carbon dioxide (CO_2). The first three pollutants are toxic substances which have a harmful effect on the respiratory system. Carbon dioxide is a major contributor to the greenhouse effect.[18]

In September 2009, the Ministry of Environmental Protection issued a report entitled "External Costs of Generating Energy (Electricity) in Israel".[19] This report quantified the costs incurred by pollutant and greenhouse gas emissions in the generation of electricity. These cost estimates are based on variables such as the population spread, climate, pollutant concentrations, etc.

---

18 State Comptroller, Annual Report 59B for 2008.

19 Ministry of Environmental Protection, "External Costs of Generating Energy (Electricity) in Israel", September 2009.

When electricity is generated using renewable technologies, these costs are eliminated, as no fossil fuel is burned.

Table 5

Emission type	Average quantity emitted per kWh generated (g/kWh)[15]	External cost per ton of emissions ($/t)	Cost of emissions per kWh generated ($/kWh)
SO_2	1.7	7,420	0.012
NO_x	1.8	4,297	0.007
PM	0.06	10,590	0.0006
CO_2	741	22	0.0164
Total			0.0375 ($/kWh)

Source: Electricity Administration, Ministry of National Infrastructures; processed data from the Ministry of Environmental Protection document entitled "External Costs of Generating Energy (Electricity) in Israel", September 2009.

It is important to note that there are other estimates of the costs of pollution resulting from the generation of electricity using conventional energy sources. The estimates, generally speaking, range from $0.02 to $0.05 per kWh.

D.1.a. Conventional backup for renewable energy technologies

Generating electricity from renewable energy sources has implications for the reliability and availability of electricity generation in Israel. In contrast to the availability of conventional power stations, the availability of stations generating electricity from renewable energy sources is limited.

The IEC's smart load management and use of natural gas as a base load fuel, however, will remedy this issue. While a laterally organized electricity grid poses many new engineering problems, the ability to use technology such as the Internet and smart grid organization, as well as collaboration with the IEC as a powerhouse of electricity generation knowledge, will help to overcome these dilemmas.

"**Capacity Credit**" is used as an estimate of a technology's reliability. It is the percentage of the installed capacity that can be relied upon in the planning of electricity generating system without compromising the baseline reliability of the generating system. The "baseline reliability" represents the reliability of the generating system before the integration of technologies based on renewable energy sources.

The capacity credit of solar energy-based technologies is higher than that of wind-based technologies because it is easier to predict the solar energy regime than the wind regime over a 24-hour period.

The model makes the following assumptions:

- The capacity credit of installations that generate electricity from solar energy using photovoltaic cell technology will be 75% of the installed capacity.
- The capacity credit of installations that generate electricity from solar energy sources using thermo-solar technology is 80% of the installed capacity (for non-hybrid stations[20]).
- The capacity credit of wind energy installations will be 25% of the installed capacity.

Determining the exact capacity credit of wind-based technologies depends primarily on the strength of the wind regime and on the frequency of the winds; in solar-based technologies, it depends primarily on the strength of the solar radiation and the temperature at the electricity generating site. The model assumes that the backup will employ gas turbines, in the form of a "cold backup". The turbines will not operate continuously, but only on demand.

D.2. Marginal cost of electricity generation, by technology

Precise estimates of savings in pollutant and greenhouse gas emissions can be made by running the electricity generation units under an optimization model designed for this purpose. The Israel Electric Corporation and the Ministry of National Infrastructures use such models. Because the process for loading units will change once the use of renewable energy is introduced, the quantities emitted per kWh generated will also change.

This change is due to ~~"clean"~~ renewable electricity generation on one hand, and to the increased pollutant emissions of conventional units, on the other. Due to the need for conventional backup, the working assumption is that, for a target of ~~10%~~ 20% of electricity generation from renewable energy sources, this increase will be

[20] Some thermo-solar stations incorporate a gas turbine as an electricity-generating component and do not require outside conventional backup.

negligible compared with the overall impact of integration of the renewable energy sources.

Table 6 - Capacity factor and the marginal costs of generating electricity using renewable energy technologies vs. combined cycle technology

Table 6 - Capacity factor and the marginal costs of generating electricity using renewable energy technologies vs. combined cycle technology

	Combined cycle	Photovoltaic up to 50 kW (roofs)	Medium photovoltaic	Thermo-solar	Wind	Biogas and biomass
Capacity factor (%)	88	18	19	21	26	75
Capacity credit (%)	-	75	75	80	25	-
Estimated cost of electricity generation per kWh[17] ($/kWh)	0.063	0.41	0.29	0.203	0.09	0.08
Estimated cost of electricity generation per kWh plus external costs ($/kWh)	0.1	0.412	0.294	0.205	0.102	0.08
Estimated additional annual cost per MW installed, in thousands of dollars (k$)	0	500	330	200	6	-160

Source: Electricity Administration, Ministry of National Infrastructures

Capacity factor The estimated electricity generation capacity of the technology: the ratio (as a percentage) between the quantity of energy actually generated and the maximum quantity of energy which the electricity installation is capable of generating, were it to operate 8,760 hours a year without interruption. The higher the percentage, the higher the generation capacity.

Capacity credit The estimated reliability of the technology: the percentage of the installed capacity that can be relied upon in the planning of the electricity generating system, without compromising the reliability of the generating system. This term expresses the conventional backup required to maintain the same level of energy reliability that would have been achieved without the integration of renewable technologies into the electricity generation system. The higher the percentage, the higher the reliability.

External costs **For combined cycle technology**– the additional cost of electricity generation arising from pollutant emission costs, storage costs and price hedging.

For renewable energy technology – the additional cost arising from the conventional backup required.

Additional annual cost The difference between the cost of electricity generated per kWh by combined cycle installations and the cost of electricity generated by renewable energy installations.

- ✓ The table shows that the cost of electricity generation per kWh using combined cycle technology is $0.063. When the external costs of air pollution and morbidity are added to the basic cost of electricity generation, the generation cost is estimated at $0.10 per kWh.
- ✓ In this model, the additional annual cost of the combined cycle technology is zero, as the additional cost is measured relative to the combined cycle technology.
- ✓ The cost of electricity generation for photovoltaic installations up to 50 kW installed on the roofs of buildings is estimated at $0.41 per kWh. When the cost of conventional backup (gas turbine) is added to this cost, the electricity generation cost is estimated at

$0.412 per kWh. Note the high external cost of electricity generation using wind technology, which is due to the requirement for conventional backup of 75% of the estimated generation.

- ✓ The additional cost of a 50 kW photovoltaic installation compared with electricity generated from a combined cycle installation, is estimated at $500,000 per MW installed.
- ✓ The additional cost of a biomass (biogas) electricity generating installation is estimated at $160,000 per MW installed.

E. MODEL FOR ALLOCATING FACTORS OF PRODUCTION WITH RENEWABLE ENERGY SOURCES

The model presented in this chapter proposes a procedure for the efficient allocation of factors of production with renewable energy sources.

The first basic assumption is that the energy efficiency target set by the Government must be encouraged, namely a reduction of 20% in the forecast demand for electricity in 2020.

The second basic assumption is that the electricity generation target set by the Government must be achieved, namely, ~~10%~~ 20% of electricity generated in 2020 must be from renewable energy sources.

Factors of production are allocated as a function of the marginal cost of the generating units. Because the marginal cost of conventional generation of electricity is significantly lower than generation of electricity from renewable energy sources, an additional cost is created. The term "cost" in this context refers to the tariff burden that will be imposed on consumers as a result of the added factors of production with renewable energy sources characterized by high generation costs compared with the cost of generating electricity by conventional means.

Electricity generation costs and indirect benefits
The model weighs the benefits of integrating renewable energy sources against the alternative cost of generating electricity with conventional technologies. To the basic cost of conventional electricity generation, the following external costs must be added: environmental pollution, price hedging, and fuel storage. To the cost of generating electricity from renewable energy sources one must add the cost of backup by conventional generation, according to the technology used.

The model presented does not include benefits and costs outside the energy sector, such as benefits provided by new jobs, distributive justice, and support for outlying areas of the country. The Ministry takes these benefits into account in its decision-making process. At the same time, because these benefits are not part of the considerations which bind the Ministry by virtue of the Electricity Law, their weighting in the decision-making process takes place outside the model. The Ministry hopes to include these benefits in future models.

The model attempts to answer three pivotal questions:

- ✓ What constitutes efficient allocation of factors of production with renewable energy sources, given the constraints of the resources?
- ✓ What is the optimal set of milestones for achieving the target of ~~10%~~ 20% of electricity generation in 2020 from renewable energy sources?
- ✓ What are the implications of the adoption of this target for the Israeli economy?

E.1. The electricity generated from renewable energy sources depends on three main sets of variables:

Geophysical variables: vacant potential land, solar radiation levels, wind regimes, climate, and the effects of greenhouse gas emissions from conventional electricity generation installations on the climate and health.
Economic variables: fossil fuel prices, alternative cost of conventional electricity generation, electricity transmission costs, environmental costs, and installation costs.
Technological improvements: electricity generation efficiency, storage capacity, reduction of greenhouse gas emissions from conventional installations, and land use efficiency.

E.2. Principles of an optimal allocation model

- ✓ **Marginal cost** – pricing by way of marginal cost ensures efficient allocation of resources and prevents waste and destruction of sources. Efficient allocation will give priority to technologies characterized by relatively low marginal cost.
- ✓ **Cost minimization** – electricity generation costs, land area requirements, rapid installation, and conventional backup requirements.
- ✓ **Alternative cost** – helps to quantify the additional burden to be borne by consumers as a result of integration of renewable energy technologies with a higher marginal cost of generation than that of combined cycle technology.

The marginal cost of electricity generation is arbitrarily set using combined cycle technology as a benchmark to compare the electricity generation costs of the other technologies (hereinafter: "conventional generation cost"). The external costs of generating electricity with fossil fuels must be added to this generation cost. In the model, the sum of the two costs constitutes the "alternative cost" to generating electricity from renewable energy sources.

Generating electricity from renewable energy sources at a higher cost than the alternative cost is defined as an "additional burden" or "additional cost". When the cost of generating electricity from renewable energy sources is lower than the alternative cost, the "additional burden" will be represented by a minus sign.

E.3. Basic assumptions for the allocation

- ✓ The renewable energy sources sector will, in the future, constitute economic and strategic potential for Israel and the world.
- ✓ In the long term, technological improvements in electricity generation efficiency will occur in both renewable and conventional technologies.
- ✓~~Renewable energy technologies are still in the nascent stages of development.~~ Israel's Cleantech sector is booming as world-wide demand[21] for renewable electricity Technologies increases. Israel must capitalize on these homegrown technologies as the starting place for the installation of renewable technologies. ~~Consequently the efficiency growth rate for renewable energy will be greater than that for conventional energy.~~In addition, the efficiencies of these technologies are expected to increase rapidly over time, much more so than conventional elecrticity generation.

---

[21] As evidenced by the December 2010 EU Renewable Energy Directive (20% Renewables by 2020)

- ✓ In the long term, technological improvements will reduce pollutant emissions resulting from the generation of electricity using conventional energy sources.
- ✓ The cost of pollutant emissions will increase in the long term, as a function of international environmental agreements which will enforce emission quotas and impose fines when quotas are exceeded.
- ✓ The installation costs of power stations using renewable technologies are expected to decline in the long term.

The order of the units according to marginal cost (from the lowest to highest cost):
Biogas and biomass (gasification); wind, 5MW and higher; thermo-solar; medium-large photovoltaic; photovoltaic up to 50 kW.

The order of the units according to land area requirement (from lowest to highest land area requirement):
This scale places the technologies in the order of the total land area required for approval by the planning authorities, and not according to the net land area used, from lowest to highest.
Biogas and biomass (gasification); photovoltaic up to 50 kW; thermo-solar; medium-large photovoltaic; wind, 5 MW and higher.

The order of the units according to likelihood of encountering difficulties in the planning and implementation (from lowest to highest):
This scale places the technologies in the order of likelihood of rapid deployment. For example: wind technology requires statutory approvals for a large land area (10 ha/MW) and the erection of measurement masts for a period of one year; on the other hand, the marginal cost of electricity generation is low relative to the other technologies.
Photovoltaic up to 50 kW; medium-large photovoltaic; thermo-solar; biogas and biomass (gasification); wind, 5 MW and higher.

E.4. Targets and constraints

- ✓ Constraints of transmission and geographical matching of generation units with demand units. The aim is to reduce the transmission costs and energy losses between the electricity generation side and the demand side. Accordingly, consideration will be given to generation units that can be stationed close to the demand units – for example, deployment of a gasification installation adjacent to a wastewater treatment plant. This type of coupling will be most efficiently facilitated by a laterally organized renewable electricity system that is coordinated by the Ministry, the IEC, and the IDF.
- ✓ Land constraint: this is the most severe constraint, because Israel has very little land available for electricity generation. Much of the land in the Negev serves as military firing zones and/or nature reserves. Limited land poses major challenges for renewable energy technologies. Land is required not only for deploying the electricity generation sites, but also for the electricity transmission infrastructure from the power generation site to central Israel. The Ministry conducted an initial land survey based on proposals by entrepreneurs for sites for electricity generation from renewable energy technologies. On the basis of these proposals, the Ministry mapped out preliminary electricity generation sites in the Negev.

  Appendices 1 and 2 contain maps depicting the "exploration areas" according to wind-based and solar-based technologies. These areas were identified after eliminating initial constraints such as military firing zones, nature reserves, land slopes greater than 3%, other existing outline plans in the land polygon, and proximity to an existing transmission system. The potential land in the Negev for the various solar energy technologies totals 35,000 hectares. Note that the survey is preliminary and will be forwarded to the planning authorities and to the various environmental organizations for comment. In addition, the Ministry will conduct a study concerning the availability of existing infrastructure that can be used to house renewable electricity technologies such as solar PV cells and wind turbines.

E.4.a. Short-term electricity generation potential

The following tables present potential electricity generation from renewable energy sources **in the short to medium term, by type of technology**.

Table 7 - Sites for generating electricity from solar energy currently in the planning stages

Site name	Installed capacity	Entrepreneur	Status
Ashalim	250	Tender	Tender published
Dimona	200	Tender	Land identified by National Council
Negev Junction	200	Tender	Land identified by National Council
Mishor Yamin	200	–	Discussion of National Outline Plan No. 10
Tze'elim	120	Shikun & Binui	
Urim	100	Sunray	
Nevatim	50		
Moshav Tidhar	10		
Moshav Zeru'a	35		
Timna	220	Eilat-Eilot	Preparation of environmental impact statement
Ketura	50	Kibbutz Ketura	Preparation of plans

Table 8 - Sites for generating electricity from wind energy currently in the planning stages

Site name	Installed capacity	Entrepreneur
Arad Valley	50	Tail-Wind
Mt. Efa	100	
Mt. Segov	100	
Mt. Efa	30	Kinetic Energies
Southern Arava – north of Eilat	75	Afcon Industries
Arad area	250	Mei Golan
Ramat Sirin	25	Afcon Industries
Gilboa	25	Afcon Industries
Assania	13.5	Mei Golan
Northern Golan Heights	200	Mei Golan
Emek Habacha	125	Emek Habacha Wind Energy
Negev Highlands (Negev Junction – Yeruham – Sde Boker)	250	Epsilon Energy

The indicated potential of 1,240 MW wind installed capacity must be treated with extreme caution. To date, wind farm deployment has been slow and cumbersome, and there are many bureaucratic procedures to get through before generation of electricity can effectively begin. Accordingly, the total potential installed capacity for wind energy is estimated at 800 MW according to the land survey, which also took existing wind regimes into account, among other factors.

Table 9 – PUA-E Solar Tenders as of March 2011, planned installation

Tender	Capacity	Location
Solar Energy Kibbutz Gevim	60MW	North West Negev
Moshav Ohad	55MW	
Zmorot Solar Park	50.064MW	
Kibbutz Ketura	40MW	South Arava
Gilat Energy; Gilad	40 MW	
Orim	35MW	
Nevatim	35MW	
Beit Hagadi	35MW	
Zerua	35MW	

E.5. Transmission from installations that generate electricity from renewable energy sources

Transmission of power from installations that generate electricity from renewable energy sources to consumers can affect cost estimates, but its main impact is on the lengthy duration of the statutory process.

Distributing the factors of production will increase transmission costs and probably also encounter resistance from the planning authorities and environmental organizations. The Ministry of National Infrastructures therefore wants to concentrate the factors of production in laterally organized clusters, which will reduce planning and transmission costs and simplify

Table 9

Cost estimates for installing power transmission lines from installations generating electricity from renewable energy sources, based on projects in the planning stages

Site name	Installed capacity (MW)	Voltage (kV)	Length of existing line (km)	Cost of installing transmission line (NIS millions)
Ashalim	280	161	11	30.5
Tze'elim	120	161	11	30.5
Urim	100	161	1.7	4.7
Nevatim	20	22	4.8	5.1
Tidhar	10	22	1.2	1.3
Zeru'a	35	161	5.1	14
Timna	225	161	2	5.5
Ketura	50	161	4	11.1
Ramat Arad	75	161	1	2.7
Arad area	200	161	1	2.8
Ramat Sirin	19	22	7	7.5
Maaleh Gilboa	11	22	3	3.2
Assania	12	22	20	21.3
Habacha Valley	110	161	21	58.3
Total	1,267		93.8 km	NIS 198.5 million

The Israel Electric Corporation carried out preliminary feasibility studies for the great majority of the sites presented in the table. From the table, the cost of deploying transmission lines of 1,267 MW installed capacity is estimated at NIS 198.5 million. The

transmission cost is affected, among others, by the length of the line and the capacity of the electricity generating installation.
the statutory process.

~~F. MILESTONES FOR ACHIEVING THE TARGET OF HAVING 10% 20% OF ELECTRICITY GENERATED FROM RENEWABLE ENERGY SOURCES BY 2020~~

~~Government resolutions and the Public Utility Authority - Electricity regulations~~

~~Government Resolution No. 4450, dated January 29, 2009, set a target whereby 10% 20% of Israel's electricity needs in 2020 must be met by renewable energy sources.~~

~~This resolution was preceded by Government Resolution No. 4095, dated September 1, 2008, which set out a series of energy efficiency measures.~~

~~In addition to these resolutions, the Public Utility Authority - Electricity published a series of regulations encouraging the use of renewable energy sources.~~

~~Table 10 - Regulations encouraging the use of renewable energy sources published by the Public Utility Authority – Electricity up until January 2010~~

~~Technology~~	~~Total quota~~
~~Photovoltaic solar installations up to 50 kW~~	**~~50 MW~~** ~~(50 MW private, 35 MW business)~~
~~"Medium" photovoltaic solar installations that connect up to the distribution grid~~	**~~300 MW~~**
~~Thermo-solar or "large" photovoltaic solar installations that connect up to the transmission grid~~	**~~500 MW~~** ~~(Hearing proceedings underway)~~
~~Wind up to 50 kW~~	**~~30 MW~~**
~~Non-solar renewable energy sources (large wind / biomass)~~	~~TBD~~

F.1. Biennial milestones, 2014-2020

Target for electricity generation from renewable energy sources in 2020: *~~6.43~~ 12.86 TWh, which constitutes ~~10%~~ 20% of the demand forecast for 2020*. In order to achieve the Government target, several multi-year targets must be defined, up until 2020. These interim targets constitute milestones towards the final target. **In tune with the demand forecasts, the milestones may change as a result of new technologies that improve system efficiency, lower installation costs and improve land-use efficiency**. The milestones presented below constitute a forecast for achieving the target; the milestone for 2014 is based, for the most part, on existing regulations in the renewable energy sector.

Table 11

<u>Forecast installed capacity from renewable energy sources, according to technology (MW installed): milestones for 2014-2020</u>

	2014-2015	2016-2017	2018-2019	2020	Percentage of installed capacity (%)
Energy efficiency target: percentage of the demand forecast (%)	7	12	17	29	
Estimate of demand forecast including energy efficiency (TWh)	60.4	61.5	64.5	64.3	
Wind (MW) [22]	250	~~400~~ **800**	~~600~~ **1200**	~~800~~ **1600**	29
Biogas and biomass (MW)	50	~~100~~ **200**	~~160~~ **320**	~~210~~ **420**	7.6
Thermo-solar or "large" photovoltaic[23] (MW)	700	~~750~~ **1500**	~~1000~~ **2000**	~~1200~~ **2400**	43.5
"Medium" photovoltaic[24] (MW)	350	~~350~~ **700**	~~350~~ **700**	~~350~~ **700**	12.7
Photovoltaic up to 50 kW (MW)	200	~~200~~ **400**	~~200~~ **400**	~~200~~ **400**	7.2
Total installed capacity (MW)	**1550**	~~1800~~ **3600**	~~2310~~ **4620**	~~2760~~ **5520**	
Percentage of generation from renewable energy sources (%)	**5.30%**	**13.00%**	**16.60%**	**20.40%**	100%
Estimate of the land area required according to the installed capacity forecast: ~ 3380 hectares[25]					

The table shows that the total installed capacity from renewable energies is expected to reach 2,760 MW in 2020. The land requirement for the implementation is 3,380 hectares. Most of the installed capacity will consist of thermo-solar installations (43.5%), after full utilization of the generation potential of wind energy installations (29.0%) and biomass energy installations (7.6%).

[22] Electricity generation installations using wind energy connected to the distribution and/or transmission grid.
[23] Electricity generation installations connected to the transmission grid.
[24] Electricity generation installations using all types of solar technologies connected to the distribution grid
[25] Estimate of land requirement for wind energy refers to the net land requirement (turbine base only).

Table 12

Forecast of electricity generation from renewable energy sources (TWh)					
	Dec-14	2016-2017	2018-2019	2020	Percent of total generation
Wind (TWh)	0.61	~~0.98~~ **1.96**	~~1.47~~ **2.94**	~~1.96~~ **3.92**	30.04%
Biomass (TWh)	0.33	~~0.66~~ **1.32**	~~1.05~~ **2.1**	~~1.38~~ **2.76**	21.10%
Thermo-solar or “large”photovoltaic[1] (TWh)	1.33	~~1.43~~ **2.86**	~~1.9~~ **3.8**	~~2.28~~ **4.56**	34.87%
“Medium” photovoltaic (TWh)	0.6	~~0.6~~ **1.2**	~~0.6~~ **1.2**	~~0.6~~ **1.2**	9.10%
Photovoltaic up to 50 kW (TWh)	0.32	~~0.32~~ **0.64**	~~0.32~~ **0.64**	~~0.32~~ **0.64**	4.89%
Total actual energy generation (TWh)	**3.19**	~~3.99~~ **7.98**	~~5.34~~ **10.68**	~~6.54~~ **13.08**	100%

The table shows that 34.87% of electricity generated from renewable energy sources will be from thermo-solar installations. Electricity generation from renewable energy sources in 2020 is expected to total 6.54 TWh.

F.2. Mechanisms and steps for implementing the policy

Establishing electricity generation clusters for renewable energy technologies

In order to simplify the planning process, the Ministry of National Infrastructures will identify potential “electricity generation clusters” in which electricity producers using renewable energy technologies will be concentrated. The electricity generation clusters will enable cooperation and pooling of resources by the electricity producers. In addition, concentrating several factors of production in a continuous cluster in both existing and new infrastructure will reduce the harming of open spaces and simplify electricity transmission. Priority will be given to renewable electricity producers that are located in high density consumption locations such as industry sites and residential areas.

The Ministry will promote the construction of the electricity generation clusters in cooperation with the Israel Land Administration, the planning authorities and the pertinent Government Ministries.

In addition to the above, it should be stressed that the Ministry has undertaken preliminary mapping of land in the Negev area, and identified sites that are not in military firing zones or in nature reserves and/or that are not incorporated in existing outline plans. The Ministry will take steps to identify additional electricity generation clusters, such as Shivta.

In addition, the Ministry of National Infrastructures, in collaboration with the IEC and the IDF will take measures to prepare the following clusters and divide them into electricity generation areas, which entrepreneurs will bid for in a tender. At this time, the first electricity generation sites that will be established are the Ashalim site, the Dimona site, and the Negev Junction and Timna.

Table 13

Potential sites to be readied as clusters for the generation of electricity from renewable energy sources			
Location	Installed capacity (MW)	Technology	Tender/Entrepreneur
Ashalim	250	Thermo-solar and photovoltaic	Tender
Timna	220	Thermo-solar and photovoltaic	Tender
Northern Golan Heights	200	Wind	Entrepreneur
Dimona	200	Under review	Tender
Negev Junction	200	Under review	Tender
Shivta	250	Thermo-solar and photovoltaic	Tender

Generating electricity using wind-based technologies

- Following requests from entrepreneurs for wind regime measurements, the Ministry has undertaken an initial mapping of potential areas for generating electricity from wind energy. The Ministry is collaborating with the Ministry of Defense, the Nature and Parks Authority and the planning authorities to remove planning and implementation barriers in these areas.
- The Ministry is working with the Israel Land Administration to proceed with land tenders for wind-based power stations.

Generating electricity using biogas and biomass technologies

In the short term, the Ministry of National Infrastructures will promote gasification and waste incineration technologies.

- The Ministry is cooperating with the Tax Authority to introduce accelerated depreciation of 25% for electricity generation installations at wastewater treatment plants and sanitary landfills. Applying accelerated depreciation at these installations will encourage their construction in view of the steep deployment costs.

The Ministry is working with the Ministry of Environmental Protection to promote such installations at sanitary landfills.

"An exclusively Israeli workforce" - electricity producers will be required to employ local Israeli personnel only.

"Amendment to the Encouragement of Capital Investments Law"- providing concessions by virtue of the Law to the renewable energy industry (with no generation component) based on original "**know-how**" in the field, pursuant to the approval of the Chief Scientist in the Ministry of National Infrastructures.[26] The Ministry is also working with the Ministry of Industry, Trade and Labor to extend the benefits under the Law to apply also to installations generating electricity from renewable energy sources.

In addition, a recommendation for tax benefits (reduction of direct taxes – corporate and dividend tax) will be brought before the Ministry of Finance for approval. The benefits will be granted to renewable energy companies that are not exporters, as

[26] Encouragement of Capital Investments Law, 5719-1959.

required by law, but that have added value for Israel (employment, intellectual property and ownership) of 70% or more.

Encouraging Israeli R&D

Establishment of an aid fund to assist Israeli R&D involved in exploiting the potential inherent in the different types of waste in Israel and in the implementation of biomass technologies; a dollar-for-dollar split between specialized venture capital funds and Government Ministries (collaboration between the Ministry of National Infrastructures and the Ministry of Environmental Protection).

Tax incentives

The Ministry of National Infrastructures and the Tax Authority are working to introduce several tax benefits in the Tax Regulations for installations generating electricity using renewable energy technologies:

- ✓ Income Tax regulations –granting accelerated depreciation of 25% for photovoltaic and thermo-solar installations.
- ✓ Primary legislation near completion: tax exempt income for households from photovoltaic installations on the roofs of private homes and from wind energy installations: up to NIS 18,000 per year.
- ✓ Granting of accelerated depreciation to electricity generation installations that use biomass technology (initially gasification), is currently under review.

Regulating the actions of entrepreneurs

Renewable energy – adoption of a binding code of ethics

The Israel Sustainable Energy Society and/or another umbrella organization as shall be chosen by the renewable energy entrepreneurs will be required to formulate a code of ethics for the actions of entrepreneurs. **The code of ethics will include**: rules of conduct, a service level agreement, and a detailed breakdown of customer rights. Any entrepreneur wishing to participate in the electricity generation quotas will be required to sign and abide by this code.

F.3. Steps by the Ministry to promote electricity generation from renewable energy sources:

- ✓ Advancing tenders for the construction of solar power stations in Ashalim with an installed capacity of 250 MW.
- ✓ A Government resolution to issue tenders for the construction of three solar power stations in the Eilat-Eilot region with an installed capacity of 50-75 MW each.
- ✓ Preparation of a call for bids (lands tender for wind measurements) in collaboration with the Israel Land Administration.
- ✓ Mapping potential land for sites available for renewable energy installations, including existing infrastructure.
- ✓ Encouraging land tenders classed as "industrial zoning", in collaboration with the Israel Land Administration at eight sites.

✓ Promoting the development of an electricity transmission infrastructure throughout Israel to receive electricity generated from renewable energy sources.

✓ Exploring the tax incentive options for R&D and for producers of electricity from renewable energy sources.

✓ Declaring the Negev and the Arava as national priority areas for renewable energy sources.

✓ Collaboration with the IEC and the IDF to facilitate mutually beneficial generation and consumption from horizontally organized renewable electricity sources.

Current IPP Process [27]

1. Apply for PUA-E License
2. Apply for planning permission from the National Planning and Building Council
3. Open a file with the IEC, including down payments. The IEC will perform a detailed analysis of grid connection options
4. Apply for a building permit
5. Apply for a tariff permit
6. If completed above, receive 90-day rush period to get the project financially ready
7. Receive a signed permit license from the Minister of Energy and Water Resources

Yasner Proposed Streamlined IPP Process

1. Apply for PUA-E License with building plans, costs, location, timeline, and projected capacity
2. PUA-E sends project request to the National Planning and Building Council, the IEC, and the MEWR.
3. Project is approved, or rejected for further research with specific reasons for rejection. The project can resubmit after allotted time
4. If project is approved, timeline of project begins

Impact of Improvements:

The Yasner modifications to the Ministry of Energy and Water Resource's renewable electricity plan increase its efficiency and effectiveness in attaining the goal of implementing renewable electricity into Israel's electricity grid. By fully integrating the IEC and the IDF into the planning and execution of this plan, it is possible to increase the target percentage of renewable electricity from 10% to 20% of total generation capacity by 2020. The IEC's industry knowledge, expertise, and infrastructure are crucial to a transition of this magnitude. The IDF, arguably the largest industry in Israel, not only has the impetus to participate in this shift-namely electricity security, but is also perfectly positioned to facilitate such change as a structured industry that influences all aspects of Israeli life. The inclusion of these two industries in the plan makes an increase from 10% to 20% renewables by 2020 eminently probable.

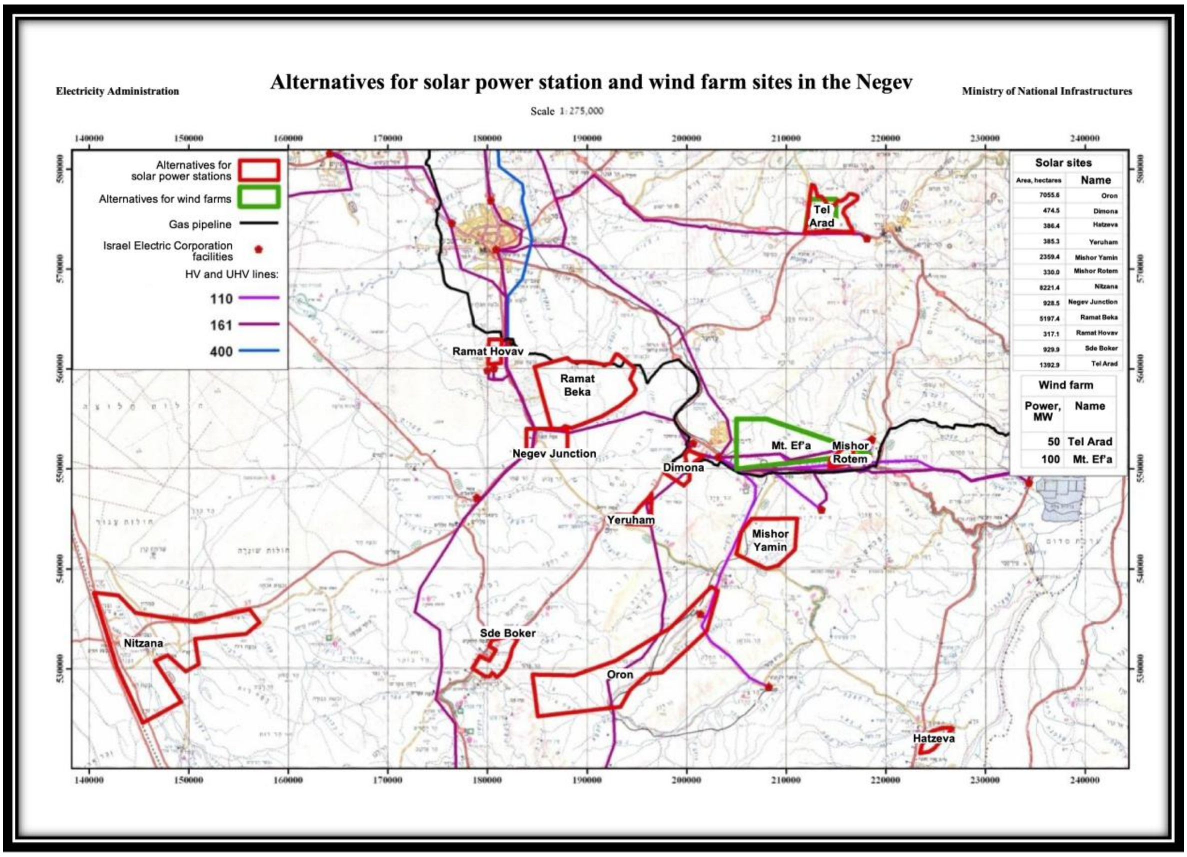
In addition, the modified plan calls for sustained large growth of the renewable electricity sector instead of small annual increases after 2014 (see Table 1), which will further increase Israel's electricity security and economic development while reducing harmful environmental impacts from reliance on conventional electricity generation.

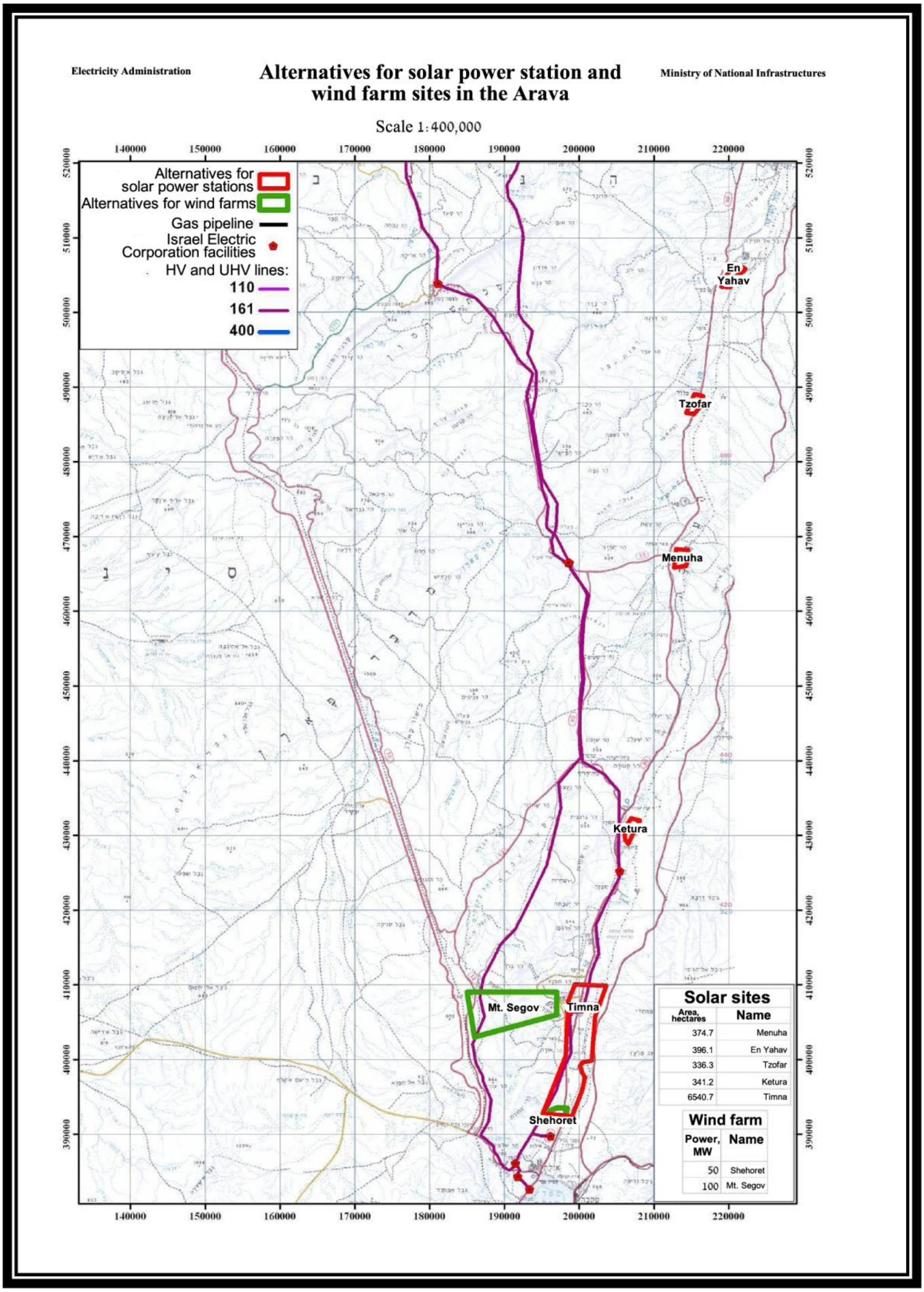
[27] Udasin, Sharon. "Country's First Large-Sized Solar Fields Approved." The Jerusalem Post, http://www.jpost.com/Sci-Tech/Article.aspx?id=261752.

Electricity security will increase as the IDF pursues electricity independence from the national grid via renewable electricity technologies. By creating a laterally organized electricity grid, this improved plan returns the electricity market to the people while insuring its consistency and reliability due to the involvement and cooperation of the industry leader, the IEC.

This revised plan fosters continued economic development by shifting from conventional electricity generation to renewable electricity generation at a greater magnitude than the unedited plan. While upfront costs of renewable technologies may seem steep, the risk of economic collapse due to reliance on foreign fossil fuel imports fraught with international relations issues, fuel shortages, and price fluctuations, is much higher.

G. APPENDICES




Electricity Administration
Alternatives for solar power station and wind farm sites in the Arava
Ministry of National Infrastructures
Scale 1:400,000
Alternatives for solar power stations
Alternatives for wind farms
Gas pipeline
Israel Electric Corporation facilities
HV and UHV lines:
110
161
400
En Yahav
Tzofar
Menuha
Ketura
Mt. Segov
Timna
Shehoret
Solar sites
Area, hectares | Name
374.7 | Menuha
396.1 | En Yahav
336.3 | Tzofar
341.2 | Ketura
6540.7 | Timna
Wind farm
Power, MW | Name
50 | Shehoret
100 | Mt. Segov

[1] "OECD. StatsExtracts. Country Statistical Profiles: Israel," Organization for Economic Co-operation and Development, http://stats.oecd.org/#. http://stats.oecd.org/#.

[2] "Israel's Energy Independence: Long-Term Policy," State of Israel Ministry of National Infrastructures, http://www.google.com/url?sa=t&rct=j&q=kugler%20ppt%20israel&source=web&cd=1&ved=0CCEQFjAA&url=http%3A%2F%2Fenergy08.tau.ac.il%2Fmedia%2Fkugler.ppt&ei=Ia4MT8S9BoLe0QGqpNXrBQ&usg=AFQjCNH1CbW7XsSkY7hmXrFeimN2B664BQ&sig2=FyYwxc1l7icdb4P4f4Oaeg.

[3] "Greenhouse Gas Emissions-Electricity/Heat; Israel," (World Resources Institute, Google Public Data Explorer). http://www.google.com/publicdata/explore?ds=cjsdgb406s3np_&ctype=l&strail=false&bcs=d&nselm=h&met_y=emissions&fdim_y=sector:e&scale_y=lin&ind_y=false&rdim=country&idim=country:82&ifdim=country&tstart=635490000000&tend=1108875600000.

[4] Alon Tal, *Pollution in a Promised Land: An Environmental History of Israel* (Berkeley: University of California, 2002). 41.

[5] Eli Shaltiel, *Pinchas Rutenberg: aliyayo u-nefilato shel "ish hachazak" b-eretz yisrael, 1879-1942* [*The Ascent and Downfall of "The Strong Man" in the Land of Israel 1879-1942*] (Tel Aviv: Am Oved, 1990).

[6] The Government of Palestine, *The Handbook of Palestine and Trans-Jordan*, ed. Harry Charles Luke and Edward Keith-Roach (St. Martin's Street, London: Macmillan and Co., Limited, 1930). 338-40.

[7] Ibid.

[8] Shmuel Avitzur, "The Power Plant on Two Rivers," Israel Ministry of Foreign Affaris, 2008. http://www.mfa.gov.il/MFA/MFAArchive/2000_2009/2003/5/The%20Power%20Plant%20on%20Two%20Rivers.

[9] "Our History," Israel Electric Corporation, Timeline. http://www.iec.co.il.

[10] "About the Company," The Israel Electric Corporation, http://www.iec.co.il/EN/IR/Pages/AboutTheCompany.aspx.

[11] "OECD. StatsExtracts. Country Statistical Profiles: Israel".

[12] "Access to Electricity (% of Population)," The World Bank Database, http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS.

[13] "Public Utility Authority-Electricity," The State of Israel: Public Utility Authority-Electricity, http://www.pua.gov.il/86-he/Electricity.aspx.

[14] Steven W. Popper, *Natural gas and Israel's Energy Future : Near-Term Decisions from a Strategic Perspective* (Santa Monica, CA: RAND, 2009).

[15] "Natural Gas Practical Guide," (State of Israel: Ministry of National Infrastructures Natural Gas Authority, 2011), 20.NG Guide p23-25

[16] "About the Company".

[17] "IEC Annual Budget 2010," Israel Electric Corporation, http://www.iec.co.il/EN/IR/Pages/budget0308-6615.aspx.

[18] "How Fossil Fuels were Formed," US Department of Energy, http://www.fe.doe.gov/education/energylessons/coal/gen_howformed.html

[19] "Energy Content of Fuels," (US Naval Academy Chemistry Department, 2003), 1. http://www.usna.edu/ChemDept/plebeChem/manual/Ex30.pdf

[20] Vaclav Smil, *Energy at the Crossroads : Global Perspectives and Uncertainties* (Cambridge, Mass.: MIT Press, 2003). 151.

[21] Jeremy Rifkin, *The Third Industrial Revolution : How Lateral Power is Transforming Energy, the Economy, and the World* (New York: Palgrave Macmillan, 2011). 10.

[22] Neal Sandler, "At the Zenith of Solar Energy," *Bloomberg Businessweek* (March 26. 2008), http://www.businessweek.com/globalbiz/content/mar2008/gb20080326_485582.htm?chan=globalbiz_europe+index+page_companies.

[23] Rifkin, *The Third Industrial Revolution : How Lateral Power is Transforming Energy, the Economy, and the World*: 13.

[24] "Peace Treaty between Israel and Egypt," (Israel Ministry of Foreign Affairs, 1979). http://www.mfa.gov.il/MFA/Peace+Process/Guide+to+the+Peace+Process/Israel-Egypt+Peace+Treaty.htm

[25] "The Natural Gas Sector in Israel," State of Israel: Ministry of Energy and Water Resources, 2011. http://energy.gov.il/English/Subjects/Natural%20Gas/Pages/GxmsMniNGEconomy.aspx.

[26] Avi Bar-Eli and Itai Trilnick, "Electric Corp. Scrambing to Buy Turbines to Avert Blackouts," *Haaretz*, (February 16, 2012), http://www.haaretz.com/business/electric-corp-scrambling-to-buy-turbines-to-avert-blackouts-1.413203.

[27] Itai Trilnick, "Electricity rates to rise 9% in April," *Haaretz*, March 23, 2012.

[28] Avi Bar-Eli and Itai Trilnick, "Forecast: Blackout. Israel is About to Run out of Natural Gas," *Haaretz*, February 2, 2012. http://www.haaretz.com/misc/iphone-article/forecast-blackout-israel-is-about-to-run-out-of-natural-gas-1.410513.

[29] "The Israel Electric Corporation Immediate Report," (The Israel Electric Corporation, 2012), http://www.iec.co.il/EN/IR/Pages/ImmediateReports.aspx.

[30] "Egyptian Elections: Preliminary Results (UPDATED)," *Jadaliyya Egypt Editors.* (January 2012) http://www.jadaliyya.com/pages/index/3331/egyptian-elections_preliminary-results_updated-

[31] Robert Seigel, "Darrag Discusses The Future of Egypt," (National Public Radio (NPR), January 26, 2012).

[32] "Brotherhood of Hate: Muslim Brotherhood's Hatred for Jews and Israel Flourishes in "New" Egypt," Anti-Defamation League, February 19, 2011. http://www.adl.org/main_International_Affairs/muslim_brotherhood?Multi_page_sections=sHeading_2.

[33] Shahin Abbasov, "Azerbaijan: Baku Faces Difficult Choice Between Turkey and Israel. September 26, 2011." EurasiaNet.org, http://www.eurasianet.org.

[34] Jason Katz, "Azerbaijan and Israel: Not a Typical Relationship," *The Huffington Post,* March 22, 2010. http://www.huffingtonpost.com/jason-katz/azerbaijan-and-israel-not_b_509229.html.

[35] Ibid.

[36] Phoebe Greenwood, "Israel and Azerbaijan: Unlikely Allies?," *The Guardian*, March 29, 2012. http://www.guardian.co.uk/world/blog/2012/mar/29/israel-azerbaijan-unlikely-allies.

[37] "Coal in Electricity Generation," World Coal Association, http://www.worldcoal.org/resources/coal-statistics/.

[38] Ronnie Granot Kohen (Israel National Coal Supply Corporation), Email Correspondence with author, February 27, 2012.

[39] Greer Fay Cashman, "Colombia seeks to broaden Israel ties," *Jerusalem Post Online*, April 29, 2010. http://www.jpost.com/International/Article.aspx?ID=174179.

[40] "Bilateral Relations: Israel and Colombia," Israel Embassy in Colombia, http://bogota.mfa.gov.il/mfm/web/main/document.asp?SubjectID=18365&MissionID=17&LanguageID=502&StatusID=0&DocumentID=-1.

[41] Cashman, "Colombia seeks to broaden Israel ties".

[42] Mariano Castillo, "How deep are relations between Colombia and Venezuela?," CNN, December 3, 2011. http://www.cnn.com/2011/12/03/world/americas/venezuela-colombia/index.html.

[43] Cashman, "Colombia seeks to broaden Israel ties".

[44] Mitchell G. Bard, "The Evolution of Israel's Africa Policy," The American-Israeli Cooperative Enterprise, 2012. http://www.jewishvirtuallibrary.org/jsource/Politics/africa.html

[45] "Highlights of Main Events-1984-1988, Volumes 9-10, 1984-1988," Israel Ministry of Foreign Affairs, http://www.mfa.gov.il/MFA/Foreign%20Relations/Israels%20Foreign%20Relations%20since%201947/1984-1988/HIGHLIGHTS%20OF%20MAIN%20EVENTS-%201984-1988.

[46] "Russia says would be threatened by Iran military action," *Reuters*, January 13, 2012. http://www.reuters.com/article/2012/01/13/us-iran-russia-nato-idUSTRE80C1BI20120113.

[47] "The Vision of the Electrc Corporation," The Israel Electric Corporation, http://www.iec.co.il/EN/IR/Pages/IECVision.aspx.

[48] "International Energy Statistics," U.S. Department of Energy, http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=2&pid=29&aid=12&cid=IS,&syid=2006&eyid=2010&unit=BKWH.

[49] "THE LAND: Geography and Climate," Israel Ministry of Foreign Affairs, http://www.mfa.gov.il/MFA/Facts+About+Israel/Land/THE+LAND-+Geography+and+Climate.htm.

[50] "Policy on the Integration of Renewable Energy Sources into the Electricity Sector," (State of Israel: Ministry of National Infrastructures, February, 2010).

[51] "Ketura Sun," Arava Power Company, http://www.aravapower.com/Field%20Profile.

[52] "Wind Power-Alternative Energy," Mei Eden, http://www.meyeden.co.il/article.asp?page=wind.

Israel captured the Golan Heights from Syira in the 1973 Yom Kippur War. Although the move was not internationally recognized, Israel annexed the Golan Heights in 1981 and extended Israeli law to the area. "Golan Heights (Israel/Syria) Historical Chronology," UN Security Council Report, http://www.securitycouncilreport.org/site/c.glKWLeMTIsG/b.2692939/.

Syria demands the return of the Heights as a part of a peace agreement with Israel.

Industry leaders in wind Cleantech in Israel are confident that in the context of a peace agreement between Israel and Syria wind power projects will be compensated. Ira Moskowitz, "Israel PM Declares a 155 MW Wind Farm Project on Golan Heights a

'National Project'," *Green Prophet*, September 23, 2010.

http://www.greenprophet.com/2010/09/netanyahu-wind-farmnational/.

[53] Edward S. Rubin and Cliff I. Davidson, *Introduction to Engineering and the Environment*, 1st ed. (Boston: McGraw-Hill, 2001). 214.

[54] "Policy on the Integration of Renewable Energy Sources into the Electricity Sector," 3 (Table 2).

[55] "Forestry & Ecology," Jewish National Fund (JNF), http://www.jnf.org/work-we-do/our-projects/forestry-ecology/.

[56] Rubin and Davidson, *Introduction to Engineering and the Environment*: 215.

[57] "Israel and Alternative Energy: Innovation and Progress," in *The Israel Project: Facts for a Better Future* (The Israel Project Jerusalem Office 2011).31.

[58] Sharon Dror, "Ormat Industries launches new wing at Yavne plant to double production capacity," *Israel Gateway; Israel's Foreign Trade Portal*, September 22, 2009. http://www.israelgateway.com/articles/296/.

[59] Rubin and Davidson, *Introduction to Engineering and the Environment*: 215.

[60] "Israel and Alternative Energy: Innovation and Progress," in *The Israel Project: Facts for a Better Future* (The Israel Project Jerusalem Office 2011).

[61] Shifra Mincer, "Suntech Eyes Israel as Country Shifts More Clearly To Solar," *AOL Energy via The Times of Israel*, March 26, 2012.

http://energy.aol.com/2012/03/26/suntech-eyes-israel-as-country-shifts-more-clearly-to-solar/.

[62] Statistical report IEC 2010, p6

[63] Na'ama Rak, "IDF Goes Green," (December 20, 2009),

http://dover.idf.il/IDF/English/News/today/09/12/2001.htm.

[64] Yaakov Katz, "IDF to use Solar Charget on Battlefield," (January 21, 2009), *The Jerusalem Post*. http://www.jpost.com/Israel/Article.aspx?id=163878.

[65] "Green Sun Lights," Israeli Air Force, http://www.iaf.org.il/4375-38191-EN/IAF.aspx

[66] Inbal Omer, "Enlight to Build 45 PV Units at IDF Bases," (January 23, 2011), *Globes*. http://www.globes.co.il/serveen/globes/docview.asp?did=1000617318&fid=1725.

[67] Rubin and Davidson, *Introduction to Engineering and the Environment*: 11.

[68] "Policy on the Integration of Renewable Energy Sources into the Israeli Electricity Sector," (The State of Israel: Ministry of National Infrastructures (February 2010), 9.

[69] Rubin and Davidson, *Introduction to Engineering and the Environment*: 23-30.

[70] "Breathing clean air," ed. Ministry of Environmental Protection (2010).

[71] Tal, *Pollution in a Promised Land: An Environmental History of Israel*: 252-55.

[72] "Abatement of Nuisances Law 5721," ed. Ministry of Environmental Protection (Israel 1961), 1.

[73] "Abatement of Nuisances Regulations (Air Pollution from Premises) 5722," ed. Ministry of Environmental Protection (Israel 1962), 1.

[74] "Air Quality ", Israel Ministry of Environmental Protection, http://www.sviva.gov.il/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Object&enDispWho=Articals%5El5616&enZone=Air_law.

[75] "Abatement of Nuisances Regulations (Air Quality) 5752,", Ministry of Environmental Protection (Israel1992), 3-5.

[76] "Clean Air Law 5768," Ministry of Environmental Protection (2008), 1.

[77] "Air Quality ".

[78] "Policy on the Integration of Renewable Energy Sources into the Israeli Electricity Sector."

[79] "Electricity Production and Environment," Ministry of Environmental Protection, http://www.sviva.gov.il/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Zone&enDispWho=Electricity_Production&enZone=Electricity_Production.

[80] Rubin and Davidson, *Introduction to Engineering and the Environment*: 194.

[81] Ibid., 38.

[82] Ibid.

[83] Moshe Yanai, Jean Koch, and Uri Dayan, "Trends in CO_2 Emissions in Israel- An International Perspective," in *Climate Change* (2009), 3.

[84] Tal, *Pollution in a Promised Land: An Environmental History of Israel*: 256-57.

[85] "International Ozone Day-September 16, 2010," Ministry of Environmental Protection, http://www.sviva.gov.il/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Object&enDispWho=News%5El5286&enZone=e_news

[86] "Government Ratifies Kyoto Protocol," Ministry of Environmental Protection, http://www.sviva.gov.il/Enviroment/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Object&enDispWho=News%5El1674&enZone=e_news

[87] "Energy Projects," Ministry of Environmental Protection, http://www.sviva.gov.il/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Zone&enDispWho=Energy_Projects_cdm&enZone=Energy_Projects_cdm

[88] Ofira Ayalon et al., "Greenhouse Gas Emissions Reduction Action Plan for the State of Israel," Samuel Neaman Institute, 2011.

http://events.awma.org/ghg2011/Abstracts/Session%207/Abstract%20%2316/%2316_Ayalon.pdf

[89] "Environment: OECD Supports Israeli Initiative to Develope a Green Growth Plan," OECD, http://www.oecd.org/document/59/0,3746,en_21571361_44315115_49002107_1_1_1_1,00.html.

[90] Changes in wind patterns due to large-scale wind generation and changes in albedo, or the reflectivity of the earth's surface, due to large-scale solar power may have the potential to alter the earth's weather cycles. More research is needed to understand the full implications, and the scale of negative consequences that could arise large-scale wind and solar generation. Due to Israel's small size, however, these issues would have a negligible affect on weather patterns. Jay Apt, Presentation, "Wind and Solar Power" Carnegie Mellon University, October 2011.

[91] "Breathing Clean Air," ed. Ministry of Environmental Protection (2012), 3.

[92] Ayalon et al., "Greenhouse Gas Emissions Reduction Action Plan for the State of Israel".

[93] Rubin and Davidson, *Introduction to Engineering and the Environment*: 71-76.

[94] Vasillis Fthenakis and Hyung Chul Kim, "Land use and electricity generation: A Life-Cycle Analysis," *Renewable and Sustainable Energy Reviews* (2008).

[95] "The Grey Resource," Israeli National Coal Ash Board (NCAB), http://www.coal-ash.co.il/english/index.html.

[96] "Environment and Safety," Israeli National Coal Ash Board (NCAB), http://www.coal-ash.co.il/english/env.html.

[97] "Noise Pollution," United States Environmental Protection Agency, http://www.epa.gov/air/noise.html.

[98] Zafrir Rinat, "Israeli Greens Opposing Wind-Power Plan," *Haaretz*, March 4, 2012. http://www.haaretz.com/news/national/israeli-greens-opposing-wind-power-plan-1.422227.

[99] Rubin and Davidson, *Introduction to Engineering and the Environment*: 46.

[100] "Environmental Impacts of Renewable Energy Technologies," Union of Concerned Scientists; Citizens and Scientists for Environmental Solutions, http://www.ucsusa.org/clean_energy/technology_and_impacts/impacts/environmental-impacts-of.html

[101] Popper, *Natural Gas and Israel's Energy Future : Near-Term Decisions from a Strategic Perspective*: 1.

[102] “Gross Domestic Product,” Investopedia, http://www.investopedia.com/terms/g/gdp.asp#axzz1oH4pgYhy.

[103] "Unemployment," Investopedia, http://www.investopedia.com/terms/u/unemployment.asp#axzz1oH4pgYhy.

[104] "GINI Index," Investopedia, http://www.investopedia.com/terms/g/gini-index.asp.

[105] Yusuf Bayraktutan, Metehan YilgÖr, and Sefer UÇak, "Renewable Electricity Generation and Economic Growth: Panel-Data Analysis for OECD Members," *International Research Journal of Finance and Economics*, no. 66 (2011): 65.

[106] Rifkin, *The Third Industrial Revolution : How Lateral Power is Transforming Energy, the Economy, and the World*: 36.

[107] Ibid., 37.

[108] Ibid.

[109] Ibid., 140.

[110] Sharon Udasin, "Israel, Cyprus, Greece sign electric cable deal," *The Jerusalem Post*, April 3, 2012. http://www.jpost.com/DiplomacyAndPolitics/Article.aspx?ID=260410&R=R1.

[111] Jonathan Gruber, *Public Finance and Public Policy*. 3rd ed. 1 vols New York: Worth Publishers, 2011. Victoria Rai Gains Baggio, (Economics and International Relations major at Carnegie Mellon University), Personal communication with the author, April 17, 2012.

[112] Lee Golan, "Israel Plans To Spearhead Transition From Oil To Alternative Fuels." *Nocamels.com - Israeli Innovation News*. June 29, 2011. http://nocamels.com/2011/06/israel-plans-to-spearhead-transition-from-oil-to-alternative-fuels/.

[113] Dan Senor, Saul Singer, and Council on Foreign Relations., *Start-Up Nation : The Story of Israel's Economic Miracle*, 1st ed. (New York: Twelve, 2009).

[114] Roben Farzad, "Israel's Clean Technology Pioneers," *Bloomberg Businessweek,* May 7, 2009. <http://www.businessweek.com/magazine/content/09_20/b4131034558887.htm>.

[115] David Shear, "8 Israeli Companies Win Cleatech Awards," *Ynet News*, November 13, 2011. http://www.ynetnews.com/articles/0,7340,L-4144110,00.html.

[116] Sharon Udasin, "Experts Call Israel a 'Laboratory' for Eco-Innovation." *The Jerusalem Post*, July 13, 2011. http://www.jpost.com/Sci-Tech/Article.aspx?id=229096.

---

117 "Coming Clean: The Cleantech Global Innovation Index 2012," (World Wildlife Fund, Cleantech Group LLC, 2012), 20.

118 Farzad, "Israel's Clean Technology Pioneers".

119 Assaf Gilad, "4 Joint US-Israel Cleantech Ventures," *Ynet News*, <http://www.ynetnews.com/articles/0,7340,L-4130446,00.html>.

120 Ibid.

121 Farzad, "Israel's Clean Technology Pioneers".

122 Ibid.

123 Karin Kloosterman, "A Clean, Green Israel Showcase," *Israel 21c*, July 31, 2011. <http://israel21c.org/environment/a-clean-green-israel-showcase>.

124 Ibid.

125 "Coming Clean: The Cleantech Global Innovation Index 2012."

126 "Memorandum of Agreement between the Governments of the United States of America and Israel - Oil March 26, 1979," ed. Israel Ministry of Foreign Affairs (1979).

127 "The Vision of the Electrc Corporation".

128 "Strategy," Israel Electric Corporation, http://www.iec.co.il/EN/IR/Pages/Strategy.aspx.

129 "Abatement of Nuisances Law 5721," 1.

130 "Abatement of Nuisances Regulations (Air Pollution from Premises) 5722," 1.

131 "Abatement of Nuisances Regulations (Air Quality) 5752," 3-5.

132 "Clean Air Regulations (Emissions Permits) ", Ministry of Environmental Protection, http://www.sviva.gov.il/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Object&enDispWho=Articals%5El6432&enZone=Air_law.

Bibliography

Primary Sources

"Abatement of Nuisances Law 5721." edited by Ministry of Environmental Protection. Israel, 1961.

"Abatement of Nuisances Regulations (Air Pollution from Premises) 5722." edited by Ministry of Environmental Protection. Israel, 1962.

"Abatement of Nuisances Regulations (Air Quality) 5752." edited by Ministry of Environmental Protection. Israel, 1992.

"About the Company." The Israel Electric Corporation, http://www.iec.co.il/EN/IR/Pages/AboutTheCompany.aspx.

"Access to Electricity (% of Population)." The World Bank Database, http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS.

Apt, Jay. Presentation, "Wind and Solar Power", Carnegie Mellon University, October 2011.

Ayalon, Ofira, Tal Goldrath, Michal Nachmany, Miriam Lev-On, and Perry Lev-On. "Greenhouse Gas Emissions Reduction Action Plan for the State of Israel." Samuel Neaman Institute, 2011. http://events.awma.org/ghg2011/Abstracts/Session 7/Abstract %2316/%2316_Ayalon.pdf.

"Breathing Clean Air." edited by Ministry of Environmental Protection, 2012.

"Clean Air Law 5768." edited by Ministry of Environmental Protection, 2008.

"Clean Air Regulations (Emissions Permits) ". Ministry of Environmental Protection, 2010.

http://www.sviva.gov.il/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Object&enDispWho=Articals%5El6432&enZone=Air_law

"Combined Cycles- List." Israel Electric Corporation (IEC), http://www.iec.co.il/EN/BusinessDevelopment/Pages/CombinedCyclesList-.aspx.

"Egyptian Elections: Preliminary Results (Updated)." *Jadaliyya Egypt Editors* (January 2012). http://www.jadaliyya.com/pages/index/3331/egyptian-elections_preliminary-results_updated-.

"Fuels." The Israel Electric Corporation, http://www.iec.co.il/EN/IR/Pages/Fuels.aspx.

Fuhrman, Nathan (Economics and Applied Mathematics major at the University of Pittsburgh) Personal Communication with author. April 15 2012.

Granot Kohenm, Ronnie (Israel National Coal Supply Corporation), Email Correspondence with author, February 27, 2012.

"IEC Annual Budget 2010." Israel Electric Corporation, http://www.iec.co.il/EN/IR/Pages/budget0308-6615.aspx.

"International Electricity Prices and Fuel Costs." U.S. Department of Energy U.S. Energy Information Administration, http://www.eia.gov/emeu/international/electricityprice.html.

"International Energy Statistics." U.S. Department of Energy, http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=2&pid=29&aid=12&cid=IS,&syid=2006&eyid=2010&unit=BKWH.

"The Israel Electric Corporation Immediate Report." The Israel Electric Corporation, 2012. http://www.iec.co.il/EN/IR/Pages/ImmediateReports.aspx.

"Israel's Energy Independence: Long-Term Policy." State of Israel Ministry of National Infrastructures, http://www.google.com/url?sa=t&rct=j&q=kugler ppt israel&source=web&cd=1&ved=0CCEQFjAA&url=http%3A%2F%2Fenergy08.tau.ac.il%2Fmedia%2Fkugler.ppt&ei=Ia4MT8S9BoLe0QGqpNXrBQ&usg=AFQjCNH1CbW7XsSkY7hmXrFeimN2B664BQ&sig2=FyYwxc1l7icdb4P4f4Oaeg.

"Natural Gas Practical Guide." 23-25: State of Israel: Ministry of National Infrastructures Natural Gas Authority, 2011.

"Memorandum of Agreement between the Governments of the United States of America and Israel - Oil March 26, 1979." edited by Israel Ministry of Foreign Affairs, 1979.

Palestine, The Government of. *The Handbook of Palestine and Trans-Jordan*. Edited by Harry Charles Luke and Edward Keith-Roach. St. Martin's Street, London: Macmillan and Co., Limited, 1930.

"Peace Treaty between Israel and Egypt." Israel Ministry of Foreign Affairs, 1979.

"Policy on the Integration of Renewable Energy Sources into the Electricity Sector." State of Israel: Ministry of National Infrastructures, February 2010.

"OECD. Statsextracts. Country Statistical Profiles: Israel." Organization for Economic Co-operation and Development, http://stats.oecd.org/.

"Our History." Israel Electric Corporation. Timeline. http://www.iec.co.il

Rai Gains Baggio, Victoria (Economics and International Relations major at Carnegie Mellon University) Email Correspondence with the author, April 17, 2012.

“Statistical Report” Israel Electric Corporation, 2010. International Energy Statistics (US EIA) http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=6&pid=alltypes&aid=12&cid=IS,&syid=2010&eyid=2010&unit=BKWH.

"Strategy." Israel Electric Corporation, http://www.iec.co.il/EN/IR/Pages/Strategy.aspx.

"The Vision of the Electrc Corporation." The Israel Electric Corporation, http://www.iec.co.il/EN/IR/Pages/IECVision.aspx.

Secondary Sources

Abbasov, Shahin. "Azerbaijan: Baku Faces Difficult Choice between Turkey and Israel." EurasiaNet.org, September 26, 2011 http://www.eurasianet.org.

"Air Quality ". Israel Ministry of Environmental Protection, 2010. http://www.sviva.gov.il/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Object&enDispWho=Articals%5El5616&enZone=Air_law.

Avitzur, Shmuel. "The Power Plant on Two Rivers." Israel Ministry of Foreign Affaris, 2008. http://www.mfa.gov.il/MFA/MFAArchive/2000_2009/2003/5/The Power Plant on Two Rivers.

"The Baku-Tbilisi-Ceyhan Pipeline: Oil Window to the West." edited by S. Frederick Starr and Svante E. Cornell. Uppsala, Sweden: Central Asia-Caucasus Institute Silk Road Studies Program, 2005.

Bar-Eli, Avi, and Itai Trilnick. "Electric Corp. Scrambing to Buy Turbines to Avert Blackouts." *Haaretz*, February 16, 2012. http://www.haaretz.com/business/electric-corp-scrambling-to-buy-turbines-to-avert-blackouts-1.413203.

———. "Forecast: Blackout. Israel Is About to Run out of Natural Gas." *Haaretz*, February 2, 2012. http://www.haaretz.com/misc/iphone-article/forecast-blackout-israel-is-about-to-run-out-of-natural-gas-1.410513.

Bard, Mitchell G. "The Evolution of Israel's Africa Policy." The American-Israeli Cooperative Enterprise, 2012. http://www.jewishvirtuallibrary.org/jsource/Politics/africa.html.

Bayraktutan, Yusuf, Metehan YilgÖr, and Sefer UÇak. "Renewable Electricity Generation and Economic Growth: Panel-Data Analysis for Oecd Members." *International Research Journal of Finance and Economics*, no. 66 (2011).

"Bilateral Relations: Israel and Colombia." Israel Embassy in Colombia, http://bogota.mfa.gov.il/mfm/web/main/document.asp?SubjectID=18365&MissionID=17&LanguageID=502&StatusID=0&DocumentID=-1.

"Brotherhood of Hate: Muslim Brotherhood's Hatred for Jews and Israel Flourishes in "New" Egypt." Anti-Defamation League, February 19, 2011. http://www.adl.org/main_International_Affairs/muslim_brotherhood?Multi_page_sections=sHeading_2.

Cashman, Greer Fay. "Colombia Seeks to Broaden Israel Ties." Jerusalem Post Online, April 29, 2010. http://www.jpost.com/International/Article.aspx?ID=174179.

Castillo, Mariano. "How Deep Are Relations between Colombia and Venezuela?" CNN, December 3, 2011. http://www.cnn.com/2011/12/03/world/americas/venezuela-colombia/index.html.

"Coal in Electricity Generation." World Coal Association, 2011. http://www.worldcoal.org/resources/coal-statistics/.

"Coming Clean: The Cleantech Global Innovation Index 2012." World Wildlife Fund, Cleantech Group LLC, 2012.

Dror, Sharon. "Ormat Industries Launches New Wing at Yavne Plant to Double Production Capacity." *Israel Gateway; Israel's Foreign Trade Portal,* September 22, 2009. http://www.israelgateway.com/articles/296/.

"Electricity: Average Price of Electricity by Sector." Israel Central Bureau of Statistics. http://www1.cbs.gov.il/energy/.

"Electricity Production and Environment." Ministry of Environmental Protection, 2009. http://www.sviva.gov.il/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Zone&enDispWho=Electricity_Production&enZone=Electricity_Production.

"Energy Content of Fuels." US Naval Academy Chemistry Department, 2003.

"Energy Projects." Ministry of Environmental Protection, 2010. http://www.sviva.gov.il/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Zone&enDispWho=Energy_Projects_cdm&enZone=Energy_Projects_cdm.

"Environment and Safety." Israeli National Coal Ash Board (NCAB), http://www.coal-ash.co.il/english/env.html.

"Environment: OECD Supports Israeli Initiative to Develope a Green Growth Plan." OECD, 2011. http://www.oecd.org/document/59/0,3746,en_21571361_44315115_49002107_1_1_1_1,00.html.

"Environmental Impacts of Renewable Energy Technologies." Union of Concerned Scientists; Citizens and Scientists for Environmental Solutions, 2002. http://www.ucsusa.org/clean_energy/technology_and_impacts/impacts/environmental-impacts-of.html

Farzad, Roben. "Israel's Clean Technology Pioneers." Bloomberg Businessweek, May 7, 2009. <http://www.businessweek.com/magazine/content/09_20/b4131034558887.htm%3E.

"Forestry & Ecology." Jewish National Fund (JNF), http://www.jnf.org/work-we-do/our-projects/forestry-ecology/.

Fthenakis, Vasillis, and Hyung Chul Kim. "Land Use and Electricity Generation: A Life-Cycle Analysis." *Renewable and Sustainable Energy Reviews* (July 23 2008): 2.

Gilad, Assaf. "4 Joint Us-Israel Cleantech Ventures." *Ynet News*, 2011. <http://www.ynetnews.com/articles/0,7340,L-4130446,00.html%3E.

"Gini Index." Investopedia, http://www.investopedia.com/terms/g/gini-index.asp.

"Golan Heights (Israel/Syria) Historical Chronology." UN Security Council Report, 2012. http://www.securitycouncilreport.org/site/c.glKWLeMTIsG/b.2692939/.

Golan, Lee. "Israel Plans To Spearhead Transition From Oil To Alternative Fuels." *Nocamels.com - Israeli Innovation News*. June 29, 2011. http://nocamels.com/2011/06/israel-plans-to-spearhead-transition-from-oil-to-alternative-fuels/.

"Government Ratifies Kyoto Protocol." Ministry of Environmental Protection, 2004. http://www.sviva.gov.il/Enviroment/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Object&enDispWho=News%5El1674&enZone=e_news

"Greenhouse Gas Emissions-Electricity/Heat; Israel." World Resources Institute, Google Public Data Explorer.

"Green Sun Lights." Israeli Air Force, 2011. http://www.iaf.org.il/4375-38191-EN/IAF.aspx.

Greenwood, Phoebe. "Israel and Azerbaijan: Unlikely Allies?" *The Guardian*, March 29, 2012. http://www.guardian.co.uk/world/blog/2012/mar/29/israel-azerbaijan-unlikely-allies.

"The Grey Resource." Israeli National Coal Ash Board (NCAB), http://www.coal-ash.co.il/english/index.html.

Gruber, Jonathan. *Public Finance and Public Policy*. 3rd ed. 1 vols New York: Worth Publishers, 2011.

"Highlights of Main Events-1984-1988 Volume 9-10: 1984-1988." Israel Ministry of Foreign Affairs, http://www.mfa.gov.il/MFA/Foreign Relations/Israels Foreign Relations since 1947/1984-1988/HIGHLIGHTS OF MAIN EVENTS- 1984-1988.

"How Fossil Fuels Were Formed." US Department of Energy, http://www.fe.doe.gov/education/energylessons/coal/gen_howformed.html.

"International Ozone Day-September 16, 2010." Minstry of Environmental Protection, 2010. http://www.sviva.gov.il/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Object&enDispWho=News%5El5286&enZone=e_news.

"Israel and Alternative Energy: Innovation and Progress." In *The Israel Project: Facts for a Better Future*. The Israel Project Jerusalem Office, 2011.

Katz, Jason. "Azerbaijan and Israel: Not a Typical Relationship." *The Huffington Post*, March 22, 2010. http://www.huffingtonpost.com/jason-katz/azerbaijan-and-israel-not_b_509229.html.

Katz, Yaakov. "Idf to Use Solar Charget on Battlefield." (January 21, 2009). Published electronically January 21. http://www.jpost.com/Israel/Article.aspx?id=163878

"Ketura Sun." Arava Power Company, http://www.aravapower.com/Field Profile.

Kloosterman, Karin. "A Clean, Green Israel Showcase." *Israel 21c*, July 31, 2011. <http://israel21c.org/environment/a-clean-green-israel-showcase%3E.

"The Land: Geography and Climate." Israel Ministry of Foreign Affairs, http://www.mfa.gov.il/MFA/Facts+About+Israel/Land/THE+LAND-+Geography+and+Climate.htm

"Maps of Radiation for the Mediterranean Basin." Solar Radiation Data (SoDa); Solar Energy Serivces for Professionals, copyright Commission Européenne - Mines ParisTech / Armines 2006.

Mincer, Shifra. "Suntech Eyes Israel as Country Shifts More Clearly to Solar." Aol Energy via The Times of Israel, March 26, 2012. http://energy.aol.com/2012/03/26/suntech-eyes-israel-as-country-shifts-more-clearly-to-solar/.

Moskowitz, Ira. "Israel PM Declares a 155 Mw Wind Farm Project on Golan Heights a 'National Project'." *Green Prophet*, September 23, 2010. http://www.greenprophet.com/2010/09/netanyahu-wind-farmnational/.

"The Natural Gas Sector in Israel." State of Israel: Ministry of Energy and Water, 2011. Resources http://energy.gov.il/English/Subjects/Natural Gas/Pages/GxmsMniNGEconomy.aspx

"Noise Pollution." United States Environmental Protection Agency, http://www.epa.gov/air/noise.html.

Odeh, Yousre. "Wind Power Potential in Palestine/Israel; an Investigation Study for the Potential of Wind Power in Palestine/Israel, with Emphasis on the Political Obstacles." Gotland University 2011.

Omer, Inbal. "Enlight to Build 45 Pv Units at Idf Bases." *Globes*. (January 23, 2011). http://www.globes.co.il/serveen/globes/docview.asp?did=1000617318&fid=1725.

Popper, Steven W. *Natural Gas and Israel's Energy Future : Near-Term Decisions from a Strategic Perspective* [in English and Hebrew.]. Santa Monica, CA: RAND, 2009.

"Public Utility Authority-Electricity." The State of Israel: Public Utility Authority-Electricity, http://www.pua.gov.il/86-he/Electricity.aspx.

Rak, Na'ama. "Idf Goes Green." (December 20, 2009). http://dover.idf.il/IDF/English/News/today/09/12/2001.htm.

Rifkin, Jeremy. *The Third Industrial Revolution : How Lateral Power Is Transforming Energy, the Economy, and the World*. New York: Palgrave Macmillan, 2011.

Rinat, Zafrir. "Israeli Greens Opposing Wind-Power Plan." *Haaretz*, March 4, 2012 http://www.haaretz.com/news/national/israeli-greens-opposing-wind-power-plan-1.422227.

Rubin, Edward S., and Cliff I. Davidson. *Introduction to Engineering and the Environment*. 1st ed. Boston: McGraw-Hill, 2001.

"Russia Says Would Be Threatened by Iran Military Action." *Reuters*, January 13, 2012. http://www.reuters.com/article/2012/01/13/us-iran-russia-nato-idUSTRE80C1BI20120113.

Samaras, Costa. "Innovative Technologies Case Study: Wind and Solar Electricity." 2009.

Sandler, Neal. "At the Zenith of Solar Energy." *Bloomberg Businessweek*. March 26, 2008. http://www.businessweek.com/globalbiz/content/mar2008/gb20080326_485582.htm?chan=globalbiz_europe+index+page_companies.

Seigel, Robert. "Darrag Discusses the Future of Egypt." National Public Radio (NPR), January 26, 2012.

Senor, Dan, Saul Singer, and Council on Foreign Relations. *Start-up Nation : The Story of Israel's Economic Miracle*. 1st ed. New York: Twelve, 2009.

Shaltiel, Eli. *Pinchas Rutenberg: Aliyayo U-Nefilato Shel "Ish Hachazak" B-Eretz Yisrael, 1879-1942* [in Hebrew] [*The Ascent and Downfall of "The Strong Man" in the Land of Israel 1879-1942*] Tel Aviv: Am Oved, 1990.

Shear, David. "8 Israeli Companies Win Cleatech Awards." *Ynets News,* November 13, 2011. http://www.ynetnews.com/articles/0,7340,L-4144110,00.html.

Smil, Vaclav. *Energy at the Crossroads : Global Perspectives and Uncertainties*. Cambridge, Mass.: MIT Press, 2003.

Tal, Alon. *Pollution in a Promised Land: An Environmental History of Israel*. Berkeley: University of California, 2002.

Trilnick, Itai. "Electricity Rates to Rise 9% in April." *Haaretz*, March 23, 2012. http://www.haaretz.com/business/electricity-rates-to-rise-9-in-april-1.420289.

Tumbale, Spencer, and Vyshaali Jagadeesan. "Solar V.S Wind Energy." https://sites.google.com/site/anatomyofglobalclimatechangevj/data-and-analysis.

Udasin, Sharon. "Israel, Cyprus, Greece Sign Electric Cable Deal." *The Jerusalem Post*, April 3, 2012. http://www.jpost.com/DiplomacyAndPolitics/Article.aspx?ID=260410&R=R1

———."Experts Call Israel a 'Laboratory' for Eco-Innovation." *The Jerusalem Post*, July 13 2011. http://www.jpost.com/Sci-Tech/Article.aspx?id=229096.

"Unemployment." Investopedia, http://www.investopedia.com/terms/u/unemployment.asp - axzz1oH4pgYhy.

"Wind Power-Alternative Energy." Mei Eden, http://www.meyeden.co.il/article.asp?page=wind.

Yanai, Moshe, Jean Koch, and Uri Dayan. "Trends in CO_2 Emissions in Israel- an International Perspective." In *Climate Change*, 2009.