Ministry of Environmental Protection

State of Israel

Israel's Second National Communication on Climate Change

Submitted under the United Nations Framework Convention on Climate Change

Jerusalem • November 2010

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Foreword by the Minister of Environmental Protection

On behalf of the Government of Israel, it is an honor and a privilege to present Israel's Second National Communication to the Conference of the Parties to the United Nations Framework Convention on Climate Change.

Much has happened in Israel since we submitted our First National Communication on Climate Change a decade ago. We ratified the Kyoto Protocol, established a Designated National Authority for Clean Development Mechanism projects, conducted studies on greenhouse gas mitigation, constructed a carbon abatement cost curve, prepared an initial adaptation assessment, and launched a voluntary registry for greenhouse gas emissions accounting and reporting.

Israel is a small, densely populated country characterized by an expanding population and economic growth against a backdrop of land and water scarcity. Under a "business as usual" scenario, forecasts indicate that mounting energy consumption coupled with escalating traffic congestion would bring about significant increases in greenhouse gas emissions by 2020. We are determined to change this trend, and our government has committed to making best efforts to achieve a 20% reduction in greenhouse gas emissions in comparison to a business as usual scenario by 2020.

Israel regards itself as a full and active partner in global efforts to promote a low carbon economy. Just over a year ago, our cabinet approved the establishment of a Ministerial Committee on Environmental Protection and Climate Change, underlining the new priority given to advancing climate change policy in Israel. Interministerial committees and expert teams are now working diligently to formulate a national climate change plan which will include both adaptation measures and a national action plan for the reduction of greenhouse gas emissions.

Since its creation some 62 years ago, the State of Israel has invested major efforts in research and development in order to overcome the country's scarcity of natural resources, especially energy, land and water. It has faced these challenges by developing cutting edge technologies in such fields as efficient management of water resources (including drip irrigation and wastewater reuse), desalination, solar energy, sophisticated agriculture and afforestation, and innovative approaches to prevent and combat desertification. Based on its accumulated experience with the management of limited water resources, intense solar radiation and high temperatures, Israel can well contribute technological solutions for reducing greenhouse gas emissions worldwide. Accordingly, Israel is ready to serve as a regional laboratory and center of excellence to prepare for and adapt to changing climatic conditions.

Protecting our planet from the ravages of climate change requires concerted efforts and mutual assistance. Israel is willing and able to shoulder its responsibilities to the best of its ability together with members of the global community. At the same time, our advanced technologies provide us with new opportunities to find innovative solutions to the challenges lying ahead, in terms of both mitigation and adaptation, and to transfer these innovative technologies to countries worldwide.

Israel's Second Communication on Climate Change outlines both our achievements and our challenges. Dozens of professionals contributed to the report hailing from every sector of Israeli society – central government, local government, the industrial sector, the electricity sector, academic and research institutions, and non-governmental organizations. Their combined efforts will hopefully make a difference in the coming years.

I believe that the information contained in this comprehensive report will help us progress on the road to a low carbon economy. I have no doubt that our efforts to both mitigate climate change and to adapt to its consequences will lead to economic, social and environmental benefits to our country as well as to people everywhere.

MK Gilad Erdan
Minister of Environmental Protection

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Acronyms

BAU	Business as Usual
BCM	Billion Cubic Meters
BGU	Ben Gurion University
BIRD	Israel-U.S. Binational Industrial Research and Development Foundation
BSF	United States-Israel Binational Science Foundation
CBD	Convention on Biological Diversity
CBS	Central Bureau of Statistics
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CFC	Chlorofluorocarbons
CFL	Compact Fluorescent Lamps
CGE	Computable General Equilibrium
CINADCO	Center for International Agricultural Development
CIRCLE	Climate Impact Research Coordination for a Larger Europe
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2 eq	Carbon Dioxide Equivalent
COP	Conferences of the Parties
CH_4	Methane
CPV	Concentrating photovoltaic
CST	Concentrated solar thermal
EU	European Union
EV	Electric Vehicle
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GWP	Global Warming Potential
HFCs	Hydrochlorocarbons
HVAC	Heating, Ventilating and Air Conditioning
ICE	Internal Combustion Engine
IEA	International Energy Agency
IEC	Israel Electric Corporation

IMS	Israel Meteorological Service
IOLR	Israel Oceanographic and Limnological Research
IPCC	Intergovernmental Panel on Climate Change
ITS	Intelligent Transportation Systems
KLL	Kinneret Limnological Laboratory
KKL-JNF	Keren Kayemeth LeIsrael-Jewish National Fund
IALC	International Arid Land Consortium
IRENA	International Renewable Energy Agency
LCGP	Low Carbon Growth Plan
LPG	Liquefied Petroleum Gas
MARD	Ministry of Agriculture and Rural Development
MCCI	Manufacturing, Construction, Commercial and Institutional
MDG	Millennium Development Goals
MDI	Metered Dose Inhalers
MFA	Ministry of Foreign Affairs
MNI	Ministry of National Infrastructure
MoEP	Ministry of Environmental Protection
MoT	Ministry of Transport
N_2O	Nitrous Oxides
NH_3	Ammonia
NOx	Nitrogen Oxides
NGO	Non-Governmental Organization
NIS	New Israeli Shekel
NMVC	Non Methane Volatile Organic Compounds
OECD	Organization for Economic Cooperation and Development
PETAL	Photon Energy Transformation & Astrophysics Laboratory
PFC	Perfluorocarbon
PHEV	Plug-in electric vehicle
PPP	Purchasing Power Parity
PUA	Israel Public Utilities Authority - Electricity
PV	Photovoltaic
R&D	Research and Development

SF_6	Sulfur Hexafluoride
SO_2	Sulfur Dioxide
TAU	Tel Aviv University
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNEP	United Nations Environment Programme
WEAP	Water Evaluation and Planning System
WFP	World Food Program
WIS	Weizmann Institute of Science
WMO	World Meteorological Organization
WSSD	World Summit on Sustainable Development

Measures and Units

°C	Degree Celcius
$	United States Dollar
€	Euro
cm	Centimeter
GW	Gigawatt
GWh	Gigawatt hour
ha	Hectare
kg	Kilogram
kha	Thousand hectares
km	Kilometer
km^2	Square kilometer
Kt	Thousand tons
kWh	Kilowatt hour
MCM	Million Cubic Meters
Mt	Million (mega) ton
MW	Megawatt
mg	Milligram

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1 Executive Summary

1.1 National Circumstances

Israel is about 470 kilometers (km) in length and 135 km in width at its widest point. Just 22,000 km^2 in size, Israel makes up for its small size with a varied topography and climate. Arid zones comprise 45% of the area of the country. The rest is made up of plains and valleys (25%), mountain ranges (16%), the Jordan Rift Valley (9%) and the coastal strip (5%).

Israel lies in a transition zone between the hot and arid southern part of West Asia and the relatively cooler and wet northern Mediterranean region. As a result, there is a wide range of spatial and temporal variation in temperature and rainfall. The climate of much of the northwestern part of the area is typically Mediterranean, with mild rainy winters, hot, dry summers and short transitional seasons. The southern and eastern parts are much drier, with semi-arid to arid climate. Throughout the area, summers are completely dry, requiring irrigation for crop production.

Israel's population at the end of 2009 reached 7.5 million residents, an eight-fold increase since its establishment in 1948. From a sparsely populated country, Israel has been transformed into a densely populated country, especially along the Mediterranean coastline. Some 92% of the population lives in an area which covers only 40% of the state's land. While average population density at the end of 2008 was 321 per square km, population density reached 7,134 per square km in the Tel Aviv district, versus 1,394 in Jerusalem and only 74 in the southern district.

Economic growth was very high (10% annual growth in GDP) in the first 25 years of Israel's existence, reflecting high immigration and accelerated development. GDP growth rates fluctuated over the years, with an average growth rate of 3% between 1997 and 2003 and 5.4% between 2004 and 2008.

Due to the lack of raw materials, industry has concentrated on manufacturing products with a high added value. Most of the country's resources have been devoted to building up its industrial exports, which have grown from $13 million in 1950 to $40.6 billion in 2008. Major industries include pharmaceuticals, electronics, agrotechnology, telecommunications, fine chemicals and computers.

The highest growth rates are in the high-tech sectors which are skill and capital intensive and require sophisticated production techniques as well as considerable investment in research and development.

The percentage of Israel's population which is engaged in scientific and technological research is among the highest in the world, and relative to the size of its labor force, the country is a world leader in the number of published authors in various fields. Israel also ranks as a world leader in the percentage of GDP dedicated to R&D.

Lack of water resources is the most severe constraint on agriculture in Israel. To meet the challenge, Israel has developed innovative methods, including highly mechanized, high-input methods and water-saving irrigation systems which have enabled it to become a leader in high-yielding agriculture. Today, agriculture accounts for nearly 60% of the water used, but approximately half of this water constitutes effluents and marginal water.

Population and economic growth in Israel have led to a dramatic increase in the number of cars – from 70,000 in 1960 to 2,391,000 by 2008. The development of public transportation has lagged behind private vehicles, but the past decade has seen a major increase in railway passengers, with their number increasing by more than ten-fold, reaching 35 million passengers by 2008.

Israel mostly relies on imported fossil fuels, especially coal, for energy generation. Since the mid 2000s, the use of natural gas has increased significantly and replaced most of the petroleum-based power generation. Electricity production has grown dramatically over the years. Between 2000 and 2008, electricity production increased from 41.4 to 54.5 billion kWh and peak demand increased from 7,900 to 10,200 MW.

1.2 National Greenhouse Gas Inventory

Israel's national greenhouse gas inventory relates to emissions and removals of the three main greenhouse gases: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), and to indirect greenhouse gases which are precursors of tropospheric ozone: carbon monoxide (CO), oxides of nitrogen (NO_x) and non-methane volatile organic compounds (NMVOCs). It also relates to sulfur dioxide (SO_2), an aerosol precursor which has a cooling effect on climate. In 2009, for the first time, data for hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6) were collected, and these gases will be included in future inventories.

By far the largest anthropogenic source of CO_2 emissions is the oxidation of carbon when fossil fuels are burned to produce energy. In 2007, about 65 million tons of CO_2 were emitted by this process compared to 50 million tons in 1996. The energy industries (power plants and oil refineries) are the largest source of CO_2 emissions (65%), followed by transport (23%). Cement production is the most important non-energy industrial process emitting CO_2. The continuous expansion of forests

Table 1.1 *Summary of GHG inventory (CO_2eq)*

(Thousand Tons unless stated otherwise)	1996	2000	2003	2004	2005	2006	2007
TOTAL	62,705	72,439	72,136	72,691	73,296	74,641	76,854
Tons per capita	11.03	11.52	10.78	10.68	10.58	10.58	10.70
Tons per GDP (2005 US Dollars PPP)	0.52	0.50	0.49	0.47	0.45	0.44	0.43
Carbon Dioxide (CO_2)	51,862	61,007	63,841	63,888	64,026	65,092	67,061
Methane (CH_4)	8,945	9,226	5,690	6,068	6,534	6,781	6,842
Nitrous Oxides (N_2O)	1,897	2,206	2,606	2,735	2,737	2,767	2,952

Source: CBS and Jean Koch et al

Table 1.2 *Recent government decisions related to climate change*

Government Decision	Content of the Decision
September 2007	Action plan on the reduction of air pollution from transportation sources
January 2008	Promotion of clean energy use by means of green taxes
August 2008	Five year (2008-2012) investment program for renewable energy, including establishing an R&D center for renewable energy technologies in the Negev
September 2008	Energy efficiency as a means of tackling climate change, with the aim of bringing about 20% savings in anticipated electricity consumption by 2020
January 2009	Establishment of targets and tools for the promotion of renewable energy including generation of 10% of Israel's electricity from renewable sources by 2020
June 2009	Establishment of a directors-general committee to prepare a climate change policy and to formulate mitigation and adaptation action plans
December 2009	Greening Government Initiative with quantitative, measurable targets for energy conservation, water savings and waste reduction and recycling
March 2010	Establishment of an interministerial committee on formulating a national plan for the reduction of GHG emissions

in Israel allows for only minor removal of CO_2 from the atmosphere.

The decomposition of solid waste is the largest source of methane emissions in Israel, constituting 7% of the total CO_2 equivalent (CO_2 eq) emissions in 2007. Total methane emissions in 2007 were estimated at 250,000 tons for solid waste, 5,900 tons for domestic wastewater and 22,300 tons for industrial wastewater. Methane is also produced through two processes in agriculture associated with domestic livestock husbandry: enteric fermentation and manure management. In 2007, annual methane emissions in the agricultural sector amounted to 44 thousand tons, 1.2% of the total CO_2 eq emissions. About 77% are contributed by enteric fermentation and about 23% by manure management.

The contribution of N_20 emissions from agriculture is dominant. Emissions are attributed to direct emissions from agricultural soils, manure management and animal grazing and indirect emissions from agriculture. N_20 emissions from agriculture totaled 5.16 thousand tons in 2007.

The inventory demonstrates the following with regard to indirect GHGs:

- NO_x: From 1996 to 2007, NO_x emissions from fuel combustion decreased at a rate of 7%, mostly due to improved vehicle technology.
- CO: From 1996 to 2007, CO emissions decreased at a rate of more than 50%, mostly due to improved vehicle technology.
- NMVOC: From 1996 to 2007, NMVOC emissions, which are emitted almost exclusively by transportation sources, have increased at a rate of 11%.
- SO_2: From 1996 to 2007, SO_2 emissions have decreased at a rate of close to 40%, mostly due to enhanced fuel quality and technological improvements in power plants.

Table 1.1 summarizes the emissions and removals of the direct GHGs from the different sectors, as estimated for the years 1996, 2000 and 2003-7. CH_4 and N_2O emissions are converted to CO_2 eq by means of the Global Warming Potential (GWP-time horizon of 100 years).

Total emissions grew by approximately 23% in the period between 1996 and 2007. Emissions per capita and GDP, however, decreased by 3% and 17% respectively. The major GHG, CO_2, dominated the increase in emissions with a 29% increase rate, followed by N_20 with an increase rate of 56%. CH_4 had a mediating effect with a 24% decrease rate due to the collection of biogas in landfills.

Within the energy sector, responsible for 85% of total GHG emissions in 2007, the energy industries, which constituted the main source of emissions, increased their emissions by 49%, followed by transport with a 38% increase rate; manufacturing industries and agriculture decreased their emissions by 9% and 82%, respectively. Emissions from industrial processes grew by 29%, while removals from forestry and the land-use change sector grew by 8%.

Following are some of the other salient findings for the period 1996-2007:

- Methane emissions decreased by 24%, mostly due to a 33% decrease in emissions from solid waste handling.
- N_20 emissions grew by 55%, with agriculture contributing an increase rate of 35%, mostly from agricultural soils, and energy contributing a 26% increase rate.
- Emissions of most of the indirect GHGs decreased, except NMVOCs, which remained unchanged. Emissions of NO_x, CO and SO_2 decreased by 8%, 53% and 29%, respectively. This trend is mostly attributed to improvements in the energy industries and transport.

1.3 Existing Policies and Measures

1.3.1 Climate Change Policy and Government Decisions

In line with Israel's environmental policy, various actions have been taken in recent years to improve environmental quality and promote sustainable development. Some contribute directly toward the mitigation of GHG emissions or towards adaptation to climate change. Others contribute indirectly to the achievement of these goals. In this context, five landmarks in Israel's environmental policy during the past decade are noteworthy:

1. Setting a target for assimilation of renewable energy in Israel.
2. Paving the path towards sustainable development policy.
3. Setting responsibilities and obligations for reduction of air pollution.
4. Preparing a climate change plan for Israel.
5. Setting a target for 20% reduction in GHG emissions by 2020 compared to a business as usual scenario.

Table 1.2 lists recent relevant government decisions on mitigation and adaptation.

1.3.2 Mitigation Measures

In addition to actions taken at the policy level, many mitigation measures have been taken by various stakeholders in Israel:

- During the second half of the last decade, the electricity industry introduced natural gas into the energy mix of Israel. New combined-cycle power plants designed to operate on natural gas were constructed and existing plants were converted to natural gas. By the end of 2009, natural gas composed nearly 35% of the total electricity production capacity in Israel.
- Since the mid-1970s the residential sector is required by law to use solar water heating systems.
- Two solar thermal power plants at a capacity of 250 MW are in planning in the southern Negev region of Israel.
- Economic incentive measures for renewable energy have been developed by the Israel Public Utilities Authority – Electricity (PUA) for the sale of renewable energy to the IEC and the related feed-in tariff and licensing arrangements for solar thermal generation.

Table 1.3 *Summary of vulnerable sectors and adaptation options*

Vulnerable Sector	Possible Impacts	Adaptation Options
Water Resources	• Reduction in water availability in aquifers and surface water bodies • Deterioration of water quality • Increased probability of flood events	• Expansion of desalination capacity • Efficient water use and effective water economy management • Improved modeling • Increased public awareness and change of consumption patterns • Enhanced water quality and quantity monitoring and modeling • Reassessment of water quality standards • Enhanced collaboration of authorities and institutions • Improved wastewater and drainage infrastructure • Enhanced management of the land-use interface in flood-sensitive areas
Agriculture	• Shortage in water supply for agriculture • Damages to crop productivity due to water deficiency and extreme climate conditions • Changes in crop growing seasons • Salination and erosion of soil • Reduced productivity of farm animals • Shortage in fresh animal feed • Increased risks of pests and farm animal diseases	• Increased use of treated effluents in agriculture • Efficient use of water and better adjustment of crop location to water availability • Better modeling and forecasts • Technological improvements in irrigation and cultivation methods and implementation of cultivation methods that prevent soil loss • Genetic improvements in crops and farm animals • Expansion and adjustment of crop varieties • Adjustment of planting and harvesting dates • Improvement of climate control systems in livestock farms • Development of substitutes for grains in animal feed • Selection of cattle species resistant to heat and pests and adaptation of animal husbandry methods
Coastal Zone	• Coastal retreat • Sand removal • Damages to coastal infrastructure and tourism • Salination of the coastal aquifer • Damages to the coastal cliff • Increased probability for the invasion of marine alien species • Coral bleaching in the Red Sea	• Incorporation of climate change implications into land-use planning • Enhanced monitoring of sea level and coasts • Adaptation of coastal infrastructure • Use of sea protections and sand nourishment techniques • Enhanced international trade control to prevent invasion of exotic marine species • Prevention of sea pollution in order to reduce stress on coral reefs

Vulnerable Sector	Possible Impacts	Adaptation Options
Human Health	• Increased incidence of parasitic and infectious diseases • Increased thermal stress • Increased risk of damages from extreme weather events	• Enhanced control and monitoring of disease carrying vectors and risk assessment • Training of health experts • Improvement and adaptation of health systems to climate change risks • Public education • Improved urban planning to reduce heat stress and air pollution
Ecosystems & Biodiversity	• Loss of plant species in the semi-arid region due to desertification • Damage to local animal species populations • Changes in species composition in the Sea of Galilee • Damages to nature reserves • Increased likelihood of forest fires	• Incorporation of climate change implications in the management of conservation areas and the establishment of ecological corridors • Research, monitoring and mapping of species vulnerability to climate change impacts • Enhanced management of forest resources along with their human interface • Forest thinning • Genetic improvements in forest tree species • Selection of resistant tree species for afforestation
Energy & Infrastructure	• Increased energy demand due to harsher heat stress, particularly during peak heat waves • Damage to infrastructure in vulnerable areas	• Use of renewable energy to meet increased energy demand • Increased energy efficiency • Adaptation of building regulations to new climatic conditions • Identification and protection of vulnerable infrastructure and industries • Enhanced resource management
Economy	• Damage to public and private property • Increased costs for goods and services • Higher burden on the insurance industry	• Cost benefit analysis of adaptation action vs. inaction in selected fields • Economic incentives that promote adaptation to anticipated climatic changes • Risk analysis for the insurance industry

- Initiatives for the promotion of wind energy and biogas and bio-diesel energy have been set in motion in recent years.
- The MoEP and the S. Neaman Institute for Advanced Studies in Science and Technology prepared a protocol for a GHG registry, intended to develop capabilities and tools for use by the private sector, industries and organizations to estimate their reduction potential.
- In 2004, a Designated National Authority for authorizing Clean Development Mechanism (CDM) projects in Israel was established, with nearly 50 projects submitted for approval to date, of which 16 have been registered with the UN.
- The introduction of catalytic converters in gasoline vehicles led to a reduction of total CO emissions from gasoline vehicles from 352 thousand tons in 2000 to 190 thousand in 2008.
- In 2009, a major energy conservation campaign was inaugurated by the MNI, the MoEP and the IEC to raise awareness of energy efficiency among the general public, with major emphasis on energy efficient appliances.
- In February 2008, the mayors of major cities in Israel signed the Convention of the Forum 15 for Reducing Air Pollution and for Climate Protection (CCP Israel).
- Numerous standards related to climate change mitigation were published in recent years, including a green building standard, a standard on the energy rating of residential buildings and a standard for energy systems management.
- In July 2007, a landfill levy entered into effect, which aims to reflect the true cost of landfilling and thereby allow competition with advanced treatment methods such as recycling and energy recovery.
- Most of Israel's operational landfills collect methane, with a 40% collection rate from total methane emissions from this source.
- Twelve wastewater treatment plants collect methane from sludge. Some use the collected methane to produce energy, while others transfer it to a thermal treatment plant for burning.
- A dairy farm reform has been completed which included construction of manure storage facilities, installation of drainage systems to reduce pollution from dairy cow wastes, and construction of biogas facilities. A similar program has recently started in the egg laying sector.
- Israel has one of the highest ratios of planted forests to natural woodlands (2:1). The planted forest area in Israel grew between 2000 and 2008 from 941 to 980 km^2.

1.4 Vulnerability and Adaptation to Climate Change

In comparison to the years 1961-1990, the A1B scenario of the IPCC, predicts a rise of 1.5° C in Israel's average temperature by 2020. According to IPCC scenarios A2 and B2, average temperature in the years 2071-2100 is expected to increase further by 5° C and 3.5° C, respectively. In addition, a 10% decrease in precipitation is expected by 2020, reaching a 20% decrease by 2050.

Another expected impact is an increase in the number of extreme events in Israel, along with a decrease in the amounts of seasonal rain. The differences in average precipitation from year to year are expected to increase compared to today. Furthermore, the intervals between dry spells and wet spells are also expected to increase. This indicates a tendency towards a more arid climate in Israel, which conforms to the IPCC forecasts for 2100.

The preparation of a vulnerability assessment to climate change and an adaptation plan to confront potential risks and opportunities is of vital importance to Israel due to its lack of adequate water resources and the vulnerability of the semi-arid climate. To address the challenges of climate change adaptation, the MoEP set up an interministerial steering committee in 2006 to check the potential impacts of climate change on Israel. By the summer of 2008, an initial report was published which addresses the anticipated impacts of climate change on Israel and presents interim recommendations on adaptation measures in each of the following sectors: water, , agriculture, coastal zone, public health, biodiversity, energy and infrastructure and the economy. These recommendations are to be developed into a national plan on climate change adaptation, which will integrate preparations for climate change in the strategic planning systems of the various economic, social and environmental sectors.

Accordingly, and following a government decision on the preparation of a climate change plan for Israel on both mitigation and adaptation measures, working groups on adaptation have been appointed. These groups are charged with bridging the gaps in existing knowledge on the impacts of climate change in Israel based on different scenarios, surveying available means for minimizing damage and vulnerability and identifying Israeli technologies for dealing with climate change that may assist other countries as well.

Although the challenges are formidable, Israel has amassed wide experience in developing cutting-edge technologies and effective management systems in such fields as water management, recycling and reuse of treated wastewater, seawater desalination, desert agriculture and afforestation, which may assist neighboring and other countries. Therefore, Israel is looking at the feasibility of establishing an information and knowledge center for adaptation to global climate change.

Table 1.3 summarizes Israel's potential impacts and adaptation options.

1.5 Forecast and Mitigation Options

Reduction of GHG emissions is an especially difficult challenge in Israel, a country with limited resources that is undergoing economic growth against a backdrop of continuous increases in both population and energy consumption. In order to meet the challenge, special emphasis has been placed on building GHG emissions scenarios while focusing on the necessary steps to reduce these emissions in an economically viable manner.

Within this process, the MoEP commissioned two studies: a survey of GHG emissions in Israel, future forecasts and mitigation options (the Heifetz study) and a carbon abatement cost curve for Israel that quantifies a range of measures across sectors (the McKinsey study). In addition, the S. Neaman Institute, Technion, is preparing a study on the implementation of the conclusions of both studies.

1.5.1 The Heifetz Study

The Heifetz study quantified Israel's abatement potential via mitigation measures in the relevant sectors (energy, transport, industry, waste, etc.), using a detailed cost/benefit analysis. In order to estimate the scope of GHG emissions in the coming decades in Israel, the Heifetz study constructed a baseline forecast termed the business as usual scenario (BAU). Mitigation options in the different sectors were reviewed, analyzed and compared with the BAU scenario in order to fully comprehend Israel's mitigation potential. As the energy sector is the major sector with regard to GHG emissions in Israel, the study focused on this sector.

The following table summarizes the foreseen emissions from all sectors until the year 2025, according to the Heifetz study.

Table 1.4 *Summary of CO_2 eq emissions from all sectors (BAU)*

	2000	2006	2010	2015	2020	2025
Total emissions CO_2 eq (1000 tons)	72,436	76,499	76,824	89,868	106,870	118,003
Emissions index (2000=100)	100	105	106	124	148	163

Source: Heifetz Study

Table 1.5 *Summary of mitigation potential*

Mitigation Options	Savings Potential of CO_2 eq. (million tons)	NIS cost per saved ton of CO_2 eq
Wind Energy	1.8	50
Solar energy	3.6	226
Energy-conscious building	8.9	(236)
Efficient lighting	2.6	(236)
Appliance efficiency	6.7	(238)
Green roofs	1.3	0
Reduction of electricity consumption (5%)	5.0	(237)
Reduction in mileage and fuel consumption (transport)	1.7	351
Total	**31.7**	

Source: Heifetz Study

Under a BAU scenario, a 63% increase in GHG emissions is expected from 2000 to 2025. This increase stems mostly from an increase in fuel combustion in the energy sector, mainly in the following sub-sectors: energy industries (49%), transport (43%) and manufacturing and construction (250%). Israel's potential for reducing these emissions and their associated costs are summarized in Table 1.5.

Following are the major conclusions of the Heifetz study:

- In the year 2025, under the BAU scenario, total expected emissions will reach 118 million tons of CO_2 eq, whereas potential abatement measures will total 31.7 million tons.
- Emissions per capita are expected to grow from 11.4 tons in 2000 to 12.7 in 2025 (+11%) under BAU or decrease to 9.3 tons (-18%) under the mitigation scenario.
- Under BAU, a 63% increase in emissions is expected from 2000 to 2025. Applying all the surveyed mitigation measures will drop the increase to 19% (27% less than expected emissions under BAU).

1.5.2 McKinsey Cost Curve for the Abatement of Greenhouse Gas Emissions in Israel

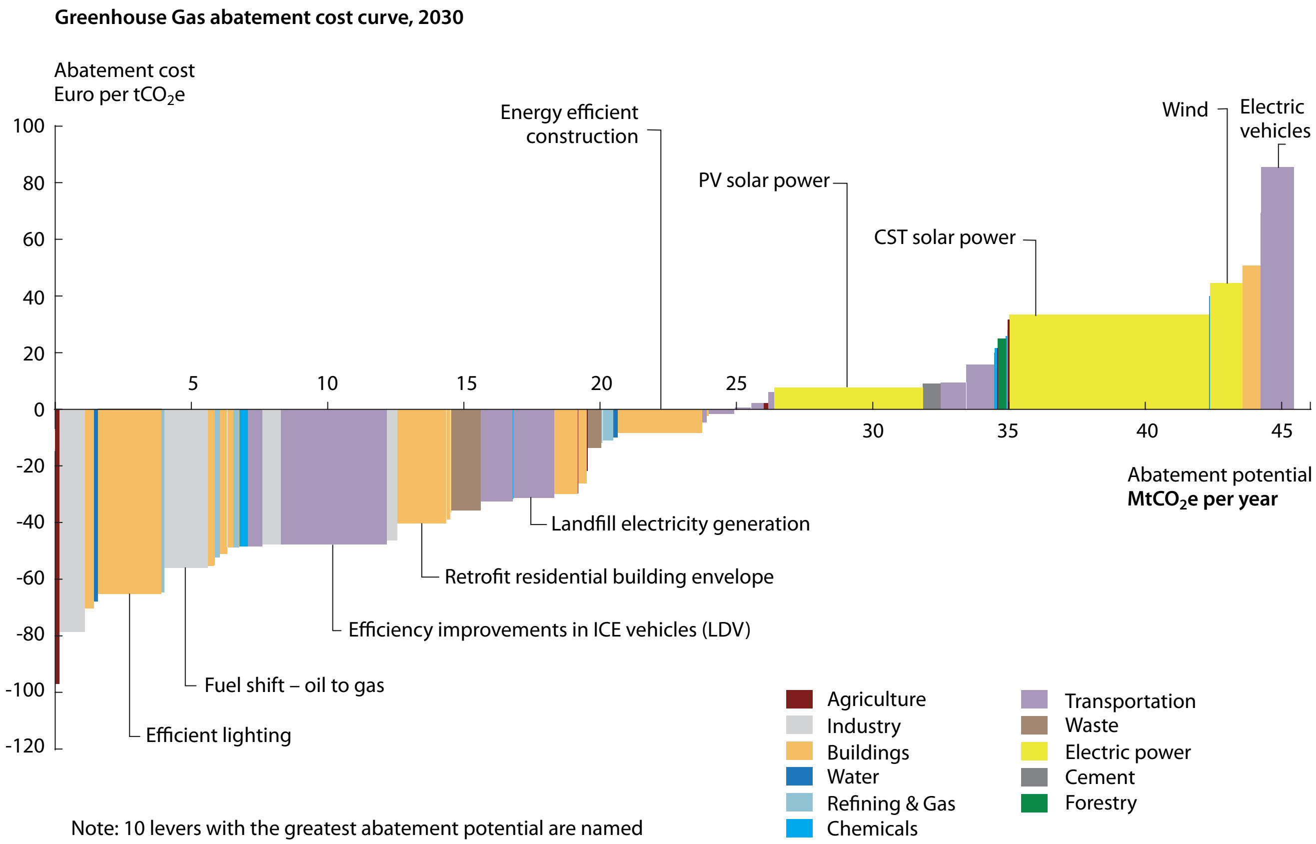
As part of Israel's efforts to prepare for combating climate change, the MoEP commissioned McKinsey & Company to further assist in estimating the potential GHG abatement in Israel and evaluate the sectoral and overall costs involved in realizing this potential. Preparation of the report was accompanied by discussions, consultations and workshops with the participation of more than 100 experts and stakeholders from various fields and ministries.

McKinsey's methodology analyzes over 200 technical measures (levers) aimed at reducing GHG emissions across 10 sectors, with the results integrated into a single cost curve. The abatement cost curve quantifies Israel's abatement potential in ten sectors and its associated costs.

Following are the main findings of the report:

- Israel's emissions are expected to double from 71 million tons ($MtCO_2eq$) in 2005 to 142 $MtCO_2eq$ in 2030, primarily due to Israel's high growth of both population and GDP per capita.

__Figure 1.1__ Israel GHG abatement cost curve (2030)



Source: McKinsey Report

- Per capita emissions are expected to grow by 40%, from 10.2 tons per person in 2005 to ~14.3 tons per person in 2030.
- Israel's abatement potential stands at 45 $MtCO_2eq$, if all the examined technical abatement measures are applied. This corresponds to approximately two-thirds of the expected GHG emissions growth and to ~32% of total BAU emissions in 2030.
- Behavioral changes, including energy efficient lighting, public transportation, bicycle use, changes in average building temperature and reduced meat consumption, could further reduce emissions by approximately 7 $MtCO_2eq$ in 2030.
- Israel's emissions will be cut by some 20% in 2020, from 109$MtCO_2eq$ to 88$MtCO_2eq$, if all examined technical abatement measures are implemented.

According to the study, most of the abatement levers fall into two categories – low carbon energy sources and improved energy efficiency. Levers to reduce the carbon intensity of Israel's energy include:

- Shifting from fossil fuels to renewables for power generation (25% of total generation in 2030).
- Shifting from coal to natural gas in power generation (36% of total generation in 2030).
- Shifting from fossil fuels to biofuels in transportation.

Levers to improve energy efficiency include:

- Using efficient light bulbs.
- Improving vehicle fuel consumption.
- Using more efficient electrical appliances (air conditioners, refrigerators, etc.).

The report concludes that Israel can reach 65% of its abatement potential by implementing 10 measures:

1. Use of concentrated solar thermal (CST) for power generation.
2. Use of photovoltaics (PV) for power generation.
3. Improved fuel efficiency of internal combustion engine vehicles.
4. Increased energy efficiency in new buildings.
5. Use of efficient lighting and lighting control systems.
6. Retrofit of residential buildings in order to increase energy efficiency.
7. Industry fuel transition – fuel oil to natural gas.
8. Use of landfill gas for electricity generation.
9. Increased penetration of electric vehicles and plug-in hybrids (assuming low carbon fuel mix).
10. Use of wind turbines for power generation.

1.5.3 Implementation of the Heifetz and McKinsey Studies

As per the announcement of Israel's President in Copenhagen at COP 15 and Israel's subsequent association with the Copenhagen Accord, Israel will strive for a 20% reduction of GHG emissions below BAU by 2020. The main actions for achieving this reduction target include 10% renewable energy for electricity generation by 2020 and 20% reduction of electricity consumption by 2020. In accordance with a March 2010 government decision to formulate a national action plan for the reduction of GHG emissions, an interministerial committee, headed by the director-general of the Ministry of Finance, was set up to specify the steps required for the implementation of such an action plan, including regulation, removal of barriers, cost benefit analysis, economic incentives and more, and to submit recommendations to the government by the end of 2010.

Four working teams are now focusing on the most promising areas of emission reduction potential in Israel:

- Energy efficiency
- Renewable energy
- Green building
- Transportation

The process is being facilitated by a team from the S. Neaman Institute, Technion – Israel Institute of Technology, which is assisting the working groups to determine the policy tools that should be implemented to attain Israel's emissions reduction target by:

- Addressing the main "policy umbrellas" which may allow goal achievement.
- Reviewing the main policy tools planned or implemented in various countries to reduce GHG emissions.
- Surveying the barriers to the implementation of GHG reduction measures in Israel.
- Developing a computable general equilibrium (CGE) economic model to assess the cross-effects of the different policy tools.

1.6 Financial Contribution, Technology Transfer and International Cooperation

In addition to local activities on mitigation and adaptation, Israel participates in and contributes to various environmental international activities which directly and indirectly relate to climate change.

Most importantly, MASHAV – Israel's Agency for International Development Cooperation, Ministry of Foreign Affairs (MFA), is responsible for the design, coordination and implementation of the State of Israel's development cooperation programs. In cases of natural disaster, MASHAV provides humanitarian assistance and participates in reconstruction and rehabilitation efforts. Guided by the

Millennium Development Goals (MDGs), adopted by the UN General Assembly, MASHAV's approach is to ensure social, economic and environmental sustainable development. MASHAV's activities focus primarily on areas in which Israel has a comparative advantage including: agriculture and rural development; water resources management; micro-enterprise development; community development; medicine and public health; gender issues; empowerment of women and education.

In addition to government agencies, NGOs in Israel take an active part in international cooperation on climate change. *Inter alia*, Israeli NGOs were a part of the official delegation of Israel to the UN Climate Change Conference in Copenhagen in 2009 and took an active part in the deliberations.

One prominent example is the KKL-JNF, a key player in the fields of afforestation and combating desertification, land reclamation and water conservation, which shares its knowledge and experience with countries worldwide and has participated in and sponsored numerous international conferences and workshops demonstrating its technical experience and applied research.

Israel also promotes multilateral and bilateral cooperation in the field of climate change. Prominent examples include:

- An implementation agreement between the Israeli MNI and the US Department of Energy on cooperation in the field of renewable energy.
- Signing of some 20 bilateral agreements between the MoEP and its counterparts in countries worldwide, which include the exchange of information and expertise on environmental protection, biodiversity conservation, combating desertification, agro-ecology and climate change.
- Membership of the MoEP in CIRCLE – Climate Change Research Coordination for a Larger Europe, an organization which seeks to coordinate European research on climate change impact, assessment and adaptation by networking and aligning national research programs in the 19 partner countries.
- Membership in the EU's Framework Programs on R&D since 1996, in which a significant portion of funds are dedicated to environmental and climate change research.
- Participation in three International Energy Agency (IEA) forums for technological and scientific cooperation.
- Signing and ratification of the Statute of the International Renewable Energy Agency (IRENA), an intergovernmental organization for promoting the adoption and sustainable use of renewable energy worldwide.

1.7 Research and Observation

Dozens of research projects in the field of climate change have been initiated in Israel, some within the framework of regional and international studies and others with the support of different government ministries. Such research is vital to help identify the impacts of climate change and to identify options for mitigation and adaptation. Major emphasis has focused on researching the local impacts of climate change and increasing knowledge on adaptation strategies in different sectors.

The main framework for climate change research in Israel is GLOWA Jordan River, a German-Israeli-Jordanian-Palestinian cooperation project. GLOWA-JR addresses the vulnerability of regional water resources as a case study of Eastern Mediterranean ecosystems under climate change. Within the project, models/methodologies are developed for understanding the interplay between climate/land use changes (and socio-economic processes) and water resources. In addition, the project includes the development and application of climate change related regional vulnerability assessments, adaptation methods and methods to enhance stakeholder involvement.

Additional research is carried out by the following organizations:

- **Israel Meteorological Service:** The head of the IMS is Israel's focal point to the IPCC. The IMS is a member of the WMO and participates in the Mediterranean Climate Data Rescue project (MEDARE) for rescuing data and metadata in the region, contributes data to the World Climate Research program and to the European Climate Assessment & Dataset project. The IMS is also a member of SEECOF (South East Europe Climate Outlook Forum).

- **Israel Oceanographic and Limnological Research (IOLR):** IOLR is a national research institution with a mission of generating knowledge for sustainable use and protection of Israel's marine, coastal and freshwater resources. Some IOLR research projects tackle climate change issues, such as climate change impacts on marine biodiversity.
- **Ministry of Environmental Protection:** The Chief Scientist of the MoEP supports studies in environmental fields, including climate change. Most of the studies in the climate change category focus on impacts and adaptation.

In parallel, research on renewable energy is carried out in Israel by both academic institutions and by industry, with funding from government ministries and investment funds. Many of the research teams cooperate with leading teams worldwide. The Solar Research Facilities of the Weizmann Institute of Science (WIS) are among the most advanced laboratories in the world for concentrated solar energy research while the Ben-Gurion National Solar Energy Center is a major research center in Israel, housing six laboratories, each of which is used for the study of one or more aspects of solar energy conversion

1.8 Education, Training and Public Awareness

One of Israel's major achievements in the past decade was to raise public awareness of the environment to a central subject in public and political discourse. Efforts today focus on increasing awareness of the challenges of climate change within the framework of the overall goal of increased education and information.

Of special importance is the Green School accreditation program, under the auspices of the MoEP and the Ministry of Education. The idea is to encourage schools, with the cooperation of administration, students, parents and community, to teach environmental subjects, to act in a sustainable manner, to conserve resources, and to advance eco-efficiency.

Formal education is augmented by informal education programs which play a pivotal role in fostering environmental awareness and participation. Both governmental and non-governmental organizations organize special events, lectures, field trips, seminars, periodicals, posters, television shows and films to increase environmental consciousness in the general public. In addition, courses are offered to youth group and community center counselors and to committed citizens on environmental activism and on means of translating ideas into action.

Some 150 environmental NGOs operate on both the national and local levels in Israel. They have been especially active in promoting education toward sustainable development and increasing awareness of climate change. Their efforts and the efforts of the general public have contributed to the formulation of climate change policy in Israel.

1.9 Constraints and Gaps

Mitigation and adaptation to climate change present major challenges both globally and locally. Despite Israel's progress in the field of climate change during the last decade, many gaps remain with regard to research, technology, policy and public awareness. Most of the gaps fall into four broad categories: fragmentation and duplication of authority for legislation and administration among different stakeholders, multiple and conflicting interests among stakeholders, financial constraints including inadequate incorporation of external costs and inadequate data, information and awareness.

2 Introduction

In 1992, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted as the basis for a global response to the great challenge of global warming.

The Convention was complemented by the 1997 Kyoto Protocol, which currently includes more than 190 Parties. The ultimate objective of the Convention and Protocol is to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system.

Israel is a party to the UNFCCC since September 1996 and a party to the Kyoto Protocol since February 2004. Accordingly, Israel is committed to contribute to the global efforts to reduce greenhouse gas emissions and combat harmful impacts of climate change.

This report is Israel's Second National Communication under the Climate Convention and the Kyoto Protocol. Since the publication of Israel's First National Communication in 2000, climate change has received growing attention from government and society in Israel. Thus, many actions have taken place in this period by policy makers, industry, research institutes and civil society. This report attempts to encompass these activities and reflect the growing efforts of Israel to understand and cope with climate change.

In 2009, Israel's government decided to prepare a climate change plan for Israel and establish a Ministerial Committee on Environmental Protection and Climate Change. The Israel Ministry of Environmental Protection is in charge of coordinating these activities and fulfilling Israel's commitments in the fields of mitigation and adaptation.

The report is organized according to the UNFCCC guidelines for National Communications from non-Annex I Parties. Israel's Second National Communication presents:

- The national inventory compiled for the years, 2000 and 2003-2007, according to the Revised 1996 Guidelines for National Greenhouse Gas Inventories of the Intergovernmental Panel on Climate Change (IPCC, 1997).
- A review of climate change-related policies and measures taken by both government and non-governmental organizations.
- A summary of a comprehensive experts' report which addresses the anticipated impacts of climate change on Israel and presents recommendations on adaptation measures in the following sectors: water, agriculture, seas and coasts, public health, biodiversity, energy, infrastructure and the economy.
- Israel's emission forecasts and mitigation options as identified by two independent

studies commissioned by the Ministry of Environmental Protection. Major mitigation measures include the following sectors: energy and buildings, transport and waste.

- A brief review of Israel's financial contribution, technology transfer and international cooperation related to climate change.
- A short review of recent research and observation efforts in Israel, focusing on climate change impacts and renewable energy.
- A summary of recent activities regarding environmental and climate change education, training and public awareness.
- A short review of some of the major mitigation and adaptation challenges that emerge from the different sections of this communication.

3 National Circumstances

Table 3.1 *General data for Israel*

Criteria	2000	2002	2004	2006	2008
Population (average) (thousands)	6,289.2	6,570.0	6,809.0	7053.7	7308.8
Population density per square kilometer	279	299	300	311	321
Area (square kilometers)	22,072	22,072	22,072	22,072	22,072
GDP (billion US Dollars) (at 2000 prices)	124,748	123,867	132,024	146,087	159,837
GDP per capita (US Dollars PPP) (at current prices)	22,397.4	23,034.3	22,819.6	24,680.1	27,382.2
Domestic product at basic prices (million US Dollars) (at current prices)	111,008	99,868	112,250	129,709	179,141
Share of manufacturing in DP at basic prices (%)	18	15	15	15	17
Share of services in DP at basic prices (%)	73	75	75	75	74
Share of finance and business services (%)	29	32	32	34	33
Share of public and community services (%)	24	23	22	21	20
Share of personal and other services (%)	3	4	4	4	4
Share of commerce, restaurants & hotels (%)	10	10	11	11	11
Share of transport, storage and communication in DP at basic prices (%)	7	7	7	7	7
Share of agriculture, forestry and fishing in DP at basic prices (%)	2	2	2	2	2
Share of construction, electricity and water in DP at basic prices (%)	8	8	8	7	7

Criteria	2000	2002	2004	2006	2008
Land area used for agricultural purposes (square kilometers)	4,204	4,337	2,957	2,851	2,892
Urban population as % of total population	90.6	91.6	91.5	91.8	91.6
Livestock population:					
Laying hens (millions)	7.1	6.	6.1	6.5	8.0
Cattle (thousands)	364	355	350	406	416
Total forest area (square kilometers)	1923	1953	1980	1981	1962
Thereof: Afforested area (total)	941	971	998	999	980
Coniferous	582	536	517	512	498
Thereof: Pines	433	423	421	417	409
Cypress	31	30	30	30	31
Eucalyptus	91	85	81	80	81
Other species total	192	229	254	256	262
Broadleaves & orchards	145	144	135	142	122
Natural groves & shrubs	26	38	63	58	81
Unemployment rate (%)	8.8	10.3	10.4	8.4	6.1
Life expectancy at birth (years)					
Male	76.7	77.5	78.0	78.5	79.1
Female	80.9	81.5	82.4	82.2	83.0
Literacy rate (% of ≥15 years old who attended more than 4 school years)	95.5	95.6	95.5	95.8	96.40

Source: Central Bureau of Statistics (CBS)

3.1 Land Resources

Long and narrow in shape, Israel is about 430 kilometers (km) in length and 105 km in width at its widest point. Located at the junction of Asia, Africa and Europe, the country makes up for its small size with a varied topography and climate. Although a small country, just 22,000 km^2 in size, Israel is characterized by fertile plains and arid zones, seashores and desert, mountain ranges and the lowest point on earth – the Dead Sea – all in close proximity. Arid zones comprise 45% of the area of the country. The rest is made up of plains and valleys (25%), mountain ranges (16%), the Jordan Rift Valley (9%) and the coastal strip (5%).

The coastal plain runs parallel to the Mediterranean Sea and is composed of a sandy shoreline, bordered by stretches of fertile farmland extending up to 40 km inland. This area is home to more than half of Israel's population and includes major urban centers, deep-water harbors, most of the country's industry and a large part of its agricultural and tourist facilities.

A mountain belt runs the length of the country and is formed of sedimentary rocks originally deposited as flat layers that were folded in southern and central areas. The hills and mountains of the Galilee reach heights ranging from 500 to 1200 meters above sea level.

The Negev, comprising over half of Israel's land area, is an arid zone inhabited by only 14% of the population, living mainly in the northern part.

The Jordan Valley and the Arava, running the length of the country in the east, are part of the Syrian-African Rift. The northern stretches are fertile while the southern portion is semi-arid. The Rift Valley includes Lake Kinneret (the Sea of Galilee) which is more than 200 meters below sea level and the Dead Sea, with the world's lowest land altitude of 420 meters below sea level.

Israel's location at the meeting point of four phyto-geographic and zoogeographic zones - the Mediterranean, the Irano-Turasian (steppe), the Saharo-Sindic and the Sudanese - gives the country a rich variety of plant and animal life.

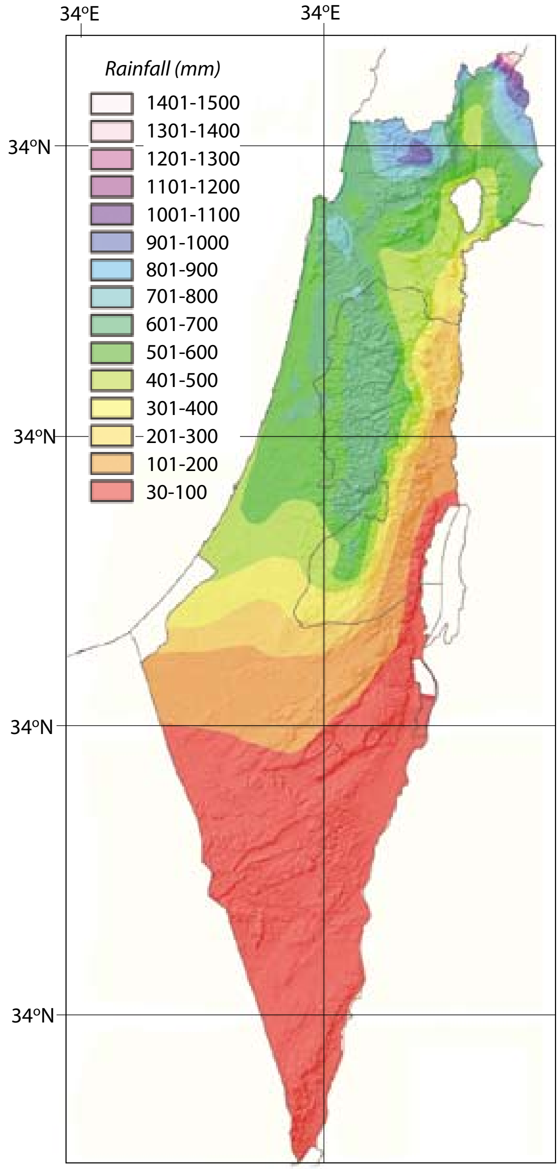
3.2 Climate

Israel lies in a transition zone between the hot and arid southern part of West Asia and the relatively cooler and wet northern Mediterranean region. As a result, there is a wide range of spatial variation in temperature and rainfall. The climate of much of the northwestern part of the area is typically Mediterranean, with mild rainy winters, hot, dry summers and short transitional seasons. The southern and eastern parts are much drier, with semi-arid to arid climate. Throughout the area, summers are completely dry, requiring irrigation for crop production.

Average annual rainfall varies from less than 30 millimeters (mm) in the southern part of Israel to as much as 1000 mm in the north. Rainfall along the Mediterranean coast ranges from 300 mm in the south to 600 mm in the north. More than 60% of the area receives less than 250 mm annually. As is typical of arid and semi-arid climates, there is considerable interannual variability in rainfall. Precipitation in wet years may be almost three times that of dry years.

Figure 3.1 *Precipitation map**

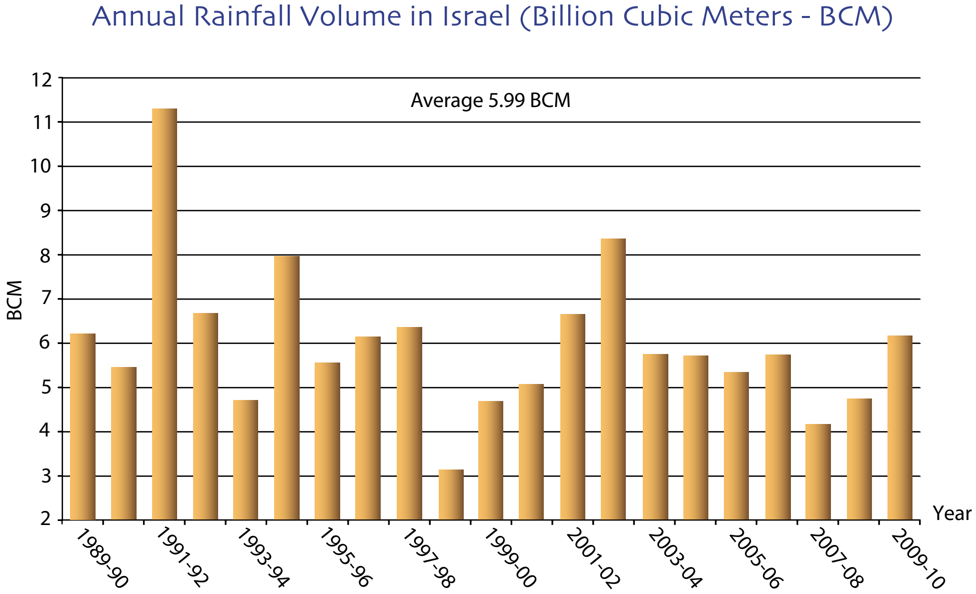
Average Annual Rainfall 1961-1990



Source: Israel Meteorological Service

* The map is intended to facilitate visualization of the geographical data and does not reflect a political determination

Figure 3.2 *Rainfall volume*



Source: Israel Meteorological Service

The annual mean of rainy days is 50-70 in the northern and central parts of Israel, going down to less than 30 in the southern region. These winter precipitations largely result from the relatively cold air masses passing over the warm Mediterranean Sea.

The coastal area belongs to the dry summer subtropical (Mediterranean) climate, although its southern continuation belongs to the semi-arid climate, characterized by potential evaporation and transpiration exceeding precipitation. This marked transition between two climatic types along the coast may serve as an important indicator of the sensitivity of the Eastern Mediterranean Basin to regional climate change (See section 6.1).

Summer temperatures are generally high, with the average maximum ranging between 29°C to 33°C in the coastal plain and the mountains and around 40°C in the Jordan Valley and Arava. In the winter, maximum temperatures average about 17°C along the Mediterranean coast and about 10°C at higher altitudes. In the Jordan Valley and Arava, winter temperatures may exceed 25°C during the day and could drop to 7°C or lower at night.

Table 3.2 *Mean temperatures (ºC) in major cities 1981-2000*

Station	Monthly Average min/max daily temperature				No. of days per year with temperature	
	January		July			
	Minimum	Maximum	Minimum	Maximum	Above 30ºC	Below 10ºC
Jerusalem	6.4	11.8	19.4	29.0	44	116
Tel Aviv	9.6	17.5	23.0	29.4	41	52
Haifa	8.9	17.0	23.0	31.1	87	67
Zefat	4.5	9.4	18.8	29.8	51	146
Beer- Sheva	7.5	16.7	20.5	32.7	126	102
Elat	9.6	20.8	25.9	39.9	202	44

Source: Israel Meteorological Service

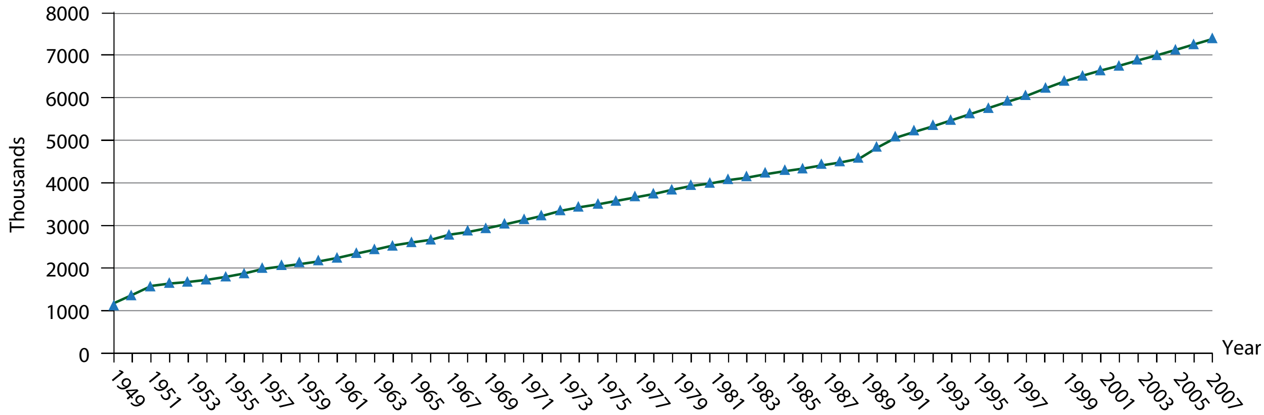
Solar radiation is very high in the summer causing high evaporation, accounting for more than 40% of the annual total evaporation.

3.3 Demography

Israel's population at the end of 2009 reached 7.5 million residents. Since its establishment in 1948, the country's population has increased more than eight-fold. The annual growth rate in that period was 3.7%, of which 37.5% originated from the immigration balance. However, these rates have been subject to significant fluctuations corresponding to the volume of immigration. In the three years following independence, the annual growth of the population was over 24%, increasing from about 650,000 at independence to nearly one and a half million at the end of 1952. In subsequent years, average annual rates of growth diminished to 3.5% until the end of the 1950s, 3.2% in the 1960s, 2.4% in the 1970s and 1.8% in the 1980s. At the end of 1989, a massive wave of immigrants arrived in Israel from the former Soviet-bloc and from Ethiopia. As a result, from 1990 to 1995, the annual growth rate almost doubled (3.5%). Afterwards, it declined gradually to 2.6% in the second half of the 1990s and back to the rate of the pre-immigration era of 1.8%, between the years 2000 to 2008.

Figure 3.3 *Population*

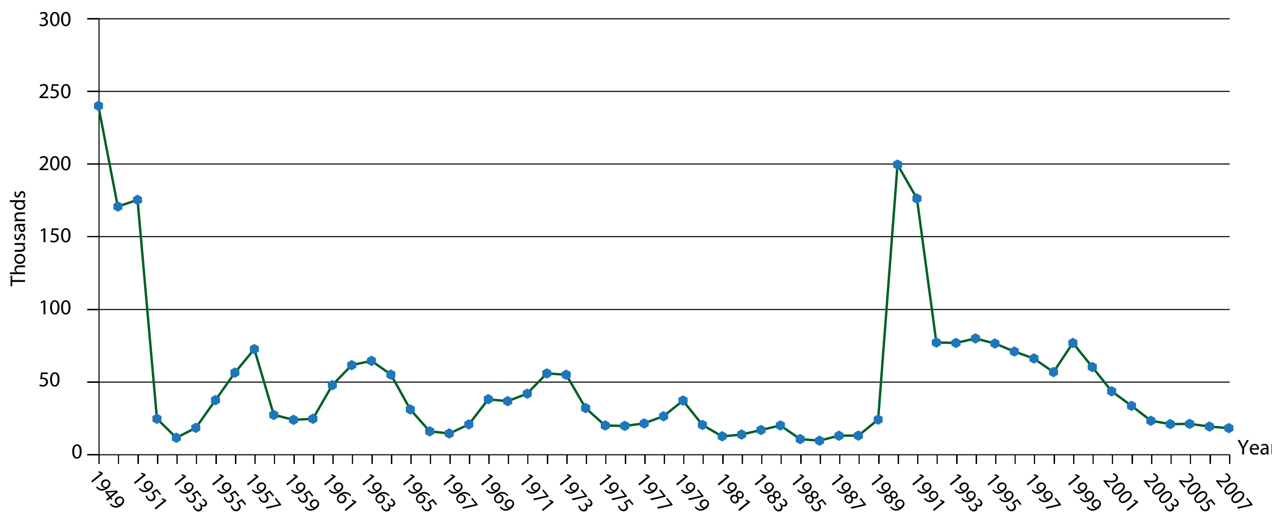
Population of Israel (Thousands) (1949-2008)



Source: CBS

Figure 3.4 *Immigration*

Immigration to Israel (Thousands) (1949-2008)



Source: CBS

About 92% of the population lives in 228 urban centers. The three largest cities are Jerusalem (763,600 inhabitants), Tel Aviv (392,500) and Haifa (264,800). Almost 3 million people reside in the greater Tel Aviv metropolitan area alone - about 41% of the total population. Just over 5% of Israelis live in unique rural cooperatives - the kibbutz and the moshav, whereas 3.1% live in other rural localities.

From a sparsely populated country in its early years, Israel has been transformed into a densely populated country. In the area north of Be'er Sheva, Israel has become one of the world's most densely populated countries. Some 92% of the population lives in an area which covers only 40% of the state's land. While average population density at the end of 2008 was 321 per square km, population density reached 7,134 per square km in the Tel Aviv district, versus 1,394 in Jerusalem and only 74 in the southern district.

3.4 Water Resources

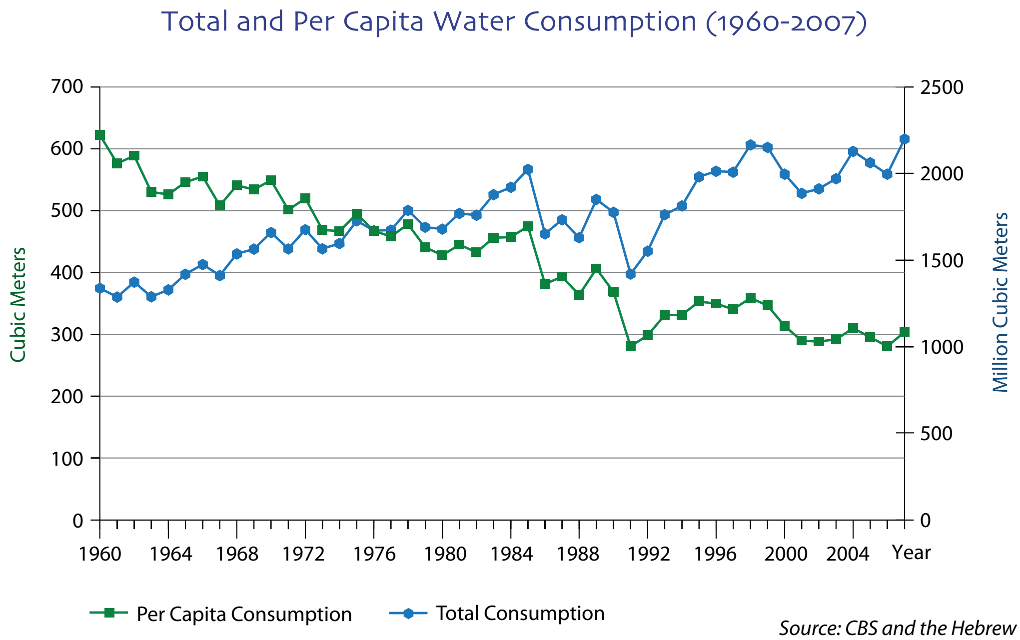
Water resources in Israel are very limited, due to the temporal and spatial characteristics of the precipitation regime on the one hand and the rising demand for water by the growing population on the other hand. In the mid-1960s Israel launched the National Water Carrier project, which transports water from the north of the country to the south. The water is abstracted from the coastal and mountain groundwater aquifers along with the major surface water source in the north, the Sea of Galilee.

In 2006, 59% of the water consumption of natural water came from groundwater, 33% from surface water and 8% from desalinated water (mostly seawater). Consequently, the electricity consumption of water abstraction reached 7% of the total electricity production by 2007.

Water scarcity in Israel has led, among others, to the development of advanced technologies for seawater and saline water desalination and to wastewater treatment and recovery. The efficiency of water use in Israel is high due to an exceptional recycling rate, which stands at about 70%.

A series of drought years since the mid-2000s caused a severe deficit in the water economy of Israel. Therefore, several measures, at both demand and supply sides, were taken by policy makers. One of these measures concerns the planned capacity of the country's desalination plants, which will dramatically increase in the next few years. As a result, the energy demand of water abstraction is predicted to significantly increase as well.

Figure 3.5 *Water consumption*



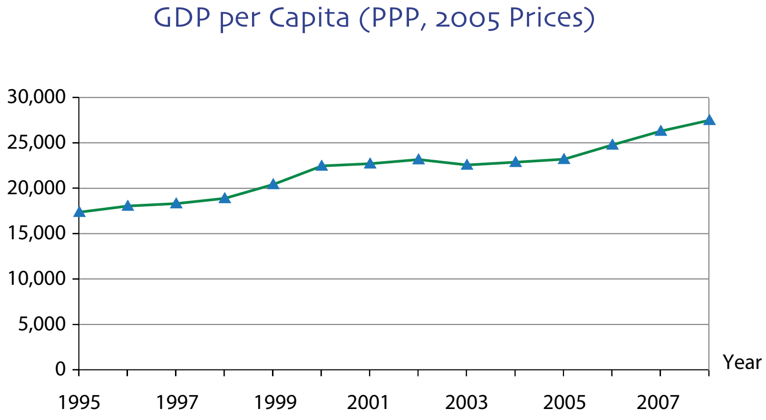
Source: CBS and the Hebrew University

3.5 Economy

Economic growth was very high (10% annual growth in GDP) in the first 25 years of Israel's existence, reflecting high immigration and accelerated development. Between 1973 and 1989 the growth rate decreased to an annual average of 3%. In 1990-1996, Israel attained one of the highest GDP growth rates (averaging 8%) in the developed world. This rapid economic growth turned into a slowdown at the end of the decade turning into a recession at the beginning of the 2000s. The average growth rate for the years 1997-2003 was about 3%. The slowdown in these years was accompanied by a sharp increase in unemployment, which reached 10.7% in 2003. From 2004 to 2008, Israel re-experienced rapid economic growth with an average growth rate of 5.4% and an unemployment rate of 8.2%.

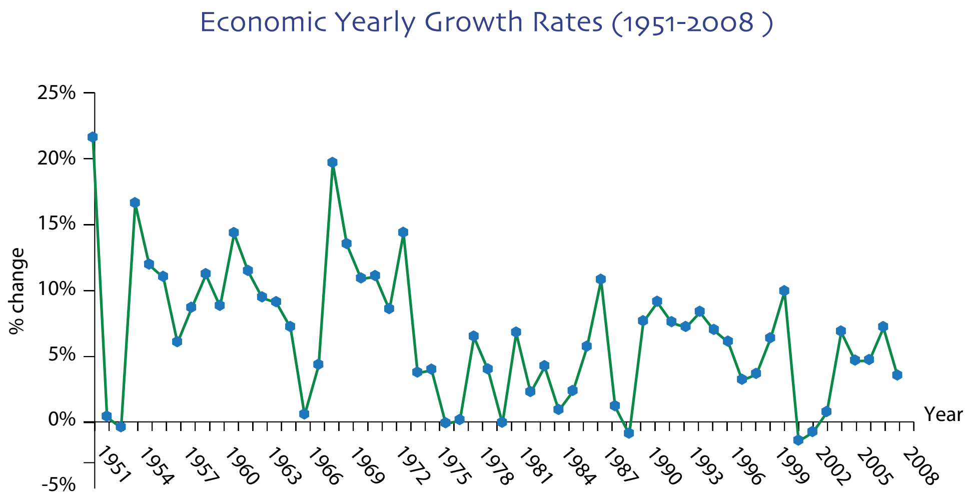
This impressive growth has been accompanied by a deficit in the balance of payments for most

Figure 3.6 *Standard of living*



Source: CBS

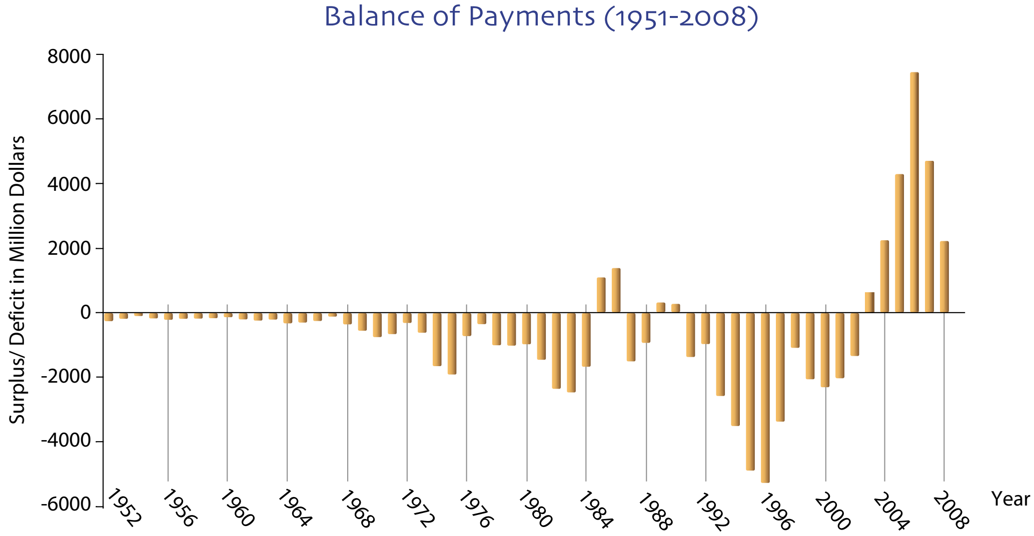
Figure 3.7 *Economic growth*



Source: CBS, 1964 – calculation change of the first five decades of the country's existence, arising from the gap between imports and exports of goods and services. However, since 2003, the trend changed and the balance of payments turned positive. In 2008, imports of goods and services totaled $84.3 billion while exports reached $102.4 billion.

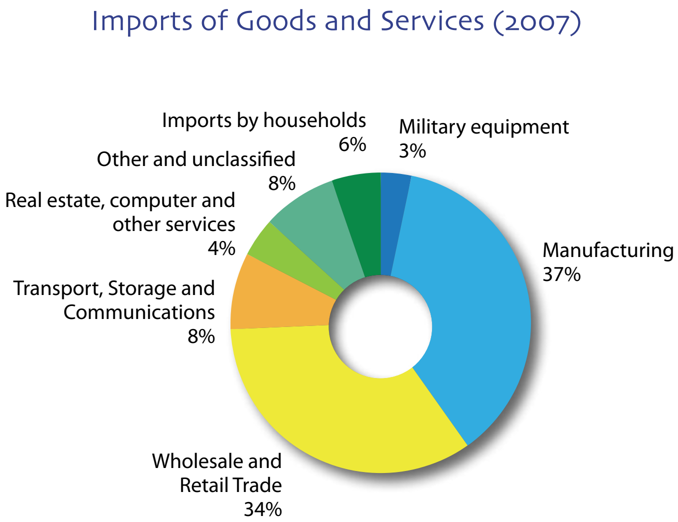
In recent years, the manufacturing and trade sectors were responsible for 71% of the total imports of goods and services. As a small economy with a relatively limited domestic market, Israel can only boost growth by expanding exports. Most of the country's resources have been devoted to building up its industrial exports, which have grown from $13 million in 1950 to $40.6 billion in 2008. Trade is conducted with countries on all five continents. Some 35% of imports and 29% of exports are with the European Union, with which Israel concluded a free trade agreement in 1975. A similar agreement, updated in 1995, was signed with the United States, whose trade with Israel accounts for 12% of imports and 31% of exports.

Figure 3.8 *International debt*



Source: CBS

Figure 3.9 *Imports*



Source: CBS

3.6 Social Services, Health and Education

Whereas GDP per capita has grown between 2001 and 2008, social spending per capita has dropped slightly during this period. Government social services include both social spheres and in-cash benefits paid by the National Insurance Institute. The largest spheres of social service activity by government are education and health along with National Insurance Allowances, mostly for pensions and child benefits. Secondary areas of activity are immigrant integration, housing, employment and personal social services. The share of government expenditures on social services grew from 30% in 1990 to 38% in 2002. However, expenditure has since declined to 35% by 2008, reflecting the government policy of reducing public expenditure.[1]

According to the National Insurance Institute, 20% of all families in 2006 had net income below the poverty line (defined as 50% of the net median income, adjusted to family size), with the average net income of a poor family being 66% of the poverty line.

The enrollment rate in the primary education system has long been close to 100%. Almost all three- and four-year olds attend some kind of preschool program, though neither compulsory nor free. Kindergarten for five-year-olds is compulsory and school attendance is mandatory from age 6 to 16 and free to age 18. Enrollment in the primary education system reached 846,000 in 2008. Some 610,000 pupils attended post-primary schools, including 356,000 in junior high schools.

Over 232,000 students are enrolled in eight universities and almost 50 other institutions of higher learning throughout the country. The percentage of Israel's population which is engaged in scientific and technological research is among the highest in the world, and relative to the size of its labor force, the country is a world leader in the number of published authors in such fields as the natural sciences, engineering, agriculture and medicine. The R&D intensity (% of GDP dedicated for R&D) for Israel in 2008 reached 4.8%, which ranks Israel as the world leader in this index.

Israel's extensive medical network and high doctor-patient ratio are reflected in the low infant mortality rate and high life expectancy. The National Health Insurance Law provides a standardized basket of medical services, including hospitalization, for all residents of the country.

Table 3.3 *Population, health and education*

	1960	1970	1980	1990	2000	2008
Population (end of year)	2,150,400	3,022,100	3,921,700	4,821,700	6,369,300	7,374,000
Life expectancy:						
Female		73.4*	75.7	78.4	80.9	83.0
Male		70.1*	72.1	74.9	76.7	79.1
Infant mortality (per 1000 live births)	31.3	22.7	15.6	9.9	5.4	3.8
School population	461,491	603,716	812,250	1,006,935	1,304,958	1,448,902
Percentage of the population with 13 years or more of formal schooling	9.1	11.8	19.2	25.3	37.4	43.0

* Average 1970-4

Source: CBS

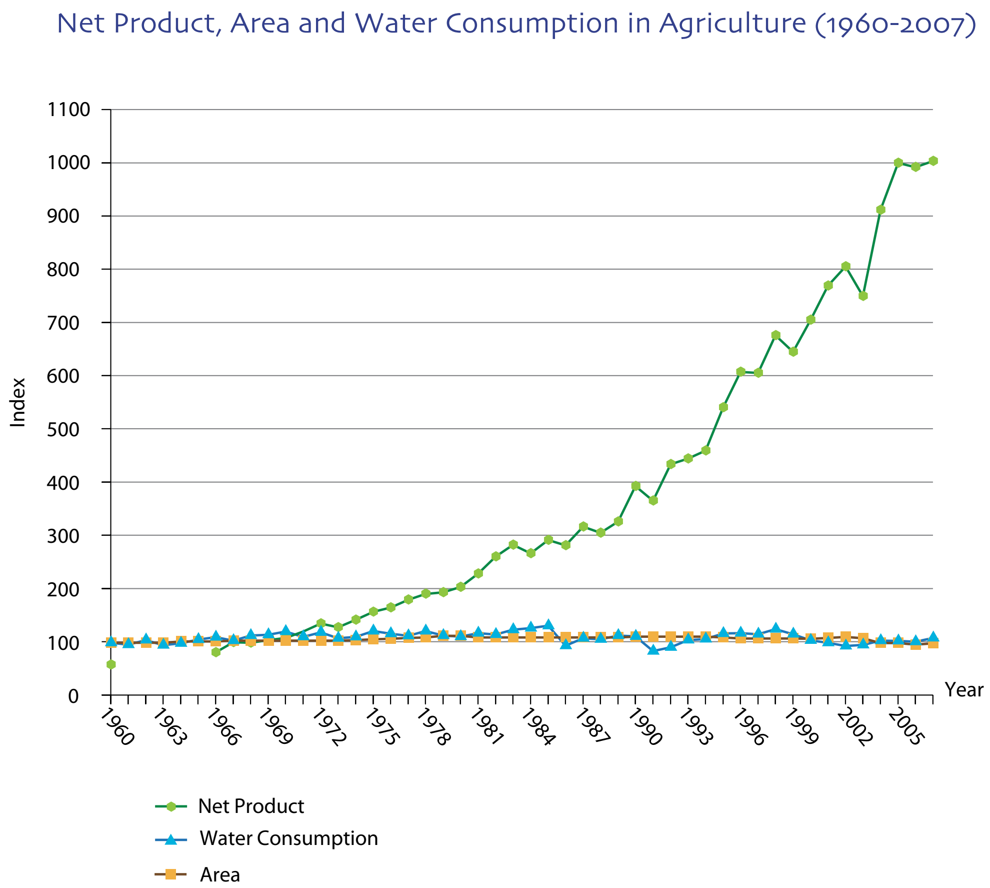
1 Source: Taub Center for Social Policy Studies in Israel (2008)

3.7 Agriculture

In the twelve years following its establishment in 1948, Israel's cultivated land area increased from 150,000 to 400,000 hectares – about a fifth of the land area. Thereafter, cultivation increased far less rapidly, stabilizing at 430,000 hectares by the beginning of the 2000s. Since then the agricultural area has slightly declined and reached about 380,000 hectares by 2008. Over half of all cultivated land is irrigated. In the first quarter century of the state's existence, output grew at an average of 6% annually; by the end of the 1980s growth in this sector had slowed to 1%.

The most severe constraint on Israeli farmers is the lack of water. Israel is a leader in high-yielding agriculture and in the development of scientific methods in all agricultural branches. To maximize efficiency of water use, highly mechanized, high-input methods and water-saving irrigation systems are employed. Israel has pioneered drip irrigation and other techniques to increase water efficiency. In order to further stretch the country's water resources, Israel also recycles wastewater for agricultural purposes and develops crop strains which can be grown with brackish water. Agriculture accounts for less than 4% of the workforce, less than 2% of GDP and nearly 60% of the water used. However, approximately half of the water used in agriculture constitutes effluents and marginal water, whereas the share of freshwater use in agriculture is constantly declining.

Figure 3.10 *Major indices in agriculture*



Source: CBS

3.8 The Manufacturing Industry

Textiles, diamonds and food processing constituted Israel's industrial base during its first decade of existence. In subsequent decades, the development of chemicals, metallurgical and electronics industries caused a major increase in industrial production.

The manufacturing sector is of great importance. In 2008 it included approximately 16% of all employed persons in the economy, constituted approximately 18% of the net domestic product, and produced approximately 97% of all export goods (excluding diamonds). The percentage of production of goods and services exported was 56% of total exports of goods and services in 2008.

Due to the lack of raw materials, industry has concentrated on manufacturing products with a high added value. Major industries include pharmaceuticals, electronics, agrotechnology, telecommunications, fine chemicals and computers.

The highest growth rates are in the high-tech sectors which are skill and capital intensive and require sophisticated production techniques as well as considerable investment in research and development. High-tech sectors accounted for 19% of the industrial output in 1995 and 31% in 2006. Jobs in the high-tech sector out of industrial jobs grew from 18% in 1995 to 24% in 2006. High-tech exports, out of total industrial exports, grew from 42% in 1995 to 53% in 2006.

In 2008 73% of the high-tech product was exported (providing approximately 50% of total industrial exports), while more traditional, low-tech firms exported some 11% - 35% of their product.

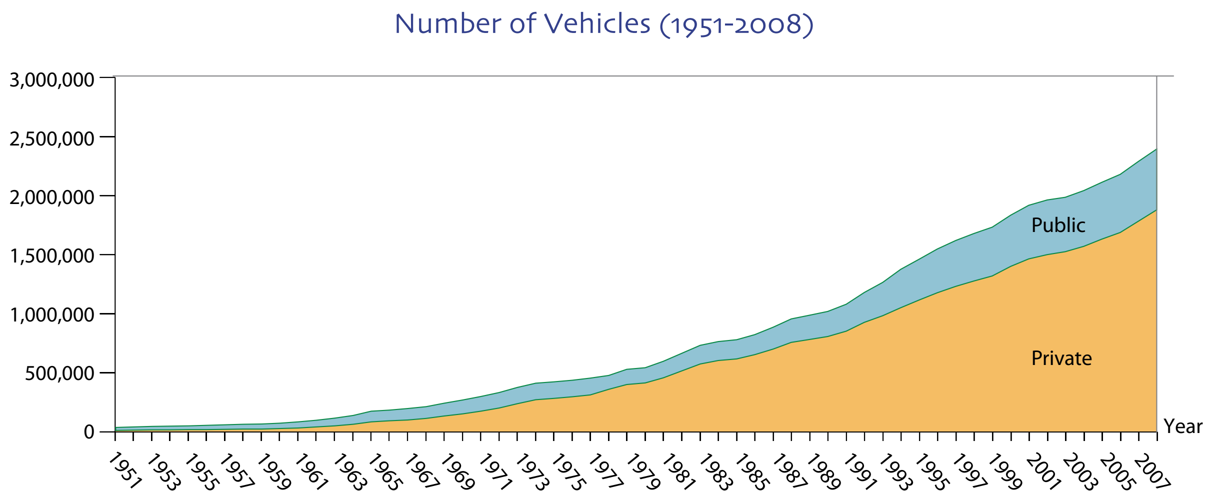
3.9 Transport and Communications

Contributing nearly 8% of the GDP, the transport and communication sector constitutes some 7% of exports of goods and services.

The total number of vehicles in Israel grew massively from 70,000 in 1960 to 540,000 in 1980, 1,832,000 by 2000 and 2,391,000 by 2008. Since the 1960s, the development of public transportation has been much slower relative to the development of private motor vehicles. As a result, the share of private cars increased from 34% in 1960 to close to 80% in the last 30 years. The increase in car ownership has not been accompanied by a proportionate increase in road surface. Thus, in 1961, there were 6,572 km in length of roads, going up to 11,810 in 1980, 13,199 in 1990, 16,450 in 2000 and 18,096 in 2008.

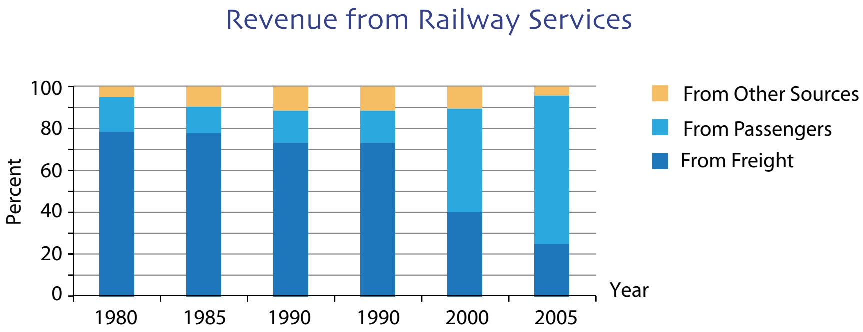
Between 1950 and 1960, inter-city rail travel grew from 1.5 to nearly 4.5 million passengers annually. In the following decades, the number of passengers decreased and reached only 2.5 million pas-

Figure 3.11 *Public and private transportation*



Source: CBS

Figure 3.12 *Railway revenues*



Source: CBS

sengers in 1990. During the 1990s and the 2000s there has been a major increase in railway passengers, and their number has increased by more than ten-fold, reaching 35 million passengers by 2008. Accordingly, railway revenues from passengers dramatically increased, with passengers traveling by train responsible for 72% of railway revenue in 2008.

3.10 Construction

In the early years of the State, residential building accounted for 90% of total construction area. Subsequently, the rate averaged to 70% until 1991 when it rose to 82% to meet the needs of renewed immigration from the former Soviet Union and Ethiopia. When immigration slowed down, beginning in 1993 until 2008, the rates of residential building out of total construction returned to 70% on average. In the past, construction was considered a leading economic activity. Yet, as of 2008, the construction sector contributes just over 5% to the GDP. While at first almost all construction was the result of government initiative and investment, the government share gradually fell between 1958 and 1989, from 48 to 10%. It peaked at 52% in 1991 (in order to meet the demand created by the immigration wave) and declined gradually to 7% by 2008.

3.11 Energy Production

Due to a lack of local natural energy resources, Israel mostly relies on imported fossil fuels, especially coal, for energy generation. Coal was introduced during the early 1980s to diversify energy resources and has become a major fuel in electricity production. Since the mid-2000s, the use of natural gas has increased significantly and replaced most of the petroleum-based power generation. Although the use of natural gas is expected to continue to grow, the size of the gas reserves and the timetables earmarked for supply in coming years are still unclear.

Solar energy, the major local, renewable, environment-friendly source of power, is being used to heat water for residences as per a regulation which mandates installation of such heaters in new houses. Israel is one of the world leaders in development of solar energy technology. Wind energy in minor capacity has also been developed in recent years.

The installed generating capacity of the Israel Electric Corporation (IEC) in 2008 stood at 11,675 MW. Two coal fired plant sites, near the coastal cities of Hadera and Ashkelon, comprise 4,840 MW of the installed capacity. Most of the remaining production capacity is based on natural gas and gas oil, in the form of combined cycle sites and gas turbines, located at various sites around the country. The last fuel oil fired plant site in close proximity to the coastal city of Haifa is currently converting to natural gas.

The coal fired and combined cycle plants are base loaded, while the gas turbines are primarily used as peaking units. Coal and natural gas fired plants produced 64.9% and 26.0%, respectively, of the total power generated in 2008, while gas oil and fuel oil accounted for only 5.9% and 3.2% of the electricity production, respectively.

Between 2000 and 2008, electricity production increased from 41.4 to 54.5 billion kWh. Over this same period, peak demand increased from 7,900 to 10,200 MW. This period witnessed an average annual increase in production and peak demand of 3.4% and an increase in consumption of 3.2%, about half of the rate in the previous decade. These data have more significance in view of the recession which prevailed in the economy in the beginning of the 2000s. Over the next five years, IEC plans to add a new 630 MW coal fired unit at the Ashkelon site. However, this plan is still under debate among the different ministries and the public.

Table 3.4 *Electricity consumption by sector (billion kWh)*

Year	Residential	Public & Commercial	Agricultural	Industrial	Water Pumping	E. Jerusalem & P.A	Total
1998	10.08	8.58	1.49	8.44	2.51	1.93	**33.03**
1999	10.30	9.40	1.56	8.60	2.32	2.12	**34.30**
2000	11.87	10.30	1.60	9.31	2.32	2.39	**37.80**
2001	12.32	11.02	1.58	9.23	2.20	2.31	**38.70**
2002	12.75	11.59	1.62	9.42	2.24	2.30	**39.92**
2003	13.37	12.00	1.67	9.73	2.50	2.45	**41.72**
2004	13.52	12.51	1.70	9.90	2.73	2.60	**42.93**
2005	13.72	13.08	1.70	10.24	2.71	2.86	**44.31**
2006	14.31	13.79	1.76	10.39	2.84	3.10	**46.18**
2007	15.05	14.77	1.85	11.18	3.02	3.46	**49.32**
2008	15.20	15.50	1.83	11.22	2.75	3.70	**50.16**

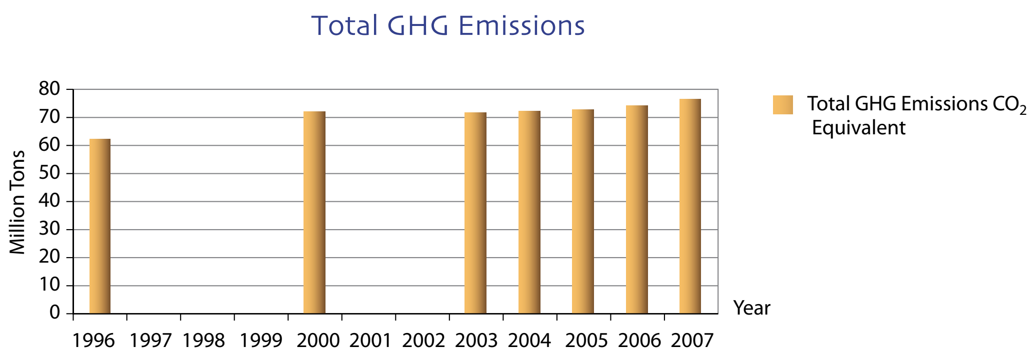
Source: IEC

4 National Greenhouse Gas Inventory

4.1 Introduction

According to the Guidelines for National Greenhouse Gas Inventories of the Intergovernmental Panel on Climate Change and the Revised 1996 Guidelines, Israel's national inventory includes the following sectors: energy, industrial processes, agriculture, land use change and forestry, and waste. It relates to emissions and removals of the three main greenhouse gases: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), and to indirect greenhouse gases which are precursors of tropospheric ozone: carbon monoxide (CO), oxides of nitrogen (NO_x) and non-methane volatile organic compounds (NMVOCs). It also relates to sulfur dioxide (SO_2), which although not a direct greenhouse gas, is an aerosol precursor and, as such, has a cooling effect on climate. In 2009, for the first time, data for hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6) were collected. Therefore, these gases will be included in future inventories. The inventories for the years 1996 and 2000 were prepared on behalf of the Ministry of Environmental Protection (MoEP) by the Soreq Nuclear Research Center. From 2003 and on, inventories are prepared on an annual basis by the Central Bureau of Statistics.

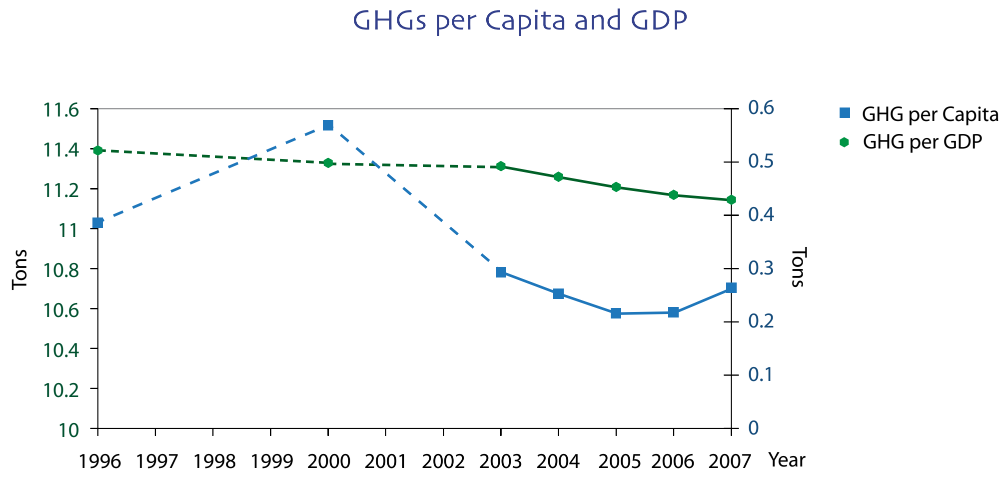
Figure 4.1 *GHG emission trends**



Source: CBS and Jean Koch et al

* Excluding: HFCs, PFCs and SF_6

Figure 4.2 *GHG emission indices**



Source: CBS and Jean Koch et al

4.2 Energy Sector

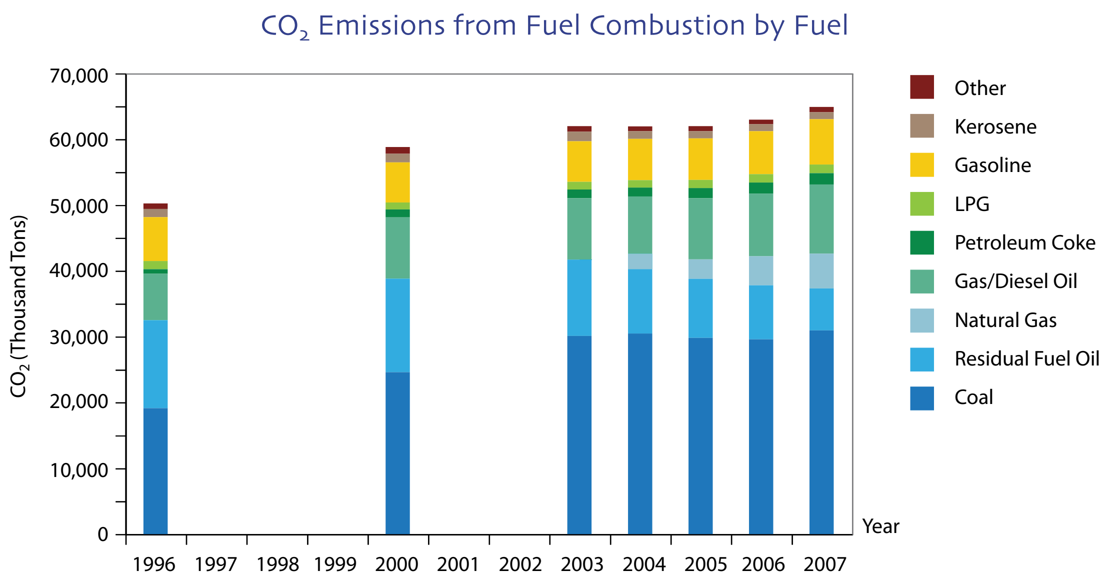
4.2.1 Carbon Dioxide

Israel's inventory is based on the breakdown of CO_2 emissions by the source categories defined by IPCC, as follows: energy industries, manufacturing industries and construction, transport, residential/ commercial/institutional sector and agriculture.

By far the largest anthropogenic source of CO_2 emissions is the oxidation of carbon when fossil fuels are burned to produce energy. In 2007, about 65 million tons of CO_2 were emitted by this process as compared to 50 million tons in 1996.

As of 2007, the energy industries (power plants and oil refineries) are by far the largest source of CO_2 emissions (65%), followed by transport (23%). Coal contributes 48% of the CO_2 emissions in the energy sector, whereas the contribution of gas/ diesel oil is 16%, and gasoline, residual fuel oil and natural gas contribute 11%, 10% and 8% respectively.

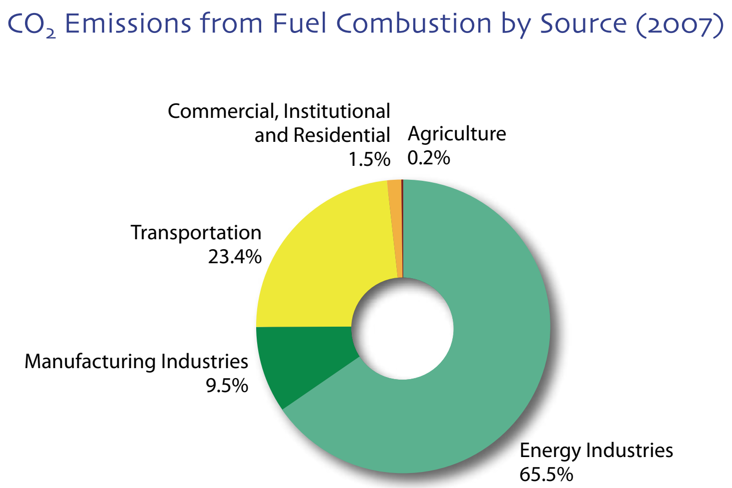
Figure 4.3 *CO_2 emissions by fuel type*



Source: CBS and Jean Koch et al

* Excluding: HFCs, PFCs and SF_6

Figure 4.4 *CO_2 emissions by source*



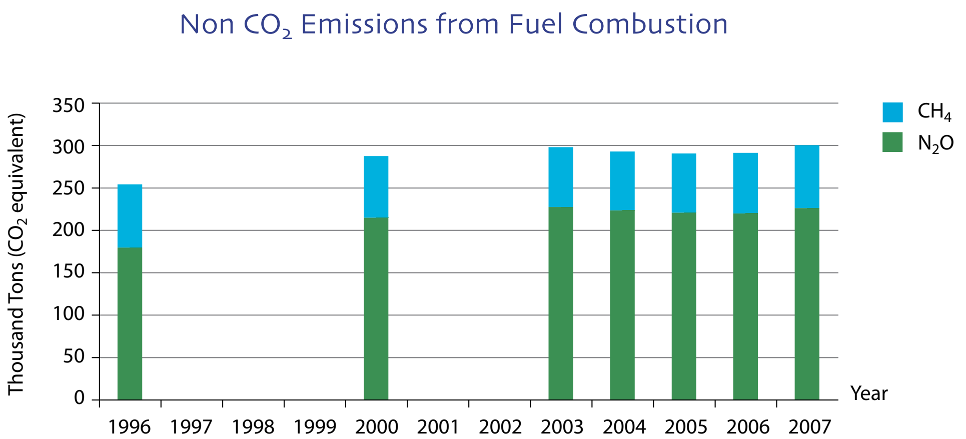
Source: CBS

4.2.2 Non-CO_2 Greenhouse Gas Emissions

4.2.2.1 Direct greenhouse gases

- **Methane** (CH_4): The contribution of fuel combustion to emissions of CH_4 is minor. Methane is produced in small quantities from fuel combustion due to incomplete combustion of hydrocarbons in fuel and its production depends on the combustion temperature.
- **Nitrous oxide** (N_2O): As with methane, the contribution of fuel combustion to emission of N_2O is minor. Nitrous oxide is produced directly from the combustion of fossil fuels, and lower combustion temperatures cause higher N_2O emissions.

Figure 4.5 *CH_4 and N_2O emissions*

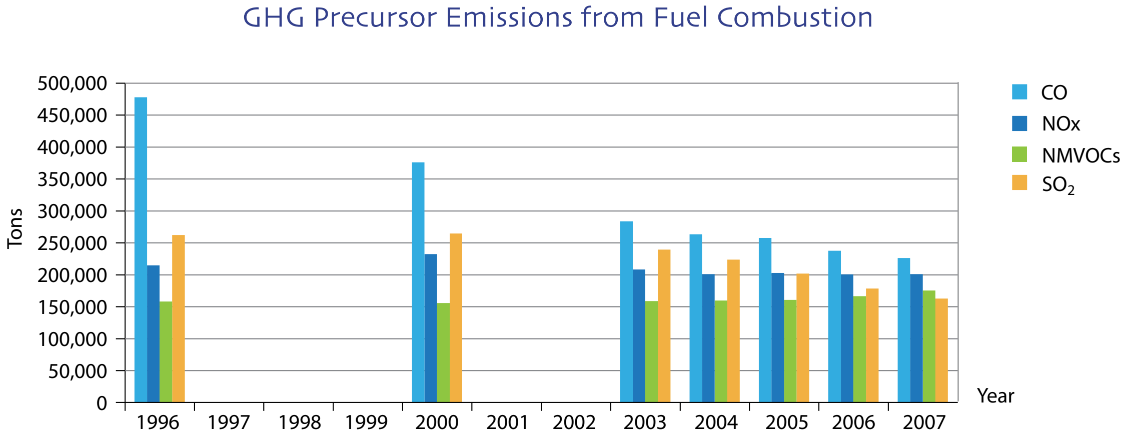


Source: CBS and Jean Koch et al

4.2.2.2 Greenhouse gas precursors

- **Nitrogen oxides:** NO_x ($NO+NO_2$) play a role in ozone formation and, as such, are indirect greenhouse gases. Fuel combustion activities, especially energy production and mobile sources, are the most significant anthropogenic source of NO_x. Two different mechanisms contribute to their formation: conversion of chemically bound nitrogen in the fuel and fixation of atmospheric nitrogen in the combustion process. The first mechanism contributes most of the NO_x emitted from coal, whereas the second mechanism is dominant in oil combustion and is the sole mechanism for gaseous fuels. From 1996 to 2007, NO_x emissions from fuel combustion decreased at a rate of 7%, in spite of an increase in emissions from energy production and an increase in transportation volume. The decrease is mostly due to improved vehicle technology.
- **Carbon monoxide** (CO) is also an indirect greenhouse gas. Most CO emissions from fuel combustion come from motor vehicles and small combustion equipment in the residential sector. CO is an intermediate product in the combustion process and its formation is influenced by the facility technology, size, age, maintenance and operation. CO emissions from mobile sources are a function of the efficiency of combustion and post combustion controls. From 1996 to 2007, CO emissions decreased at a rate of more than 50%, mostly due to improved vehicle technology.
- **Non-methane volatile organic compounds:** NMVOCs (e.g., olefins, ketones, aldehydes) are also indirect greenhouse gases. The major source of NMVOCs from fuel combustion is transportation (98%). Emissions of NMVOCs are due to incomplete combustion, and tend to decrease with increased efficiency of the combustion process and increase in plant size. Emissions from mobile sources are directly related to the amount of hydrocarbons passing unburned through the engine. Emissions due to gasoline evaporation from mobile sources are also accounted for. From 1996 to 2007 NMVOC emissions have increased at a rate of 11%.
- **Sulfur dioxide:** SO_2 is not a greenhouse gas. However, its presence in the atmosphere has a cooling effect on climate, due to its reaction with photochemically produced oxidants to form sulfate aerosols. Emissions of SO_2 are directly related to the sulfur content of the fuels. From 1996 to 2007, SO_2 emissions have decreased at a rate of 38%, mostly due to enhanced fuel quality and technological improvements in power plants.

Figure 4.6 *Indirect GHG emissions*



Source: CBS and Jean Koch et al

4.3 Industrial Processes

4.3.1 Carbon Dioxide

Greenhouse gases are emitted from a large variety of industrial processes not related to energy. The main emission sources are industrial production processes which chemically or physically transform materials. Due to confidentiality constraints, data for each individual process are no longer available.

Cement production is the most important non-energy industrial process emitting CO_2. Carbon dioxide is produced during the production of clinker, an intermediate product from which cement is made. In the cement kiln, calcium carbonate from limestone is calcined to form lime (calcium oxide) and carbon dioxide.

Much smaller quantities of CO_2 are emitted from lime and ammonia production. Calcined limestone (quicklime) is formed by heating limestone to decompose the carbonates, a process which releases CO_2. Dolomite may also be processed at high temperature to obtain dolomitic lime and release CO_2. In most instances, anhydrous ammonia is produced by a catalytically assisted reaction of natural gas or other fossil fuels in the presence of steam. Natural gas is used as the feedstock in most plants, while other fuels (e.g., heavy oils) may be used with the partial oxidation process. Hydrogen is chemically separated from the fuel and combined with nitrogen to produce ammonia. The remaining carbon is emitted as CO_2. Since the end of the 1990s there is no production of ammonia in Israel.

Soda ash is used as a raw material in a large number of industries, including glass manufacture, soaps and detergents, pulp and paper production and water treatment.

4.3.2 Non-CO_2 Emissions from Industry

Nitric acid is used as a raw material mainly in the manufacture of nitrogenous fertilizers and is produced in three plants in Israel. The production of nitric acid generates nitrous oxide as a byproduct of the high temperature catalytic oxidation of ammonia.

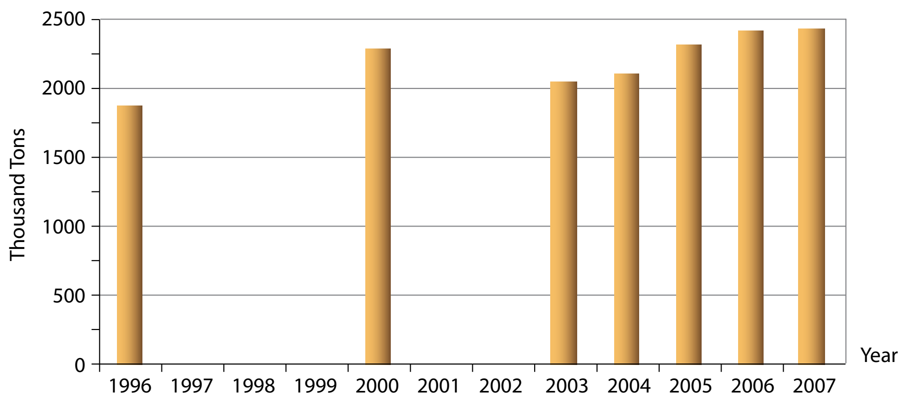
Emissions of SO_2 are attributed to cement production (sulfur in the clay raw material), production of sulfuric acid and ammonia production. NMVOC emissions are attributed to road paving with asphalt and production of various other chemicals. CO emissions are attributed to ammonia production. NO_x emissions are attributed to production of nitric acid. Due to confidentiality constraints, these emissions data are not available.

4.4 Agriculture

4.4.1 Methane

Methane is produced through two processes associated with domestic livestock husbandry:

Figure 4.7 *CO_2 emissions from industrial processes*



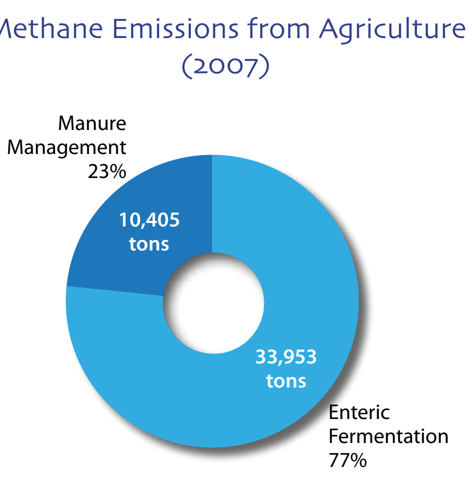
Source: CBS and Jean Koch et al

enteric fermentation and manure management. In 2007, annual methane emissions amounted to 44 thousand tons, 1.2% of the total CO_2 equivalent (CO_2eq) emissions.

About 77% of the total emissions are contributed by enteric fermentation, of which more than 55% are from dairy cattle and 88% from all cattle. The elevated contribution of dairy cattle is explained by a high emission factor of 148 kg CH_4 /head/yr in Israel. The emission factor takes into account the feed energy requirements for the different physiological functions (i.e., maintenance, feeding, growth, lactation and pregnancy). Its high value is largely due to a record milk production of more than 30 kg/head/day.

Manure management contributes 23% of the emissions, mainly due to cattle and poultry manure. The contribution of poultry slightly exceeds that of dairy cattle based on the assumption that manure from dairy cattle in Israel is mainly managed in dry systems, which do not favor anaerobic conditions.

Figure 4.8 *CH_4 emissions from agriculture*



Source: CBS

4.4.2 Nitrous Oxide

N_2O production in the soil is biogenic and results primarily from nitrification and denitrification processes. In most agricultural soils, biogenic formation is enhanced by an increase in available mineral nitrogen, which in turn increases nitrification and denitrification rates. Therefore, addition of fertilizer nitrogen directly results in extra N_2O formation. In 2007, direct emissions from agricultural soils amounted to 2.66 thousand tons N_2O; synthetic fertilizers and animal waste contributed 40% and 29% of that amount, respectively.

N_2O is also emitted from two sources related to animal production: manure management and animal grazing. N_2O emissions from different animal waste management systems amounted to 0.87 thousand tons in 2007, of which emissions from solid storage contributed 78%. Waste produced by animals grazing on pasture induced direct soil emissions of 0.45 thousand tons N_2O.

Finally emissions are also indirectly induced by agricultural activities through two pathways: volatilization and subsequent atmospheric deposition of NO_x and NH_3 (originating from the application of fertilizers and manure) and nitrogen leaching and runoff. In 2007, emissions from the first pathway were estimated at 0.30 thousand tons per year; emissions from the second at 0.89 thousand tons per year. Indirect emissions from agriculture therefore added up to 1.19 thousand tons N_2O in 2007.

Table 4.1 *Total N_20 emissions from agriculture in 2007 (thousand tons)*

Direct emissions from agricultural soils	2.66
Soil emissions from grazing animals	0.45
Indirect emissions from agriculture	1.19
Total	**4.29**
Animal waste management	0.87
Grand total	**5.16**

Source: CBS

4.5 Waste and Wastewater

4.5.1 Methane

The largest source of methane emissions in Israel is the decomposition of solid waste. In 2007, the total quantity of municipal solid waste was 4.3 million tons, including domestic, commercial and yard waste. Based on an 18.7% fraction of degradable organic carbon in the waste, and 40% fraction of methane collection in landfills (from 2003 onward), the total methane emissions were estimated at 250 thousand tons in 2007. The contribution of methane emissions from decomposition of municipal solid waste amounted to 7% of the total CO_2eq emissions of that year.

Although emissions from waste have decreased since 2003 due to the collection of biogas in landfills, the contribution of waste to GHG emissions remains significant. This is due to large production of solid waste, on the one hand, and the fact that most of the waste is landfilled (although major efforts are currently being invested in increasing the waste recovery rate by means of legislation, economic incentives and education). Waste management practices encourage the development and maintenance of anaerobic conditions within the landfill: the waste is compacted to minimize void space and is covered with a daily to weekly soil layer.

Wastewater can produce methane if treated anaerobically. The main factor which determines the methane generation potential of wastewater is the amount of organic material in the wastewater stream, expressed in terms of Biological Oxygen Demand (BOD). In Israel, the average BOD5 value (5-day test) of wastewater is 60 g/person/day. This value is higher than the value for domestic wastewater itself and takes into account that about 20% of the industrial wastewater streams are discharged with domestic wastewater. Total methane emissions in 2007 were estimated at 5,900 tons for domestic wastewater and 22,300 tons for industrial wastewater.

4.6 Forestry

Vegetation withdraws carbon dioxide from the atmosphere through photosynthesis. In Israel, afforestation programs have been implemented for several decades and are continuing today, causing a net removal of CO_2 from the atmosphere.

In 2007, Israel's forest area included 83,200 hectares of plantations (including 50,300 hectares of conifers, 8,000 hectares of eucalyptus and 24,900 hectares of broad-leaved trees) and about 99,400 hectares of natural woodlands. Although most forests are composed of conifers and broad-leaved trees, the relatively small area planted with eucalyptuses contributes about 12% of the CO_2 removals.

Table 4.2 *Calculation of CO_2 removal by forests (2007)*

Forest Category	Area (kha)	Growth Rate (tons dry matter/ha/year)	Commercial Harvest (ktons dry matter/ha/year)	CO_2 Removal (kton)
Plantations:				
Conifers	50.3	4.5	47.2	295.7
Eucalyptus	8.0	5.5	5.7	63.0
Broad-leaved	24.9	1.5	4.4	56.3
Natural woodlands	99.4	0.6	2.3	86.9
Total	**182.6**		**60**	**501.8**

Source: CBS

4.7 Summary of the Inventory

The following table summarizes the emissions and removals of CO_2, CH_4 and N_2O from the different sectors, as estimated for the years 1996, 2000 and 2003-7. Methane and nitrous oxide emissions are converted to CO_2eq by means of the Global Warming Potential (GWP) which is a measure of the radiative effects of the different greenhouse gases relative to CO_2. The GWP values used are 21 for methane and 310 for nitrous oxide (for a time horizon of 100 years). Emissions from international aviation and sea transport are not included in the national totals.

The summary table shows that total emissions grew by approximately 23% in the period between 1996 and 2007. Emissions per capita and GDP, however, decreased by 3% and 17% respectively. The major GHG, carbon dioxide, dominated the increase in emissions with a 29% increase rate. Nitrous oxide increased by 56% and methane had a mediating effect with a 24% decrease rate due to the collection of biogas in landfills.

Carbon dioxide emissions by sector are presented in Table 4.4. Within the main contributor, the energy sector (85% of total GHG emissions in 2007), the energy industries, which constituted the main source of emissions, increased their emissions by 49%, followed by transport with a 38% increase rate. Manufacturing industries and agriculture decreased their emissions by 9% and 82%, respectively. Emissions from industrial processes grew by 29%, while removals from forestry and land-use change grew by 8%.

Table 4.3 *Summary of GHG inventory (CO_2eq)*

(Thousand Tons unless stated otherwise)	1996	2000	2003	2004	2005	2006	2007
TOTAL	**62,705**	**72,439**	**72,136**	**72,691**	**73,296**	**74,641**	**76,854**
Tons per capita	11.03	11.52	10.78	10.68	10.58	10.58	10.70
Tons per GDP (2005 US Dollars PPP)	0.52	0.50	0.49	0.47	0.45	0.44	0.43
Carbon Dioxide (CO_2)	51,862	61,007	63,841	63,888	64,026	65,092	67,061
Methane (CH_4)	8,945	9,226	5,690	6,068	6,534	6,781	6,842
Nitrous Oxides (N_2O)	1,897	2,206	2,606	2,735	2,737	2,767	2,952

Source: CBS and Jean Koch et al

Table 4.4 *CO_2 emissions by sector**

	1996	2000	2003	2004	2005	2006	2007
Total emissions and removals (Thousand Tons)	**51,862**	**61,007**	**63,841**	**63,888**	**64,026**	**65,092**	**67,061**
Energy	**50,344**	**58,917**	**62,071**	**62,044**	**62,088**	**63,068**	**65,022**
1. Energy industries	28,466	36,412	40,155	40,665	40,674	41,343	42,571
2. Manufacturing industries and construction	6,720	6,912	6,125	5,901	6,112	6,032	6,155
3. Transport	11,031	14,018	14,626	14,320	14,117	14,549	15,198
4. Commercial, institutional	3,520	379	496	502	506	470	462
5. Residential sectors		838	548	541	557	553	527
6. Agriculture, forestry and fishing	607	358	121	116	122	121	109
Industrial processes	**1,888**	**2,303**	**2,056**	**2,120**	**2,330**	**2,434**	**2,440**
Land-use change and forestry	**-370**	**-213**	**-286**	**-276**	**-392**	**-411**	**-401**

Source: CBS and Jean Koch et al

The following table presents methane emissions for the period 1996-2007. As already mentioned, methane emissions decreased in this period by 24%, mostly due to a 33% decrease rate in emissions from solid waste handling.

* In the 1996 inventory, the Commercial and Institutional Sectors also include the residential sector and land use change was not calculated.

Table 4.5 *CH_4 emissions by sector* (thousand tons)*

	1996	2000	2003	2004	2005	2006	2007
Total emissions (CO_2eq)	**8,945**	**9,226**	**5,690**	**6,068**	**6,534**	**6,781**	**6,842**
Energy	**75**	**77**	**75**	**73**	**74**	**74**	**78**
Agriculture	**891**	**920**	**835**	**845**	**878**	**929**	**932**
A. Enteric fermentation	681	702	645	654	681	712	713
B. Manure management	210	218	190	191	197	217	218
Waste	**7,980**	**8,228**	**4,780**	**5,150**	**5,581**	**5,778**	**5,832**
A. Solid waste disposal on land	7,770	8,019	4,225	4,587	5,011	5,203	5,239
B. Wastewater handling	210	210	555	563	570	574	592

Source: CBS and Jean Koch et al

The following table presents the emission trend for nitrous oxide. Emissions of this gas grew between 1996 and 2007 by 55%. Agriculture contributed an increase rate of 35%, mostly from agricultural soils, whereas emissions from energy grew by 26%.

Table 4.6 *N_2O emissions by sector** (thousand tons)*

	1996	2000	2003	2004	2005	2006	2007
Total emissions (CO_2eq)	**1,898**	**2,206**	**2,606**	**2,735**	**2,737**	**2,767**	**2,952**
Thereof:							
Energy	**179**	**215**	**227**	**223**	**221**	**220**	**226**
Agriculture	**1,181**	**1,300**	**1,378**	**1,427**	**1,428**	**1,496**	**1,600**
A. Manure management	248	256	238	239	249	269	270
B. Agricultural soils	933	1,044	1,140	1,188	1,179	1,226	1,330

Source: CBS and Jean Koch et al

* The Energy Sector also includes emissions from Industrial Processes due to confidentiality constraints

** Industrial Processes and Waste are not detailed due to confidentiality constraints.

The following table presents emissions of indirect GHGs for the period between 1996 and 2007. Emissions of most of these gases decreased in this period, except NMVOCs, which remained unchanged. Emissions of NO_x, CO and SO_2 decreased by 8%, 53% and 29%, respectively. This trend is mostly attributed to improvements in the energy industries and transport.

Table 4.7 *Precursors emissions by sector (thousand tons)*

	1996	2000	2003	2004	2005	2006	2007
NO_x							
Total	**220**	**237**	**209**	**202**	**204**	**202**	**202**
Thereof: Energy	215	232	208	201	202	201	201
CO							
Total	**478**	**376**	**284**	**263**	**257**	**237**	**226**
Energy	478	376	284	263	257	237	226
Thereof: Transport	469	367	274	253	247	227	215
NMVOCs							
Total	**247**	**239**	**247**	**229**	**233**	**238**	**248**
Energy	158	156	159	160	161	166	175
Industrial Processes	89	84	88	69	72	72	73
SO_2							
Total	**281**	**284**	**274**	**256**	**235**	**213**	**199**
Energy	262	264	239	223	202	178	163
Industrial Processes	19	19	34	32	34	34	36

Source: CBS and Jean Koch et al

The following table presents the emissions of international bunkers, which are not included in the national inventory, for the period 1996-2007. As to the direct GHGs, the major contributor to international bunkers' emissions is carbon dioxide which is responsible for more than 99% of the direct GHG emissions. Emissions of this gas grew by 57%. Emissions of nitrous oxide and methane grew at rates of 36% and 157% respectively. Both aviation and marine transport contributed to these trends.

Indirect GHG emissions also grew in the reviewed period, with increase rates of 126%, 114%, 150% and 166% for NO_x, NMVOCs, SO_2 and CO respectively.

Table 4.8 *International bunkers (thousand tons)*

(Thousand Tons)	1996	2000	2003	2004	2005	2006	2007
Direct (CO_2eq):							
Total	**2,225**	**2,803**	**2,650**	**2,753**	**2,955**	**3,141**	**3,485**
CO_2	**2,207**	**2,781**	**2,631**	**2,732**	**2,933**	**3,117**	**3,460**
Aviation	1,924	2,298	1,790	2,025	2,069	2,310	2,400
Marine	283	483	841	707	864	807	1,060
CH_4	**0.7**	**1.0**	**1.4**	**1.3**	**1.5**	**1.5**	**1.8**
Aviation	0.3	0.3	0.3	0.3	0.3	0.3	0.4
Marine	0.4	0.7	1.2	1.0	1.2	1.1	1.5
N_20	**17.4**	**21.3**	**17.7**	**19.5**	**20.2**	**22.2**	**23.6**
Aviation	16.7	20.1	15.7	17.7	18.1	20.2	21.0
Marine	0.6	1.2	2.1	1.7	2.1	2.0	2.6
Indirect:							
NO_x	**13.7**	**19.3**	**24.2**	**22.5**	**25.8**	**25.7**	**31.0**
Aviation	8.1	9.7	7.6	8.6	8.8	9.8	10.2
Marine	5.6	9.5	16.6	14.0	17.0	15.9	20.9
NMVOCs	**2.1**	**2.9**	**3.5**	**3.3**	**3.7**	**3.8**	**4.5**
Aviation	1.4	1.6	1.3	1.4	1.5	1.6	1.7
Marine	0.8	1.3	2.2	1.9	2.3	2.1	2.8
SO_2	6.0	9.3	12.0	11.8	13.4	12.7	15.0
Aviation	3.7	4.4	3.4	3.8	3.9	4.4	4.6
Marine	2.4	4.9	8.6	8.0	9.5	8.3	10.4
CO	6.5	9.6	13.6	12.2	14.3	13.9	17.3
Aviation	2.7	3.2	2.5	2.9	2.9	3.3	3.4
Marine	3.7	6.4	11.1	9.3	11.4	10.6	13.9

Source: CBS and Jean Koch et al

Existing Policies and Measures 5

5.1 Environmental Policy regarding Mitigation and Adaptation

Global warming and the urgent need to reduce GHG emissions call for joint mitigation policy and action by countries worldwide. Local adaptation and preparedness measures are also required as a fundamental part of national environmental policy. In the Mediterranean Sea basin, the impacts of climate change may have adverse impacts on many areas such as water, agriculture, drainage systems, the energy sector and the coastal environment. A sound climate change policy should be prepared in collaboration and coordination with all relevant parties, taking into consideration possible direct and indirect impacts.

Five landmarks in Israel's environmental policy during the past decade are noteworthy in the wide context of climate change policy. The first landmark set a target for assimilation of renewable energy technologies in Israel. The second landmark paved the path toward sustainable development of the Israeli economy. The third landmark set responsibilities and imposed obligations for reduction of air pollution by the government, local authorities and the industrial sector. The fourth landmark directly related to the preparation of a climate change plan for Israel. The fifth landmark set Israel's target for a 20% reduction in GHG emissions by 2020 compared to a BAU scenario:

1. In November 2002, the Israeli government decided on targets for renewable energy use in electricity production: 2% in 2007 and 5% by 2016. The Ministry of National Infrastructure (MNI) encourages the production of electricity from renewable energy, especially, solar, wind and biomass, mainly for the following reasons:
   - Reduction of fossil fuel imports;
   - Reduction of air pollution and its associated costs;
   - Promotion of modern technologies in general and local technologies in particular.
2. In May 2003, the Israeli government decided, *inter alia*, that the policy of the Government of Israel will be based on the principles of sustainable development and that each government ministry will draft a strategic plan for sustainable development. The government decision includes both specific sections, which relate to the tasks of the different ministries in drafting their strategic plans for sustainable development, and general provisions. Most importantly, the decision states: "The policy of the Government of Israel shall be based on the principles of sustainable development

practice, that combine a dynamic economy, wise use of natural resources, protection of ecosystems, and the granting of equality of opportunity to all, in order to respond to the needs of the present and future generations..." Most of Israel's government ministries have already prepared sustainable development strategies aimed at promoting the integration of the three components of sustainable development - economic development, social development and environmental protection - in government policy.

3. A Clean Air Law was enacted in 2008 and will come into force in 2011. The aim of the law is: "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." Among the provisions of the Clean Air Law:

    - A new regulatory framework for setting stationary and ambient emission standards and regular revision of air quality standards for air pollutants.
    - Preparation of a national plan for the reduction of air pollution.
    - Procedures for monitoring and assessment of air pollutants, compilation of air quality data, and air pollution forecasts.
    - Emissions permit requirements for major industrial sources of pollution.
    - Concentration of enforcement procedures and penalty frameworks under one statutory body.
    - Obligations of local authorities to prevent and reduce air pollution in their jurisdiction.
    - Provision of authority to the MoEP to deal with vehicular pollution.

4. In June 2009, Israel's government approved a decision to prepare a climate change plan for Israel. The decision followed an earlier resolution, in May 2009, to establish a Ministerial Committee on Environmental Protection and Climate Change, headed by the Environmental Protection Minister. In accordance with the decision, a directors-general committee was established, headed by the director general of the MoEP, and including the directors general of all relevant ministries. Its mission: to prepare a climate change policy for Israel and to formulate a national action plan, which will include mitigation and adaptation plans. To facilitate the process, professional working groups on different fields of mitigation and adaptation have been set up. The working groups on mitigation were charged with preparing scenarios and means for the reduction of GHG emissions, each in its particular field (e.g., energy, transport, agriculture, planning and building, etc.). They were also asked to recommend national targets for GHG emissions reduction based on Israeli studies and the post-Kyoto negotiations for a global agreement. In addition they were asked to specify existing and proposed reduction measures, the reduction potential of each measure, the cost of implementation, recommendations for implementation, action plans and timetables (See sections 7.1 and 7.2). The working groups on adaptation are focusing on such areas as biodiversity, public health and water resources. They were charged with closing the gaps in existing knowledge on the impacts of climate change in Israel based on different scenarios, surveying available means for minimizing damage and vulnerability and identifying Israeli technology for dealing with climate change that may assist other countries (See section 6.1).

5. During the UN Climate Change Conference in Copenhagen, in 2009, Israel's President, Mr. Shimon Peres, announced that the Israeli government will strive to reduce its GHG emissions by 20% by 2020, compared to a BAU scenario. In January 2010, the Minister of Environmental Protection endorsed Israel's declaration in a letter to the Executive Secretary of the UNFCCC. In this letter, the Israeli government declares its association with the Copenhagen Accord and sets the path to achieve the an-

nounced mitigation goal through the incorporation of 10% renewable energy in electricity generation and 20% reduction in electricity consumption by 2020. In order to achieve this goal, an interministerial steering committee was established (approved in a government decision of March 2010), which, with the assistance of the S. Neaman Institute for Advanced Studies in Science and Technology in the Technion – Israel Institute of Technology (See section 7.4) will prepare a National Action Plan for the reduction of GHG emissions. The letter also notes Israel's intent to be actively involved in the forthcoming climate change negotiations towards the COP16.

5.2 Mitigation and Adaptation Actions

In line with Israel's environmental policy, various actions have been taken in recent years to improve environmental quality and promote sustainable development. Some contribute directly toward the reduction of GHG emissions or towards adaptation to climate change. Others contribute indirectly to the achievement of these goals. In addition, the MoEP commissioned updated studies on mitigation and adaptation, which will set the base for further actions in these fields. The studies are detailed in chapters 6 and 7. The following sections provide an overview of the main steps which have already been taken in the various sectors in Israel in relation to climate change.

5.2.1 Energy and Manufacturing Sectors

GHG Mitigation-related Measures

- During the second half of the last decade, the electricity industry introduced natural gas into the energy mix of Israel. New combined-cycle power plants designed to operate on natural gas were constructed and existing plants were converted to natural gas, with the Eshkol power plant in Ashdod the first to convert to natural gas use in February 2004. By the end of 2009, natural gas composed nearly 35% of the total electricity production capacity in Israel. Two power plants (Ashdod and Tel Aviv), which were fueled by heavy fuel-oil in the past, were converted to operate by natural gas. In addition, three sites with combined cycle gas turbines became operational in 2009 and others are planned to start operations in the near future.
- The MoEP and the S. Neaman Institute for Advanced Studies in Science and Technology prepared a protocol for a GHG registry. All processes and reporting methods for the Israeli registry were defined in cooperation with a large team of stakeholders, including: Israel Electric Corporation, Manufacturers Association of Israel, Egged and Dan (public transportation cooperatives), Nesher Cement Co., Israel Union for Environmental Defense (environmental NGO), Forum 15 (The Israeli Forum of Self-Government Cities), CBS, Israel Defense Forces, MNI, Israeli Institute of Energy and Environment and Ministry of Agriculture and Rural Development (MARD). The goal of the team was to establish a registry protocol with reporting instructions to guide organizations and companies from all business sectors in reporting their GHG emissions and to develop capabilities and tools for use by the private sector, industries and organizations to estimate their reduction potential. The Israeli protocol was developed with full attention to stakeholder needs and in accordance with agreements and understandings already achieved regarding similar protocols around the world. The registry, which was officially launched on July 1, 2010, will serve several needs:

For reporting entities - participating in the reporting process will serve as a learning tool for quantifying GHG emissions, internalizing and streamlining required procedures, reducing emissions, managing business risks associated with GHG emissions and identifying reduction opportunities. It will improve the public image of organizations regarding sustainability and commitment to the community through transparency and public reporting. It will also develop understanding of the emissions quantifying process in preparation for the anticipated mandatory emission reporting and reduction scheme. Finally, it will also enhance the capacity of a business entity to function within the

Table 5.1 *Status of CDM projects in Israel*

#	Project	Sector	CER Potential Per year (Tons of CO_2)	Documents Presented	Status
1	Hiriya landfill	Waste	93,452	PDD	LOA
2	Talia landfill gas recovery and electricity production	Waste	73,640	PDD	LOA
3	Retamim landfill rehabilitation	Waste	56,000	PDD	LOA
4	Taibe landfill methane reduction	Waste	20,000	PPD	LOA
5	Ganei Hadas landfill gas recovery	Waste	287,479	PDD	LOA
6	Evron landfill gas recovery	Waste	114,497	PDD	LOA
7	Nimra landfill gas recovery	Waste	25,000	PIN	LONO
8	Petach Tikva landfill methane reduction	Waste	36,500	PIN	LONO
9	Efe'e landfill gas treatment	Waste	80,000	PDD	NA
10	Te'enim landfill gas treatment and electricity production	Waste	40,000	PDD	NA
11	Hagal landfill gas treatment	Waste	70,000	PDD	NA
12	Swine methane capture from manure treatment in Kibbutz Lahav	Agriculture	9,212	PDD	LOA
13	Biogas combined heat and power treatment plant in Emek Hefer	Agriculture	19,437	PDD	LOA
14	Manure compost treatment in Kibbutz Nirim	Agriculture	16,900	PDD	LOA
15	Treatment of dairy farm wastes in the Golan Heights	Agriculture	103,403	PDD	LOA
16	Treatment of dairy farm wastes in Be'er Tuvia	Agriculture	195,574	PDD	LOA
17	Anaerobic treatment for dairy farm manure in Ein Ha'Horesh	Agriculture	130,068	PDD	NA
18	Offis textile fuel switch	Fuel switch	9,243	PDD	LOA
19	Biomass based steam generation at Galam factory	Fuel switch	31,920	PDD	LOA
20	Natural gas fuel switch in American Israel Paper Mills	Fuel switch	47,662	PDD	LOA
21	Dead Sea Magnesium natural gas fuel switch	Fuel switch	21,395	PDD	LOA
22	Bromine Compounds natural gas fuel switch	Fuel switch	13,206	PDD	LOA
23	Dead Sea Bromine - Periclase natural gas fuel switch	Fuel switch	25,965	PDD	LOA
24	Rotem Amfert natural gas fuel switch	Fuel switch	18,511	PDD	LOA
25	Dead Sea Works ovens natural gas fuel switch	Fuel switch	28,492	PDD	LOA
26	Dead Sea Works power plant fuel switch	Fuel switch	105,881	PDD	LOA

27	Steam generation by renewable biomass at the Strauss factory	Fuel switch	10,771	PDD	LOA
28	Biomass based steam generation at Gan Shmuel food factory	Fuel switch	19,000	PDD	NA
29	American Israel Paper Mills natural gas cogeneration	Energy	578,243	PDD	LOA
30	Wind turbines in the Golan Heights	Energy	39,042	PDD	LOA
31	Ashdod refineries natural gas electricity generation	Energy	95,886	PDD	LOA
32	Nesher Ramla cement factory natural gas electricity generation	Energy	53,768	PDD	LOA
33	Natural gas power plant in Ben Gurion Airport	Energy	141,020	PIN	LOA
34	Wind turbines in the Gilboa mountains	Energy	83,700	PIN	LOE
35	Transfer of Haifa IEC power plant to natural gas	Energy	172,000	PIN	LOE
36	Demand side energy efficiency program in Israeli municipalities	Energy	59,000	PIN	LONO
37	Rotem natural gas fired power plant	Energy	737,000	PIN	LONO
38	Ashalim solar power plant	Energy	200,000	PIN	LONO
39	Beer Tuvia natural gas power plant	Energy	737,000	PIN	LONO
40	Ze'elim solar thermal power plant	Energy	174,000	PIN	LONO
41	Dalia Power Energies combined cycle natural gas power plant	Energy	859,415	PDD	NA
42	Optimization of clinker grinding process at the Ramla Cement Plant	Industrial efficiency	120,000	PDD	LOA
43	N_2O emissions reduction in Fertilizers & Chemicals Ltd.	Industrial efficiency	87,383	PDD	LOA
44	N_2O emission reduction in Haifa Chemicals Ltd.	Industrial efficiency	500,000	PIN	LOA
45	Dead Sea Magnesium SF_6 reduction	Industrial efficiency	273,616	PDD	LOA
46	Ortal Diecasting magnesium SF_6 reduction	Industrial efficiency	11,025	PDD	LOA
	Total		**6,625,306**		

Source: MoEP

Table Legend

PDD- Project Development Document

PIN- Project Idea Note

LOA- Letter of Approval

LONO- Letter of No Objection

NA- In Process or other

global GHG trading markets and document its record of past emission reductions in preparation for future requirements.

For the government – reported data will offer a future tool for better insight into emission sources and means for their reduction within the framework of newly developed policy measures.

For the public – exposure of relevant data through public reports will enable a better understanding of the issue, will build heightened awareness and will enhance personal commitment and action.

The protocol includes, *inter alia*, information regarding:

- Reporting systems worldwide and in Israel;
- Structure of the registry and reporting system;
- Guidelines for calculating the emissions in different sectors;
- Reporting and quality management requirements.

In order to allow for vetting of the process and examination of the methods, it was agreed to define the first reporting year (2010) as a "pilot" year during which the process will be thoroughly tested.

- In 2004, a Designated National Authority for authorizing Clean Development Mechanism (CDM) projects in Israel was established. By the beginning of 2009, 48 projects were presented for approval to Israel's Designated National Authority for the CDM in the areas of waste, agriculture, fuel switch, energy and industrial efficiency. 16 CDM projects have been registered with the United Nations between February 2006 and July 2009, with a potential annual reduction of more than 1.8 million tons of CO_2. Certified Emission Reductions (CERs) issued by Israel to date have reached 249,843 tons. Table 5.1 presents the current status of the presented projects in Israel.
- In August 2008, the Israeli government approved a five-year program for investment in the field of renewable energy. The goals of the plan, slated for implementation in 2008-2012, are to increase renewable energy sales and increase research and development investments in the field. One proposal calls for establishing a research and development center for renewable energy technologies in the Negev over a five-year investment period.
- In January 2009, the Israeli government approved a proposal on establishing targets and formulating tools for the promotion of renewable energy, especially in the Negev and Arava arid regions. The decision calls for generating 10% of Israel's electricity from renewable sources by 2020, with 5% by 2014, and for identifying and allocating lands in the Negev and Arava for the construction of power plants from renewable energies.
- BIRD Energy, a program for U.S. - Israel joint renewable energy developments, funded by the U.S. Department of Energy, the MNI and the BIRD Foundation, published a call for joint proposals on renewable energy in 2010.

Progress in Promoting Renewable Energy Technologies

- **Solar Energy:**
  - Since the mid-70s the residential sector is required by law to use solar water heating systems.
  - Two solar thermal power plants in a capacity of 250 MW are in the process of planning in the Negev (Ashalim), in accordance with a government decision of March 2008. These plants will use a solar tower technology. This technology already exists in Israel at the Weizmann Institute of Science and in a pilot in Dimona, which was set up by a private company (See section 7.1.11).
  - Economic incentive measures for renewable energy have been developed by the Israel Public Utilities Authority – Electricity (PUA) for the sale of renewable energy to the IEC and the related feed-in tariff and licensing arrangements for solar thermal generation. The renewable premiums reflect the cost of the avoided CO_2, NO_x, SO_x and particulate

emissions due to the replacement of fossil-fuel generators during each time-of-use period.

- In 2008, PUA approved an incentive plan to buy electricity from individuals and companies who install a photovoltaic solar panel system on their roofs (feed-in tariff).

- **Wind Energy**:
  - A wind farm with an installed capacity of 6 MW and eight turbines is in operation.
  - In 2003, the IMS, supported by the MNI, conducted a comprehensive survey on wind potential in the Negev and Arava regions of southern Israel, which discovered such potential in higher sections of the Negev hills, southeast Judean Hills, Elat hills and Gulf of Elat.
  - The MNI signed a permit to establish an additional wind farm with a maximal capacity of 200 MW.
  - The MNI has published a plan whereby citizens will be able to install wind turbines of up to 50 MW on their roofs, with the generated electricity to be sold directly to the IEC.
  - The Israel Nature and Parks Authority published a call for proposals on placing vertical wind turbines in national parks and nature reserves in order to provide electricity for these sites and sell the surplus electricity to the IEC. The vertical wind turbines would not endanger birds and will be placed only in locations which do not create landscape damage.

- **Biogas and Bio-diesel Energy:**
  - Three installations currently produce biogas from landfills in a total capacity of 5.1 MW.
  - A new installation for the production of biogas from wastewater with a capacity of 1.8 MW has begun operating in Jerusalem.
  - Three kibbutzim produce biogas from cattle manure and other cattle farms are considering the establishment of biogas installations as well.
  - Jordan and Israel have announced a new joint project for refining bio-diesel from dry organic waste. The new installation is planned for 2010 on the Israeli Jordanian border at an estimated cost of €4 million.
  - In March 2010, PUA (Israel's Electricity Authority) published a call for proposals on tariffs for electricity generation from the biogas created from waste treatment and from biomass.

Other Environmental Measures

- Measures have been implemented to reduce air pollution from all sources - transportation, electricity production, industry and quarrying operations, mostly through the use of low-sulfur fuels and improved fuel combustion technologies. In the energy industry, for instance, emissions of sulfur dioxide fell from 209 thousand tons in 2000 to 147 thousand tons in 2007 (See section 4.2.2).

- Efforts have been invested in implementing the provisions of international conventions on ozone depletion and climate change - the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer (both ratified in June 1992).

- A countrywide 24-hour monitoring system provides updated information on the state of air pollution. A sophisticated online air resources management system will soon be operational to help forecast air quality levels, analyze pollution events and facilitate policy making and planning. Along with the coming into force of the Clean Air Law in 2011, the monitoring system will provide information on air quality from more than 100 monitoring stations.

- A coal power plant was required to install equipment to reduce NO_x and SO_x emissions. In addition, two power units were shut down for failure to meet the required standards for air pollution.

- Preparation of environmental impact assessments is compulsory for developments such as power stations, airports and seaports. In addition, planning authorities usually require environmental impact assessments for major roads, railways, marinas, quarries, waste disposal sites and some industries.

- Incorporation of environmental conditions including limits on air pollution into the business licenses of industrial plants is stipulated in the Licensing of Businesses Law. These conditions may be enforced through investigation and criminal indictment or through administrative closure if risk to the environment is anticipated. Framework specifications for different industrial sectors have being prepared including, *inter alia*, gas turbines, cement plants, dairy farms, oil and coal-fired power plants, and refineries.
- A program for the reduction of industrial pollution emissions is in effect. It sets different requirements for large plants which will be subject to emission permits, based on Best Available Techniques (BAT) and Integrated Pollution Prevention and Control (IPPC), and for small plants and medium plants, which will be subject to framework conditions for different sectors, based on TA Luft 2002 standards and European Directives. Some 150 industrial plants have been defined as IPPC plants and will be subject to emission permits, within the framework of their business license.
- A Green Label is awarded by the MoEP and the Standards Institution of Israel to products with reduced environmental impact relative to comparable products. Encouraging industrial plants to apply for a green label for their products increases demand for "green consumption," which benefits manufacturers, consumers and the environment, while providing the company with a positive corporate image and opening up international markets.

5.2.2 Transport

Recent years have seen a flurry of activity to reduce vehicular pollution in Israel: fuel quality improvements, research studies, innovative technologies, regulatory and enforcement mechanisms, roadside inspection and public awareness campaigns. Yet, the real breakthrough came in the form of a far-reaching government decision on the reduction of air pollution from transportation sources, which was approved in September 2007.

The government decision calls for the following steps, among others:

- Setting stricter mandatory emission standards for smoke emissions from diesel vehicles and carbon monoxide emissions from gasoline-powered vehicles, adapted to each vehicle model.
- Authorizing Green Police inspectors to order drivers to stop their cars for pollution inspection, and, in case of non-compliance with emission limits, instructing owners to stop using their vehicles.
- Calling on the Ministry of Transport and Road Safety (MOT) to prepare a pollution reduction program for the center of Tel Aviv which is based on restricting the movement of polluting vehicles.
- Implementing a plan for the scrapping of old vehicles, which offers owners payment for transferring their old inefficient vehicles for scrapping and metal parts recycling.
- Calling on the Ministry of Transport and Road Safety to renew roadside air pollution tests for vehicles by its enforcement patrols which check the working order of vehicles.
- Calling on the relevant officials in the Ministry of Finance and the Tax Authority to present a program for encouraging employees to reduce their private car use and switch to public transportation or other alternatives that reduce private car use.
- Imposing a differential tax on vehicles, based on the "green index" published by the Green Tax Interministerial Committee. This index divides cars into 15 groups of pollution that form the basis for tax credits.
- Prohibiting the movement of heavy vehicles on main traffic arteries during peak hours, with the exception of vehicles designated for passenger transport.

- Giving preference in tenders for service vehicles in government agencies to fuel-efficient, environment-friendly vehicles.
- Establishing a national vehicle laboratory to assist in checking vehicle compliance with advanced standards and to contribute to wise decision making on the subject.
- Reviewing the advantages and disadvantages of electric cars charged from the national electricity grid and recommending policy.
- Granting significant economic incentives for promoting alternative fuels, which are not oil-based, as well as diesel substitutes.

Other Environmental Measures

Along with the above-mentioned government decision, other important measures to reduce pollution from transportation during the last decade should be noted as well:

- Improvements in fuel quality including in the sulfur content of fuels for transportation: a reduction from 0.05% to 0.001% in diesel oil, and from 0.015% to 0.001% in gasoline.
- Reduction of CO emissions from transportation due to the introduction of catalytic converters in gasoline vehicles, which led to a reduction of total emissions from gasoline vehicles from 352 thousand tons in 2000 to 190 thousand tons in 2008.
- Enforcement against polluting vehicles: six mobile inspection stations operate in Israel in addition to pollution inspectors employed by the MoEP. In 2008, 24,000 vehicles were inspected, of which 12% exceeded the standards and were fined or removed from the road until their repair.
- The MoEP plans to support local authorities in their efforts to reduce air pollution and GHG emissions in their jurisdiction.

5.2.3 Residential and Commercial Sector

Government Plans

In September 2008 the Israeli government approved a proposal on energy efficiency, which aims to bring about 20% savings in anticipated electricity consumption by 2020. The program relates to energy efficiency as a means of tackling climate change. Among the proposed measures: energy savings in the home and in government structures, green building, higher energy efficiency standards for electrical appliances, information programs on wise use of electricity and establishment of an energy efficiency fund. The MNI encourages energy efficiency in the following ways:

- Market transformation - In 2009, a major energy conservation campaign was inaugurated by the MNI, the MoEP and the IEC to raise awareness of energy efficiency among the general public. Major emphasis was placed on raising public awareness of energy conservation in purchasing new appliances.
- Resource acquisition – The MNI accompanies and supports specific energy consumers in order to improve the energy efficiency of their equipment and buildings.
- Data analysis – The MNI is upgrading its data collection and analysis capacity in order to improve the decision making process in this area.
- Assimilation of the Performance Contracting Method – The MNI assimilates and encourages large and small energy efficiency projects. The support granted depends on the achieved level of energy savings.
- Tenders – In 2009 and 2010, the MNI published numerous tenders on energy efficiency, including a pilot project for the distribution of energy efficient light bulbs, consulting on energy efficiency in hotels, energy efficiency in buildings serving government ministries, small-scale energy efficiency projects, and more.

Local Authority Plans: Forum 15 (The Israeli Forum of Self-Government Cities)

Forum 15 brings together fifteen major municipalities in Israel, which receive no financial aid from the government and are managed as closed economies on the basis of their independent financial resources. The cities of the Forum include nearly 3 million residents (approximately 40% of

Israel's population) but it is estimated that more than 80% of Israel's population makes use of the municipal and metropolitan services provided by these cities.

Recognition that cities are responsible for a significant amount of air pollutants and GHG emissions, but can also play a central role in providing solutions for climate change and improved quality of life, has prompted the mayors of Forum 15 plus another three major municipalities to sign a unique convention in February 2008 – The Convention of the Forum 15 for Reducing Air Pollution and for Climate Protection (CCP Israel). The convention is a local version of the ICLEI's cities for climate protection campaign.

Main Components of the Convention:

The convention calls for developing municipal master plans for the reduction of air pollution and protection of climate, setting clear, measurable targets for reducing urban GHG emissions and air pollution, and achieving the first results of the following five CCP milestones within three years:

1. Establish a basic inventory and forecast for key sources of air pollution and GHG emissions in the city.
2. Set targets for air pollutant and GHG emissions reduction (no less than 20% by 2020 in comparison to 2000).
3. Develop and adopt a short to long term local action plan to reduce air pollution and GHG emissions.
4. Implement all measures and actions derived from the local action plan in the city and municipality.
5. Monitor and control air pollution and GHG emissions and report on the actions and measures implemented within the framework of the local action plan.

In order to provide the municipalities with the necessary support tools for implementation, Forum 15 set up a task force for steering and control, consisting of all stakeholders. The Local Sustainability Center, initiated by the Heschel Center for Environmental Learning and Leadership, the MoEP, the Porter School of Environmental Studies at Tel Aviv University and ICLEI, were central partners in the process of developing the initiative and in setting up the task force.

Most of the municipalities (14 out of 18) have already conducted their baseline emissions inventory and forecast and are now defining their annual goals for reductions in GHG emissions. This is accompanied by the development of local action plans and initiatives to reduce GHG emissions and air pollution in four main areas:

- Transportation and fuels: creating bicycle paths, inspecting vehicular air pollution, encouraging public transportation, car pooling and walking and enhancing street lighting efficiency.
- Energy conservation and environmentally friendly construction: applying enhanced environmental building standards for public buildings, improving energy efficiency of public irrigation systems, installing photovoltaic cells on the roofs of public buildings and recovering energy from landfills.
- Waste and recycling: enhancing public access to recycling installations for paper and organic waste and establishing waste sorting stations.
- Green spaces: rehabilitating degraded open spaces and initiating municipal afforestation projects.

Other efficiency measures in the residential and commercial sector

- In 2005, Israel Standard 5281 for buildings with reduced environmental impact (green buildings) was published by the Standards Institution of Israel.
- A standard on the energy rating of residential buildings (Israel Standard 5282 Part 1) was approved by the Standards Institution of Israel in 2005 and a standard on the energy rating of office buildings was approved in 2007 (Israel Standard 5282 Part 2).
- In 2008-2009, several regulations and standards were published on energy efficiency and energy labeling of electrical appliances (including refrigerators, air conditioners, dishwashers, washing machines, baking ovens and clothes

dryers), in addition to regulations and standards published in previous years.

- In 2009-2010, educational programs on energy efficiency targeted at kindergarten, elementary school and junior high school have and will be incorporated into the formal educational system.
- Legal requirements for the installation of solar water heaters in new buildings and compliance with a standard which mandates thermal insulation levels that provide thermal comfort at reasonable energy consumption are in force in Israel. This accounts for 80% of all water heating requirements annually and provides a savings to the energy market of 3-4% of primary energy consumption.
- In January 2010, the Standards Institution of Israel published a new management system standard for energy systems management, ISO 50001. The standard is expected to help save at least 10% of the energy consumption of organizations. Pilot programs in a number of companies are expected to begin in 2010.

5.2.4 Waste and Wastewater

The MoEP waste policy is to increase recycling and reuse rates and to decrease the amount of generated waste in general and landfilled waste in particular in an environmental manner. The target is to gradually decrease the landfilled waste amount by at least 50% by 2015.

A Solid Waste Management Master Plan was approved by the National Planning and Building Board in 2006. The plan provides a comprehensive and sustainable framework for waste management in Israel. It relates to the different stages of waste generation, to all generators of waste and to the different treatment solutions. The plan is based on the following methods of waste treatment and management, in descending priority: reduction at source, recovery and landfilling as the last option.

In July 2007, Amendment 9 to the Maintenance of Cleanliness Law, dealing with the imposition of a landfill levy, entered into effect. The objective of the levy is to reflect the true cost of landfilling (one of the main components of the cost is the emission of methane from decomposition of the organic matter in landfills) and to allow for fair competition with advanced treatment methods - recycling and energy recovery from waste.

According to the law, the funds collected by means of the landfill levy are deposited in a separate and dedicated account of the Maintenance of Cleanliness Fund to be used for the development, establishment and greater efficiency of alternative means to landfilling which have a lesser impact on the environment as well as for their promotion. Thus, the funds collected from the landfill levy are returned to local authorities or the private sector for the purpose of establishing recycling and recovery infrastructures.

With regard to mitigation steps, two major measures in practice should be noted:

- At the end of the 1990s, the MoEP started to collect methane from landfills for the purpose of reducing environmental hazards and GHG emissions. Today, most of Israel's operational landfills collect methane, with a 40% collection rate from total methane emissions from this source. Methane is currently used for energy in three installations in a total capacity of 5.1 MW. One of these installations – Hiriya – is a closed landfill, undergoing restoration. The economic potential of methane collection and use is being examined for the remaining 52 closed landfills that are planned for restoration.
- Currently 12 wastewater treatment plants collect methane from sludge. These plants constitute 28% of the wastewater treated in Israel. Some of the facilities use the collected methane to produce energy, while others transfer it to a thermal treatment plant for burning. The amount of collected methane from wastewater plants in 2008 is estimated at approximately 4,000 tons.

Other related measures in the waste sector

- All 77 unregulated landfills in Israel for municipal solid waste were closed and replaced by a small number of regulated landfills which enforce stringent conditions for operation and regulations regarding sealing and methane collection.

- The Deposit Law for Beverage Containers came into force in 2001 and was amended in 2010. The amended law raises the original deposit fee and applies responsibility for the collection and recycling of beverage containers on manufacturers and importers.
- Israel's recycling rate has grown significantly over the past ten years - from 3% in the early 1990s to about 27% (including industrial waste) in 2008.
- In recent years major efforts have been made to increase Israel's recycling rate, largely through the above mentioned landfill levy and financial aid to local authorities for the implementation of recycling projects and infrastructure. In parallel, recycling programs in schools and recycling projects on the community level, in conjunction with awareness raising campaigns, have raised public awareness of the importance of recycling environment-friendly products and services.
- In 2008, out of a total of 500 million cubic meters (MCM) of sewage produced in Israel, about 70% of the effluents were reclaimed. In recent years new or upgraded intensive treatment plants were set up in municipalities throughout the country. The ultimate objective is to treat 100% of Israel's wastewater to a level enabling unrestricted irrigation in accordance with soil sensitivity and without risk to soil and water sources.
- In January 2010, Israel approved stringent regulations on wastewater quality which obligate both producers of wastewater and operators of wastewater treatment plants to treat their wastewater to the levels set in the regulations (at least tertiary level).
- In December 2009, Israel's government approved a decision to make government ministries more environmentally efficient. The Green Government decision calls for:
    - Setting quantitative, measurable targets for the reduction of electricity, water and paper consumption in government ministries.
    - Reducing the quantity of waste produced and increasing use of products made from recycled materials.
    - Committing to a switch to energy efficient, low pollution transport.
    - Requiring internal auditors of government ministries to present performance reports to the MoEP, which will compile the data and present annual reports to the government and to the public.

5.2.5 Agriculture

Although agriculture accounts for less than 5% of GHG emissions in Israel, it is a key player in land use and water management and therefore has a great potential for adaptation and mitigation solutions. As a part of the Government's Strategic Plan for Sustainable Development (See section 5.1), the MARD is committed to developing policy strategies based on sustainable development principles with respect to, *inter alia*, water resources and pollution; air pollution; land degradation and desertification; biodiversity; and climate change. In recent years, agricultural policies have indirectly contributed to national climate change policy goals, usually with co-benefits in the fulfillment of other environmental objectives:

- From 1999 to 2007 the MARD and the MoEP provided NIS 493 million in investment grants to facilitate enhanced environmental standards in dairy farms. As part of this dairy farm reform, support was granted for activities such as construction of manure storage facilities, installation of drainage systems to reduce pollution from dairy cow wastes, and construction of biogas facilities.
- A similar program has recently started in the egg laying sector, in which the MARD supports producers by covering a share of their investment costs to meet environmental standards.
- The reform programs in livestock farms have led to an increase in manure recycling and advanced waste treatment methods and to the establishment of regional manure collection and recycling sites.

- Installation of cooling systems in dairy farms has led to an increase in milk production and a net reduction in methane emissions.
- Most of the nitrogen for fertilization is applied via pressurized irrigation systems, which can reach 85-95% efficiency and, therefore, the contribution of fertilization to GHG emissions is minimized. The improved efficiency of water use in agriculture contributes to adaptation of agriculture to climate change as water resource availability is projected to decline and become more variable.
- Some 217 water reservoirs have been established throughout Israel, with the help of the Keren Kayemeth LeIsrael-Jewish National Fund (KKL-JNF). Some of the reservoirs harvest floodwaters while others store recycled effluents. These reservoirs provide 50% of the water used in Israel for agricultural purposes.
- Since the late 1990s a decline in inorganic fertilizer use was observed in Israel. The decline in demand can mainly be attributed to the increased use of reclaimed wastewater for irrigation while considering its chemical composition and nutritional value. In 2006 about a third of the total water consumption in agriculture was met by reclaimed water.
- Due mainly to land and soil conservation considerations, the last decade has shown an increase in adoption of minimum tillage or no till practices, mainly for rain-fed crops. This trend led in turn to energy savings from agricultural machinery.
- Organic waste derived from livestock manure and sewage sludge is wisely used according to stringent regulations set by the MoEP and the Ministry of Health. Almost all the waste from livestock manure and about a half of the sewage sludge is currently recovered for use by the agricultural sector.
- Agro-forestry in Israel consists mostly of Eucalyptus and Paulownia tree species. They are grown mainly on marginal land and use reclaimed wastewater. The area of agro-forests increased from 100 hectares in 2001 to 7000 in 2007. Agro-forestry has probably contributed to carbon capture, although there are no current estimates of carbon sequestration from agriculture activities in Israel.

5.2.6 Land Use and Forestry

- In 2004 the KKL-JNF adopted a policy document regarding sustainable management of the areas and projects under its responsibility in Israel. Accordingly, the KKL-JNF is obligated to incorporate climate change considerations into its activities using advanced guidelines for reduction of GHG emissions from soils and increasing carbon sequestration in open space land.
- Israel has one of the highest ratios of planted forests to natural woodlands (2:1). The KKL-JNF is responsible for planting new forests and forest renewal activities. The planted forest in Israel is continuously increasing, although the potential land for afforestation is limited. The planted forest area in Israel grew between 2000 and 2008 from 941 to 980 km^2 (See Table 3.1). In addition, KKL-JNF encourages afforestation activities within the private and public sectors outside of the forest area. Forestry and forest rehabilitation methods have been developed for drylands. KKL-JNF has succeeded in developing forests growing under conditions of only 200 mm of annual rainfall. Agro-technology systems include runoff and rainfall catchment basins, reuse of treated wastewater, utilization of brackish water for salt-tolerant crops and trees, and development of saline-resistant crops. These have allowed for the development of agroforestry and farming in areas with minimal rainfall.
- National master plans, such as Israel 2020 and the National Master Plan for Building, Development and Conservation, relate, among other elements, to spatial conflicts within the small land area of the country. These plans are based on the principles of concentrating development in and around urban centers, protecting open space and limiting suburban sprawl, and improving mass transit.

6 Vulnerability and Adaptation to Climate Change

6.1 Introduction

It is widely recognized that adaptation to the adverse effects of climate change is vital in order to reduce its impacts. In 2007, the UN Climate Change Conference, held in Bali, produced an Action Plan which identified adaptation as one of the key building blocks required to strengthen future response to climate change. At the December 2009 UN Climate Change Conference in Copenhagen, the importance of adaptation was again emphasized, especially the establishment of comprehensive adaptation tools.

In Israel, the preparation of a vulnerability assessment to climate change and an adaptation plan to confront potential risks and opportunities is of vital importance due to its lack of adequate water resources and the vulnerability of the semi-arid climate. To address the challenges of climate change adaptation, the MoEP set up an interministerial steering committee in 2006, headed by its Chief Scientist, to check the potential impacts of climate change on Israel. The objective of the committee was to recommend ways of preparing and adapting to climate change in a way that would reduce potential damages, on the one hand, and promote the development of new concepts and technologies to address the problems, on the other hand.

With the aid of working groups, made up of experts in different disciplines, a draft document was presented for comments during a workshop held in the beginning of 2008. By the summer of 2008, the results of the two year process were evident in the form of an initial though comprehensive report which addresses the anticipated impacts of climate change on Israel and presents interim recommendations on adaptation measures in each of the following sectors: water, drainage, agriculture, seas and coasts, urban environment, public health, biodiversity, energy and the economy. Plans now call for these interim recommendations to be developed into a national plan on climate change adaptation.

6.1.1 Past Changes in Climate in Israel and in the Middle East

Nearly 5% of the land areas in the world are characterized by a Mediterranean climate, which is distinguished by rain during the winter and a lack of precipitation during the summer (in the northern hemisphere).

Climate in the Middle East has varied considerably over the past hundreds and thousands of years. For example, some 20,000 years ago, the average temperature was 8°C lower than today's temperature, and 6,000 years ago, the temperature was 1-3°C higher than today's temperature. Similarly, research studies point to changes in precipitation over the last 10,000 years. For example, southern Israel encountered variations of 15% to 40% of the current average rainfall with major differences in the fauna and the flora in the different periods and changes of tens of meters in sea level.

The historical high correlation between human settlement and climate change attests to the sensitivity of systems in this area to climate change. However, it is still unclear how and to what extent human and natural systems would tolerate rapid climate change in this region.

6.1.2 Expected Climate Changes in Israel

According to the A1B scenario of the Intergovernmental Panel on Climate Change (IPCC AR3), the maximum temperature in Israel is expected to rise by 1.8° C by 2020 compared to the years 1960-1990, whereas the average temperature is expected to increase by 1.5° C. According to IPCC scenarios A2 and B2, average temperature is expected to increase by 5° C and 3.5° C in the years 2071-2100, respectively, compared to the years 1961-1990. In addition, a 10% decrease in precipitation is expected by 2020, reaching a 20% decrease by 2050.

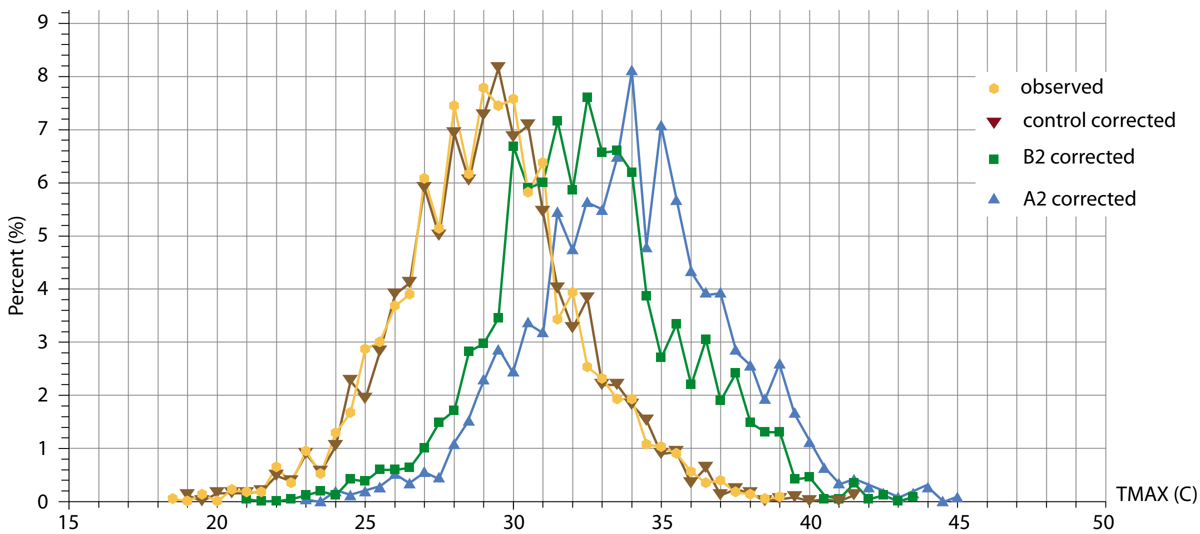
Another expected impact is an increase in the number of extreme events in Israel, along with a decrease in the amounts of seasonal rain. According to the B2 scenario, extreme rainy days are expected to be concentrated in autumn and early winter, while according to the A2 scenario, extreme rainy days are expected to be concentrated in January and in the spring. The differences in average precipitation from year to year are expected to increase compared to today, with increases in very rainy years compared to years of extreme drought. Furthermore, the intervals between dry spells and wet spells are also expected to increase. This indicates a tendency towards a more arid climate in Israel, which conforms to the IPCC forecasts for 2100.

6.2 Vulnerable Sectors

Climate change is expected to impact several sectors in Israel, as will be discussed in further detail in the following paragraphs. Among the major potential impacts:

- Reduced precipitation.
- Increased water demand (due to warming and increased evaporation).

Figure 6.1 *Projected changes in maximum temperature distribution**



Source: Alpert et al. 2007

* Refers to Mt. Cana'an according to A2 and B2 IPCC scenarios.

- Increased frequency of extreme events (heat or cold, floods).
- Changes in crop yields.
- Increase in agricultural pests, plant diseases and weeds.
- Risk of damage to coastal infrastructures due to rising sea levels.
- Morbidity and mortality due to heat waves and new vectors of disease and increased risk of food-borne infectious diseases due to elevated temperatures.
- Increased energy demand (air conditioning, desalination).
- Changes in biodiversity, especially in the Mediterranean Sea (jellyfish, reduction in commercial fisheries).
- Increased risk of forest fires.

6.2.1 Water Resources

The hydrological system impacts on and is impacted by climatic conditions. Temperature changes affect the rates of evapotranspiration, cloud characteristics, ground humidity, storm intensity, snowfall, and snow melting in different areas. Changes in precipitation affect the timing and intensity of droughts and floods, surface runoff regimes, and recharge rates of water reservoirs. In addition, patterns of vegetation and ground humidity also have an impact. An increase of 1-2°C and a decrease of 10% in precipitation, for instance, could lead to a decrease of 40-70% in the annual average flow of rivers, which will impact agriculture, water and energy supply.

Israel's water potential, based on a 36 year multi-annual average, is estimated at some 1555 million cubic meters (MCM) per year. Excluding the eastern mountain aquifer, the Negev and the Arava desert, the water potential is estimated at some 1400 MCM per year. However, according to Israel's Water Authority, high fluctuations are evident between the years, with a standard deviation of 477 MCM. Out of the total, some 650 MCM of water per year are from the Sea of Galilee (the only natural freshwater lake in Israel and a primary source of water), 110 MCM per year from the Western Galilee, 130 MCM per year from the eastern basins, 320 MCM per year from the mountain aquifer, 25 MCM per year from the Carmel coast, 250 MCM per year from the coastal aquifer, and 60 MCM per year from the Negev and Arava desert basins. Nearly 60% of all water resources is allocated to the agricultural sector (although about half is non-potable water including effluents and marginal water), 35% to the domestic sector, and 5% to the industrial sector.

In the wake of five consecutive years of drought which have significantly reduced Israel's freshwater reserves and in preparation for future climate changes, Israel has decided to include climate change within the framework of its strategic program for the water sector.

Israel's adaptation report points to the following potential impacts of climate change on water in Israel:

- Increase in the frequency and severity of floods, which may cause major damage to property and to people.
- Reduction of 25% in water availability in 2070-2099 in comparison to 1961-1990.
- Reduction in groundwater recharge.
- Loss of 16.3 MCM of water for each kilometer along the coastal plain, as a result of a potential rise in sea level of 50 centimeters.
- Changes in the salinity level of the Sea of Galilee.

6.2.1.1 Groundwater

In general, a decrease in precipitation volume as a result of climate change will lead to decreased recharge, but estimates of the amount of rainfall reaching groundwater are difficult to obtain. Infiltration from the upper soil layer into groundwater depends on evaporation and water consumption by plants and humans, before filtration into the ground. The impacts of climate change could bring about changes in the diversity of plants that cover the ground, consequently leading to changes in enrichment capacity. An increase in extreme events, which will lead to high amounts of precipitation in short time periods, will lead to increased flooding and erosion and to decreased filtration. However, all components affecting groundwater enrichment should be assessed, and not only the change in the quantity or distribution of precipitation.

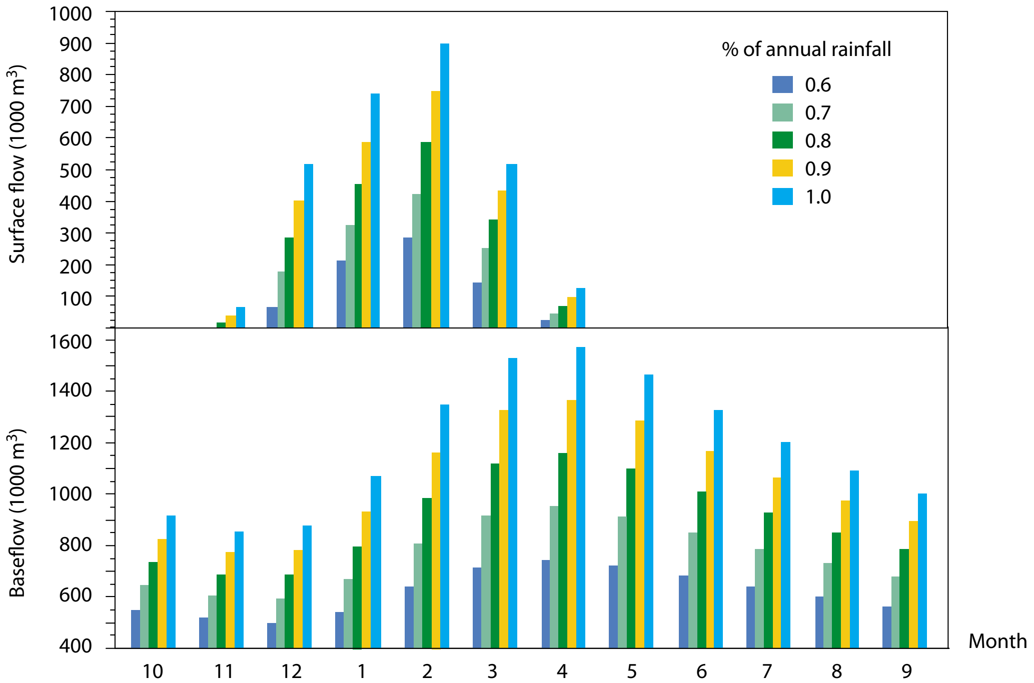
The coastal aquifer – The increase in population and urbanization along the coastal plain reduces water penetration into the ground and increases surface runoff. An increase in rain intensity could lead to a further reduction in the enrichment capacity of this aquifer and to a decrease in its water quality, although water could infiltrate in other areas. Additional damage to the coastal aquifer is expected due to the potential rise in Mediterranean Sea level.

The mountain aquifer – Flood waves are created every year in the basins of the streams which feed the mountain aquifer. A number of reservoirs have been constructed in order to capture and utilize this floodwater. An increase in rain intensity is expected to increase the flood waves, beyond the capture and utilization capacity of these reservoirs. While this water could benefit the streams as ecosystems, it will be lost to the water economy. In addition, reduced precipitation will lead to lower enrichment of this aquifer as well.

6.2.1.2 Surface water

Sea of Galilee (Lake Kinneret) - An increase in rain intensity could lead to increased quantities of water entering the Sea of Galilee. Changes in precipitation distribution and increased evaporation will lead to a different spatial distribution of runoff water in the winter, and will impact the recharge of the groundwater and the spring flows, which refill the different water reservoirs. These will affect water availability in the upper basin of the Jordan River and the salinity of the Sea of Galilee. According to one scenario, which investigated the implications of a 20% decrease in precipitation and a 20% increase in evaporation in the upper Jordan River basin area, a reduction of 110 MCM per year is expected, nearly 43% of the annual recharge of the major springs of the Jordan River. Another study, which checked monthly flows in the Jordan River under changing annual precipitation rates

Figure 6.2 *Average base and surface flows in the Jordan basin**



Source: Rimmer 2008

* Calculated by the HYMKE model for five scenarios of rainfall reduction, in percentages (60, 70, 80, 90, and 100), compared to current conditions.

above Mount Hermon, also found a more pronounced decrease in the percentage of surface flows compared to the reduction in precipitation.

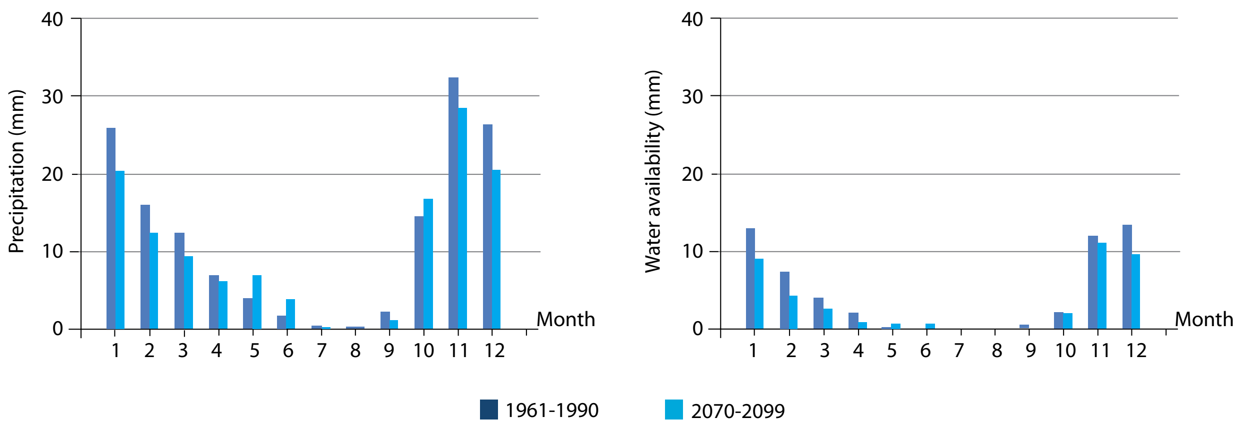
The Kinneret Limnological Laboratory has investigated the effect of continued decreases in available water for the Sea of Galilee on the future salinity of the lake. It was found that a continued linear decrease at the current rate of water flushing the Sea of Galilee will increase its salinity up to 470 mg of chlorine by 2040.

Within the framework of the GLOWA-Jordan River project, initial estimates of the availability of water resources in the semi-arid area of the Jordan River were carried out for the years 2070-2099, compared to the years 1961-1990, according to the IPCC B2 scenario. This area spans 90,000 km, from the north Jordan basin to the Gulf of Aqaba in the south, and from the Mediterranean Sea coast to the Jordan plain. According to the aforementioned study, a decrease of 11% is expected in the overall average precipitation in the area (the average seasonal precipitations are expected to decrease from 141 mm during 1961-1990 to 125 mm in 2070-2099), bringing about a 25% decrease in water availability in the coming decades, and even more in some areas.

In the Negev area, water shortage already exists under current climatic conditions and, therefore, the continued decrease in precipitation is not expected to worsen water availability in this area. However, in the northern area and in the coastal plain, a decrease in precipitation is expected to reduce water availability. Extended extreme drought conditions may endanger the very livelihood of wooden plants and various mammals feeding on them.

Floods - The increased incidence of major flood events, observed in recent years, which may be attributed to global warming, burdens natural and human drainage systems. Large floods cause severe damages to the ecological environment, to property, to the economy, and to human life. In a cost-benefit analysis for floods in the Ayalon basin (estimates relating to 1987 prices), damages for rain events at a probability of 1 in 50 years were estimated at NIS 89 million, and for rain events at a probability of 1 in 100 years, at NIS 338 million. The direct damage from the floods of the severe winter of 1991/2 was estimated at over NIS 200 million. In addition, indirect damages were caused due to road blockages, loss of work days, and loss of income, estimated at tens of millions of NIS. A trend of more extreme rain events and greater severity of extreme precipitation events will lead to the increased frequency and severity of floods and concomitantly to severe damages to property and humans. The benefits from minimizing these damages include prevention of ecological hazards such as enhanced risk of extinction of wildlife and

Figure 6.3 *Total average monthly precipitation amounts and monthly water availability in the Jordan basin in 2070-2099**



Source: Menzel et al. 2007

* According to the IPCC B2 scenario, compared to the years 1961-1990.

plants, prevention of agricultural produce loss, prevention of damages to private and public property (public structures, roads), prevention of disruptions to economic activities and loss of income to individuals and the economy as a whole, prevention of damage to and loss of human lives, improvement in the quality and quantity of national water resources, and improvement of national soil resources.

In summary, for the Mediterranean region, the increase in temperature is less significant than the expected changes in precipitation, in evapotranspiration, in surface runoff and in ground humidity, which are critical factors for the management and planning of the water economy. Decreased precipitation, especially in countries in which the exploitation of water sources is extensive, such as Israel, may lead to national water crises, with a continued decrease in the levels of water reservoirs, basins, and rivers. Population growth and recently occurring droughts place water sources under pressure and require novel approaches for the planning and management of the water economy, in order to avoid conflict and environmental damage.

6.2.2 Agriculture

The economic value of agriculture in Israel is comprised of NIS 25 billion per year for agricultural produce, $1.2 billion for agricultural products for export, and $0.9 billion for processed food. The total area cultivated for agriculture is 4,300 square km.

In addition to agricultural output, agriculture is also a public commodity which provides external benefits such as preservation of open space in the rural and urban environment, scenic views, diverse and unique landscapes, contribution to tourism, pollutant absorption, and contribution to air quality. Nearly 40% of Israel's agriculture has landscape value, which is highly rated, due to the density of population and the lack of green areas in the natural landscape. Therefore, damage to agriculture, beyond damaging certain crops, may also have an adverse impact on green areas, tourism and more.

The indirect economic benefits which Israeli agriculture provides were estimated at NIS 1.3 billion per year (2002 prices). This value incorporates different aspects. A savings of $50 million a year is estimated through the utilization of effluents in agriculture, at a quality lower than that required for discharge to natural streams. The absorption of approximately 2 million tons of CO_2 per year has been estimated at about $20 million per year, due to the possibility of emissions trading. The extent of agro-tourism has been estimated at approximately NIS 75 million per year, which is expected to increase with the growth in population and incoming tourism.

Agriculture also serves as an open area for the development and conservation of wildlife and for rainwater infiltration to groundwater. Hence, the social-environmental contribution of agriculture goes beyond its business contribution.

Israel's adaptation report points to the following potential impacts of climate change on agriculture in Israel:

- Damage to crops due to a reduction in water availability in the soil, 20% increase in water demand for irrigation, reduction in fruit and vegetable yields, emergence of new pests and pathogens and increase in the frequency of animal and plant diseases.
- Sharp cutbacks in allocations of freshwater resources for agricultural irrigation.
- Possible advantages to growth due to an increase in CO_2 concentrations in the atmosphere, but potentially also leading to reduced crop yields and intensified use of herbicides.
- Increased risk of soil erosion.
- Benefit to certain crops from higher winter temperatures.
- Reduced productivity of farm animals.
- Shortage of animal feed and increase in its cost.
- Shortening of the productivity season of pastureland.
- Damage to populations of pollinating insect species.

- Damage to the nutritional value and shelf life of agriculture produce.

In recognition of the potentially severe impacts of climate change on agriculture in Israel, the Chief Scientist's Office of the MARD has issued a call for proposals on research studies on the subject in September 2009. The aim is to generate the necessary information for the purpose of developing tools for confronting and adapting to future climate changes (See section 9.4).

Implications of climate changes on agriculture - Israeli agriculture is particularly vulnerable to climate change, due to the proximity to the aridity line, the relatively low amount of cultivated areas, and the steep gradient from north to south and from west to east along the country. Possible climate changes expected to impact agriculture include: change in precipitation amounts, change in temperature trends, ecological changes and increased concentrations of CO_2. Severe damage to agriculture is expected primarily as a result of the potential increase in extreme weather events, rather than as a result of changes in the annual average.

Implication of changes in precipitation - An increase in extreme rain events will lead to increased surface runoff, increased transport of pollutants to surface water bodies, increased infiltration of pollutants into groundwater and damage to crops. An increase in extreme rain events will also increase the risk of soil erosion, whereas, approximately 40% of field crop areas and agricultural lands and 10% of fruit grove areas are classified in the category of severe erosion.

Decreased amounts of precipitation will lead to decreased infiltration and decreased availability of water in the ground for summer and winter crops. In the wake of a decrease in precipitation, the rainy season may shorten, requiring earlier irrigation of summer crops, as well as extensive irrigation, as a result of inadequate flushing of salts from the soil profile during the winter. In addition, farmers growing rain dependent crops are currently unprepared for drier conditions. Since water demand will increase with the expected decrease in precipitation, dramatic cuts in the allocation of freshwater sources to agriculture are expected in coming years, with the possibility of a complete ban on freshwater supply to agriculture during periods of prolonged droughts.

Studies have demonstrated the ways in which the expected decrease in precipitation in Israel will lead to economic damages in the agriculture sector. One study examined the influence of two climatic scenarios (A2 and B2) for the years 2070-2100 on wheat, a central crop in the southern region of Israel, and cotton, which represents the more humid north. For wheat, under the A2 scenario, the profit turned negative (between -145% and -273% relative to current values), and under the B2 scenario (more moderate), a mixed trend was obtained (between -43% and +35% relative to current values), probably due to an increase of 17% and 10% in precipitation amounts in January and March, respectively, under this scenario. This demonstrates that even under the moderate B2 scenario, a change in the distribution of precipitation during the growth period significantly affects the expected crops. For cotton, on the other hand, under both scenarios, a significant decrease in crops was found, leading to significant economic losses (-240% under the A2 scenario and -173% under the B2 scenario, relative to current values), and an increase of 25% in water consumption. It was found that farmers could compensate for the water loss by nitrogen fertilization and additional irrigation, in the case of the moderate scenario, but not by changing the dates of seeding. Therefore it is anticipated that crops which are currently rain-dependent will become irrigation-dependent in the future, due to the expected decrease in water supply in the area.

Another research study examined three damage scenarios to agriculture as a result of a possible 4% reduction in precipitation. According to the first scenario, an arbitrary cut in the production of all crop groups will lead to an annual loss of approximately \$208 million (2000 prices). According to the second scenario, which included partial preparedness by the agricultural sector, the expected annual loss will be \$101.5 million (2000 prices), including some \$40 million from indirect cuts in water for irrigation. A third scenario took into account expanded use of desalination for the supply of potable water for household consumption. The annual cost of this scenario is approximately $126 million (2000 prices, cost assumed at 80 cents per cm of desalinated water).

It should be noted that these two studies did not examine adaptation actions, such as technological improvements, crop improvements, agro-technical changes (such as crop rotation), and the effect of increases in CO_2 concentrations and other atmospheric changes on crops.

Implications of changes in temperatures -The implications of an increase or a decrease in temperatures depend on the intensity, frequency and duration of the heat or cold periods. A number of positive impacts are expected from temperature increases, due to the fact that farmers adapt their crops to the climatic conditions in the area. This adaptation is largely accomplished by utilization of the heat conditions. Thus, Israeli agriculture is relatively tolerant to heat conditions. In Israel, especially in warmer areas, fruit, vegetables and flowers are grown during the winter, and are primarily exported to Europe. This allows Israeli products to reach the market early, and to sell for high prices in the European and local markets. In this case, higher temperatures have an advantage by overcoming water scarcity while using irrigation.

Another benefit to crop yields, in the wake of temperature changes, is expected from the change in seeding and blooming times of the crops. This change could prolong the growth season.

One research study examined the economic implications of the adaptation of Israeli agriculture, excluding farm animals, to increased temperatures. The study used a model which takes into account adaptation activities which farmers could take, such as crop rotation, changes of crop types, and technological techniques. When irrigation quotas were dictated to farmers, a slight increase in temperature (forecast for the year 2020) led to increased profits, but the continued increase in temperatures (expected by 2100) led to decreased profits. Without limits on the irrigation quotas, the temperature increase led to profit increases over time. Thus, additional irrigation helped to reduce the effects of the temperature. Nonetheless, it should be taken into account that the research assumption was that water supply will not change with climate change.

A potential damage to agriculture, due to temperature change, is reduced productivity of farm animals. Animals on an agricultural farm (chickens, cattle, sheep, etc.) are very sensitive to heat and, therefore, their suitability and ability to produce high quality yields, under Israel's heat conditions, is problematic. Nonetheless, Israel has been coping with the constraints of climate for many years, by such means as improved living conditions for the animals, use of better structures, air conditioning systems, and others. Hence, it is assumed that this sector will almost not be directly affected by climate change, in terms of expected increased temperatures and humidity in this region. Nonetheless, the need for heating or cooling of the livestock sheds (and greenhouses) is expected to increase. In addition, one of the main consequences of climate change on farm animals is on their food (animal feed) since 30% of the cow feed on Israeli farms grows in Israel and is based on rain water. A series of arid years, or an extreme arid year, could lead to shortage of animal feed.

Implications of ecological changes - Ecological changes, expected in the wake of climate change, include risks of wood drying or fires in dry habitats, and shortening of the production season of grazing areas, thus damaging the animal feed.

Also, in recent years, an increase has been observed in farm animal diseases, which originate from mosquitoes and pests. This increase could be caused by a number of factors, including climate change (i.e., rise in temperature, which leads to an increased rate of pathogen growth). The increase of nocturnal summer temperatures, observed in recent years, contributes to maintaining high temperatures during most hours of the day, which enables a more rapid growth of disease vectors. In addition, a northbound migration of insect populations has been observed, with southern insect populations overtaking the habitats. In extreme weather areas, such as the Arava desert, a small change in climatic conditions is significant for insects, and could lead to the deterioration of certain insect species, which have managed to survive to date. In areas with a moderate climate, a small change is not expected to lead to the deterioration of these populations.

Economic implications of climate changes

There are a number of economic considerations which accompany the implications of climate change on agriculture:

- A rise in the incidence, intensity and frequency of extreme weather events will damage crops and will cause severe economic damages. For instance, in 2008, the damage from a freeze wave was estimated at more than NIS 500 million.
- The expected decrease in water availability in the area will lead to heavy economic damages to agriculture. About 60% of the water supply is diverted to irrigation, and water supply is heavily controlled via consumption quotas. Nearly all crops are irrigated, except field crops. In 2006, freshwater contributed only 47% of the water allocated for agricultural use and its relative part in agriculture continues to lessen with the years. Nonetheless, there are sectors which consume mostly freshwater, such as orchards, vegetables, flowers, and the cattle sector. A cut of 50% or more in freshwater quantities for agriculture is very realistic according to the climatic scenarios expected in Israel, and the economic damage is estimated at billions of NIS. Reducing agricultural water consumption by 200 MCM per year, as expected according to several forecasts for 2020, will lead to reduced income of approximately $100 million a year and a loss of thousands of jobs.
- A decrease in the feed quality for livestock and an increase in its prices will lead to reduced profits. The shortening of the production season of grazing areas will lead to increased usage of more expensive feed substitutes. For instance, grazing lands in humid Mediterranean climate areas currently save cattle growers $83.2 per hectare a year and $116.5 per hectare a year for sheep growers.
- A loss of soil, due to erosion, is estimated at some NIS 15 per cubic meter. In the case of 100,000 hectares, which are a million cubic meters of land, the damage adds up to NIS 15 million.

6.2.3 Coastal Zone -The Mediterranean Sea

The Israel Oceanographic and Limnological Research (IOLR), a national research institution, was established with the mission of generating knowledge for sustainable use and protection of Israel's marine, coastal and freshwater resources (See section 9.13). It has been monitoring the Mediterranean Sea level since 1992.

Research studies have shown that in the Eastern Mediterranean area, sea level is expected to rise by 0.5-1 meter by 2100. Sea level in the Israeli coast is expected to rise by some 0.5 meter by 2050 and by approximately a meter by the year 2100. While some researchers claim that increased evaporation, due to the temperature increase, could be a moderating factor on the rise of sea level, others claim that this conclusion is unfounded.

An increase in the height and intensity of waves which penetrate inland, due to the increased intensity of extreme weather events, will increase the penetration of sea water inland in lower areas, and will cause damages to water sources and to coastal natural resources and infrastructure.

Israel's adaptation report points to the following potential impacts of climate change on Israel's Mediterranean coast:

- A 10 cm rise will lead to a 2-10 meter retreat of the coastline and to the loss of 0.4-2 square km of coast every 10 years.
- Retreat of the coastal cliff and expansion of the risk zone of the infrastructure constructed on the coastal cliff by 40-50 meters eastward.
- Damage to coral colonies in the Gulf of Elat.
- Damage to coastal tourism and recreation.
- Damage to coastal structures (e.g., jetties and marinas, intake points of cooling seawater for coastal power plants) and to archaeological sites.
- Damage to species and ecosystems of the coastal environment.

- Increased water temperature in the Mediterranean Sea will lead to increased penetration and increased establishment of alien species originating in the Red Sea/Indian Ocean.

6.2.3.1 Implications of the rise in Mediterranean Sea level

A rise in Mediterranean Sea level may have many implications, but there is no model today which accurately presents the anticipated and possible implications on the coastline, aquifers, archaeological sites, habitats, and others.

Nonetheless, several consequences in case of sea level rise are expected. A 10 cm increase in sea level (assuming a slope of 1-5% in the Israeli coast) will lead to a coastal retreat of 2-10 meters, which will lead to a loss of 0.4-2 square km every 10 years. A one meter increase in sea level will flood a 50-100 meter wide belt on sandy beaches, which constitutes more than half the length of the Israeli coastline. One estimate, based on a scenario in which such an increase will take place until the year 2060, predicts that 8.4 square km of beaches will be lost, with an economic damage of NIS 4-5 billion. A one meter rise will also increase the extent of the rocky beach bays and will shift the storm line an average of some 100 meters eastward (inland) on sandy beaches. In other beaches, the coastline will migrate tens of meters and, in certain places, could shift by over 100 meters, depending on the level of rise, the strength of the sandstone (kurkar) ridges and cliffs along the coast, and the change of the wave regime and frequency of strong storms. Migration of the coastline eastward will also lead to the infiltration of sea water to river deltas.

Migration of the coastline is affected not only by changes in sea level, but also by the height of the land and the sand balance, which is affected in populated coastal areas by human intervention in these processes (e.g., construction, sand mining, digging from the coastal strip and sea bed and the artificial transport of sand on land and in the sea).

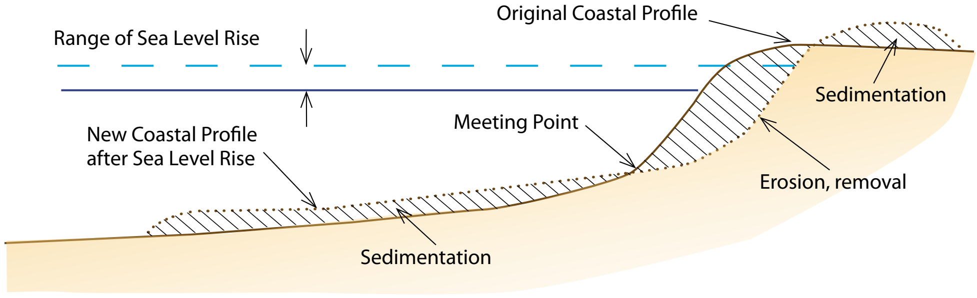
Sea level rise will lead to the increased retreat of the delta beaches and to an increase in the amount of sand which is transported to the beaches of Israel, assuming that the wind and wave regimes will not change significantly in terms of flow directions. Due to the relative location of the Israeli coast in the Mediterranean Sea, the direction of the highest waves, which is generally westerly, is not expected to change. However, if wind frequency and intensity will change, a multi-annual change in the quantities of the transported sediments could occur, and perhaps even in the net direction of the transport, on a multi-annual average. Under such conditions, it is hypothetically possible that the sand transport balance will shift along the coast, and coastal retreat may increase. Coastal facilities and structures, such as sewage outfalls, sewage and fuel pipes, docks, marinas, harbors, breakwaters, and others, are situated along the sand transport path on the beaches. Increased sand removal from the coasts and the lack of sand on the other side of coastal structures, along with sea level rise, will also lead to the migration of the coastline eastward. At the same time, if the abrasion will be consistently larger than the sand accumulation process, the coastline will shift inland, even if sea level remains stable.

The shift of the swash zone (the border of sea and land, which is several tens of meters wide), due to the rise in sea level and the shifting of the waterline eastward, will transfer part, or most, of it beyond the range of the current coastline, to sloping areas, with a higher slope than the current strip. In these areas, the supply of sand from the waves will decrease and the exposure of the west sandstone slopes will increase. In a steeper swash zone, waves descending into the sea will grow stronger and will carry the sand which has been deposited by the rising wave back to the sea. This phenomenon is currently observed in extremely steep beaches and is expected to widen to additional coasts.

In the wake of sea level rise, the coastal profile (the shape of the local section, perpendicular to the coastline) is expected to shift towards the coast, with an upward diversion, and the sand which will be detracted will sink in the hindpart of the coast (Figure 6.4).

Additional possible consequences of sea level rise include damage to tourism, to recreational activities on beaches, to coastal structures, docks,

Figure 6.4 *Change in coastal profile as a result of sea level rise*



Source: Rosen 2005

marinas, and archaeological sites, to coastal ecosystems, and to the coastal biodiversity. Based on initial estimates, lesser impacts are expected on the coasts of the Gulf of Elat than on the Mediterranean Sea coasts, due to the different nature of the coast in terms of the profile slope and coastal structure, except for severe damage to the coral colonies, due to the warming of the water (coral bleaching).

6.2.3.2 Implications of sea level rise on the coastal aquifer

The depth of the coastal aquifer is approximately 150 meters along the coastline, and it shallows out to a few meters some 10 km eastward from the coastline. Today, the maximal penetration of sea water inland is 1000 meters from the coastline. In areas where sea water has penetrated deeper into the aquifer as a result of over-pumping, pumping wells have become salinated and have been shut down as drinking water sources, and even as irrigation sources. In areas of over-pumping, the level of groundwater has decreased, so that depressions have been formed at a depth of 1-3 meters below sea level, mostly 1-3 km from the coastline. Therefore, the penetration of the freshwater/seawater interface beyond one km into the coast could cause severe damages to water sources.

According to the lithological parameters of the aquifer, the rise in sea level will primarily influence the upper layers in areas of low topography, mostly in river delta areas which flow into the sea, such as the Yarkon and Ayalon in Tel Aviv. The coastal erosion processes, due to sea level rise, could erode the less penetrable materials, so that more penetrable layers will become exposed, and the coastal aquifer will become more vulnerable to sea water penetration and erosion.

Studies suggest that the total loss of groundwater due to a possible increase of 50 cm in sea level could reach 16.3 MCM per km of coast. This loss will worsen if the frequency of arid years will increase, during which the recharge rate of the aquifer will not reach the annual average.

6.2.3.3 Implications of sea level rise on the coastal cliff

Seventy kilometers out of Israel's 190 km coastline are characterized by a coastal cliff, measuring 30-40 meters in height. All cliffs, by nature, are unstable and define the landscape for short time periods. The rate of cliff retreat is determined by its general strength and the wave climate along the coast. Waves, which erode the base of the cliff, and surface runoff activity, are amongst the main processes which contribute to the collapse of cliffs. These natural processes are accelerated by human activities at the hinterland of the cliff (primarily construction and development), by sea level rise, which may occur in the wake of climate change, by the filtration of rainwater, irrigation water and sewage water, and by strong winds. Natural barriers (such as beach rocks) or artificial barriers (such as breakwaters) contribute to an early breakage of the waves, and so protect the cliff locally and for a limited time, but have no influence on the rate of cliff retreat (except for such barriers as sea walls, which prevent contact of the seawater with the bottom of the cliffs completely). Cliff retreat occurs in a ragged, winding line, which is a combination of the local strength of the cliff (its resistance to erosion and abrasion), the local wave regime, and random events. Such retreat does not damage the cliff's morphology, and it maintains its shape as long as there is no human intervention in the natural processes.

The coastal strip is densely populated, and the collapse of the cliff in dense areas, such as Netanya and Ashkelon, is a special problem, since human activity on the cliff and on its hinterland additionally contributes to the weathering of the cliff. The coastal area in the center of the country has remained stable over the last 2000 years, but during the 20th century, moderate erosion began following sand mining from the beaches (until 1965), construction of coastal structures, and lack of coastal maintenance.

The expected rise in sea level and in the frequency and intensity of winter storms will cause severe damage to the coastal cliff of Israel, which will continue to recede during the current century by tens of additional meters. The cliff will continue to collapse for dozens of years, until it reaches a stable slope, even if actions to protect its base are taken. The retreat rate of the top of the cliff eastward, as measured by comparing aerial photographs from 1945 and 2004, is a few tens of centimeters per year (approximately 20 to 30 cm). Although the rate of coastal retreat is rapid on a geological scale, and even on a historical scale, it is not expected to endanger or jeopardize the residential infrastructure east of the cliff rim if a 50-meter wide strip will be allocated east of the cliff in which construction, digging, paving and development will be prohibited. Maintaining the width of this strip will help preserve the cliff in its natural condition for at least 200 years, assuming that the present rate of retreat is maintained. Nonetheless, researchers claim that under the conservative assumption that the processes impacting on the cliff will not change in the future, the area of risk for cliff destruction until 2100 is 20-30 meters eastward from the current cliff line in 65% and 80% of the cliff length, respectively. According to this assumption, there are some areas in which tens of buildings fall within a risk area.

Migration of the water line by some 10-30 meters eastward, expected by the year 2100 (given coastal slopes of single degrees), in the wake of a one meter rise of Mediterranean Sea level, will increase the rate of cliff retreat by tens of additional meters by the year 2100, whereas the assumed risk area will be 40-50 meters east of the current cliff line.

Cliff retreat will cause extensive economic damage, including damage to existing properties and infrastructure in the proximity of the cliff, loss of valuable real estate (because of their proximity to the sea), damage to construction plans in the making, damage to high-value lands (beaches, nature reserves), destruction of archaeological sites and heritage buildings, loss of coastal areas due to sea flooding, and consequently, an eastward retreat of the territorial water of Israel.

Estimates of the damages due to cliff retreat have been undertaken according to an estimate of alternative building costs for existing buildings and for properties which could be damaged. The damage to existing buildings has been estimated at between NIS 67 and NIS 90 million, if the retreat rate is accelerated to an average of some 0.5 meters per year, reaching up to NIS 276 million if the retreat rate reaches a one meter per year average. The market value of the properties which could be damaged has been estimated at between NIS 195 and NIS 265 million if the rate of annual retreat increases to approximately 0.5 meters per year. If retreat rates will increase to about one meter per year, the economic loss is estimated at NIS 800 million.

A gradual decrease in the land resources along the rim of the cliff, despite their high economic value, is inevitable, and even if their existence can be prolonged by the construction of protective walls, their value will decrease at the rate of the required investment for implementation and maintenance. The expected damage from the loss of construction potential and the loss of value due to proximity to the beach is not significant, assuming that the construction potential is realized in alternative land. The damage to archaeological sites is difficult to estimate, since these are not commodities. The value of sites may be estimated by the costs required to protect them.

Some researchers expect no damage to natural reserves from the continued retreat of the cliff, on the grounds that coastal cliff retreat is a natural process and nature reserves in the cliff area enable these processes to continue. Therefore it is generally believed that protection of the cliff will damage landscape and natural values. However, this may not necessarily be true in the case of accelerated retreat as a result of sea level rise, a process which could be faster than the ability of the natural systems to adapt, as is the case with other natural processes, which may be harmed and are already harmed today by climate change. On the other hand, protection of the cliff and the absolute prevention of its retreat will also interfere with natural systems.

The economic loss due to coastal recession (diminishment of coastal areas) of some 10 meters in 20 years is estimated at NIS 180 million. On the other hand, activities to protect the coast, which will extend its area by one meter, will lead to an economic value of the same amount. The cost estimate per meter of cliff length is between NIS 12,500 to NIS 35,000, based on the means of protection.

In April 2010, Israel's government approved the principles of a policy paper on the protection of the Mediterranean coastal cliff, prepared by the Ministry of Environmental Protection and the Environmental Policy Center of the Jerusalem Institute for Israel Studies. The anticipated budget for implementation and for completion of the protective steps enumerated in the policy paper totals some NIS 470 million (about $125 million) over a 20 year period.

6.2.3.4 Implications of water temperature increase in the Mediterranean Sea

The increase in water temperature will increase the ability of alien species from the Red Sea to become established in the Mediterranean Sea. Species from the Red Sea, limited by the temperature range and salinity, expand the limits of their distribution in the Mediterranean Sea via the Suez Canal. The warming of the water could impact on a variety of population characteristics, such as breeding and survival ability, and could establish inter-relations between species. Hence, it may affect the dominance and frequency of alien species from the Red Sea, which may provide them with an advantage over the Mediterranean Sea species. One consequence of pushing out the local biota is damage to fishery, since most of the alien species are of lower nutritional value than the local species.

An example of an invading species is the *Rhopilema nomadica*, a type of jellyfish, which has appeared in Israel in huge flocks every summer since the mid-1980s. The *Rhopilema nomadica* feeds on zooplankton, which is the major food source for many fish species. Consequently, inadequate quantities of food are left for the local fish species during the summer, and the fishery sector is damaged. In addition, the *Rhopilema nomadica* damages tourism and coastal infrastructures. Local authorities report a decrease in the number of tourists on the beaches, due to the risk of jellyfish stings. Also, the jellyfish block water pipes used in the cooling systems of ships and coastal power plants.

6.2.4 Human Health

One of the re-emerging diseases as a result of climate change is malaria. Malaria is a parasitic (infectious) disease, endemic to over 100 countries worldwide, and transferred to humans by the bite of the female *anopheles* mosquito. There is a risk of outbreak of this disease in countries where it had been eradicated dozens of years ago, especially due to the high mobility of tourists and immigrants.

Since the 1960s, Israel has been considered a malaria free country, although every year, 60-100 cases of imported malaria are reported by people who have contracted the disease overseas. Eradication of the disease has been achieved without the elimination of the disease carrying mosquito population and, today, six species of malaria carrying *anopheles* mosquitoes are found in Israel, four of them with permanent populations, concentrated in freshwater sources. Therefore, the possibility for renewed local morbidity in Israel exists, especially given the disease distribution in neighboring countries such as Turkey. Such a new outbreak of malaria will mostly damage tourism, and will require spraying of larger areas. However, malaria is not expected to break out in Israel, despite climate change, since local conditions do not favor the spread of the disease.

Another disease which could re-emerge as a result of climate change is West Nile Fever, which is mainly transferred among fowl by mosquitoes in water rich organic matter. The virus exists in the Middle East and also in extensive areas of Africa, Asia, and Eastern and Southern Europe. The main danger for humans is an emergence of meningitis and encephalitis, especially in the elderly or in immuno-compromised patients. In Israel, the main outbreaks of the disease occurred in the 1950s and in 2000. In following years, the number of infected people decreased due to improved preparedness and management by authorities and increased public awareness.

Israel's adaptation report points to the following potential impacts of climate change on public health:

- A rise in extreme weather events along with higher temperatures may increase the mosquito population and change its distribution.
- Low probability risk of renewed outbreak of malaria.
- Higher temperatures in the beginning of the spring may bring about an earlier appearance of West Nile Fever due to the rise in mosquito hazards.
- Increased heat stress may harm the elderly, the ill and workers exposed to heat.

6.2.4.1 Implications of climate change on public health

A change of several degrees in temperature range will probably not affect mosquitoes, which can survive a wide temperature range, and already cope with existing temperatures in Israel. Increased temperatures in early spring (March) could lead to the earlier appearance of West Nile Fever, due to an increase in mosquito hazards. Increased heat stress in urban areas could also contribute to the outbreak of the disease.

In addition, following rainy years, an increase in the mosquito population and the number of incubation areas is noted. Therefore, extreme precipitation events could potentially increase their population levels and change their distribution. However, for a significant increase in the mosquito population to occur, large amounts of rain are required over a number of years.

An increase in heat loads will hurt the elderly, the sick and workers exposed to heat. However, most of the buildings in Israel are already equipped with air conditioners and therefore the expected impacts may not be significant. An increase in flood events, due to the increase in extreme rain events, will lead to an increase in injuries and deaths as a result of damages to infrastructure and buildings and could put a heavy burden on the health services.

A workshop on the impact of climate change on public health took place in Israel in December 2009, with the participation of experts from the MoEP, Israel's universities and hospitals. One of the presented studies related to the potential rise in humidity as a result of climate change, which, along with high temperature, is a major contributor to heat stress and consequent human discomfort. A study on climate and mortality in Tel Aviv based on a time series approach, which was conducted within the framework of the CIRCLE EU project, found that humidity had a greater effect on daily mortality and morbidity than temperature. While the impact of temperature and humidity in the city of Tel Aviv, where air conditioning is highly used, seems to differ from European Mediterranean cities, further research is needed to explore the effect of different climate indices on mortality and morbidity in Tel Aviv in order to institute effective public health intervention. Furthermore, it was noted that further research is necessary in order to understand the impacts of climate change on foodborne and waterborne diseases.

6.2.5 Biodiversity

Biological diversity is an overall indicator for the extent of variance and diversity in the natural world. Biodiversity includes the number and diversity of animals, plants, and microorganisms, the genetic diversity within and between population species, and the existing diversity between different ecological systems in nature.

Despite Israel's limited space (22,000 km^2), it is home to some 2,388 species of plants, approximately 100 species of mammals, and some 450 species of birds. This wealth stems from a number of factors:

- The geographical location of Israel, which is a land bridge between the temperate climate areas of the north and desert areas, and beyond them, with the rain forest strip of Africa and Asia. This bridge allows for the passage of animals and plants from one habitat to another.
- The diversity of Israel's landscapes and climate zones, including mountainous, transverse areas, flat plain areas, and many other landscapes. These create a large diversity of ecosystems.
- The climate changes which have taken place throughout history, which enabled the infiltration and local adaptation of species from equatorial regions and from tempered regions in the north.

A total of 146 species of mammals, amphibians, fish and birds are in danger of extinction in Israel and about 410 plant species are endangered. About 20% of the area of Israel is allocated to nature reserves. However, the nature reserves in the north of Israel are relatively small, which makes it difficult to maintain a functioning ecosystem. Southern reserves are larger, but they face different difficulties such as intensive human activity.

Israel's adaptation report points to the following potential impacts of climate change on biodiversity:

- Spatial movement northward in the distribution of Mediterranean species and their replacement by desert ecosystems, which will migrate from the Negev.
- Appearance of blue-green algae in the Sea of Galilee, which produce toxins, and may adversely impact the quality of potable water and reduce biodiversity in the lake.
- Lower vulnerability of some species of plants and butterflies to the forecasted reduced precipitation. However, prolonged intra-seasonal periods of dryness will adversely impact plant life.
- Increased dry conditions and a lengthening of the dry season which will increase risks of forest fires.

6.2.5.1 Implications of climate change on biological diversity

Israel has sensitive biological systems, vulnerable to climate changes, such as the Red Sea coral reef and ecosystems in relatively isolated locations such as Mount Hermon, Mount Meron, and the Carmel. Areas rich in species (in terms of number) respond faster to climate change than areas poor in species. The resistance of various species to potentially more severe heat and dryness conditions depends on the different species.

A rise of 1.5°C is expected to lead to a spatial shift northward of 300-500 km in the distribution of Mediterranean organisms and the occupation of the area by desert ecosystems from the Negev. The desert line will move northward and Mediterranean systems, which are currently on the edge of the desert, will be transformed into desert. As a result, species that are less resilient to dryness could be pushed aside. A sequence of arid years, or a decrease in precipitation, could adversely impact the functioning of these ecosystems.

One study has found that an increase in extreme rain events benefits the vegetation in arid areas, but damages the vegetation in more humid areas, such as Mediterranean and humid Mediterranean climates.

A reduction in precipitation or changes in the distribution of precipitation will adversely impact on the infiltration of water to the soil, causing plant species which require more water to disappear, while more resilient plants will survive. The main threat is to forest areas, groves, and open areas in the semi-arid zone. The most significant effects of precipitation changes are expected in this region, which is already susceptible to impacts of climate and droughts, and whose main constraint is water availability. Nonetheless, other studies have demonstrated that a 5-25% reduction in precipitation amounts, a 1.5°C increase in the average seasonal temperature, and a 10% increase in moisture, will have minimal impact on the primary productivity in leafy vegetation in the semi-arid area, since the vegetation in this area is adapted to stress conditions and makes optimal use of the available water.

Research in the semi-arid region shows that over the last 3,000 years, fluctuations of 20% in precipitation have occurred, shifting from moist and stable conditions, with approximately 600 mm of rain, to dry conditions, with some 450 mm of rain. This fluctuation in precipitation did not cause any significant change to the environment, although it can clearly be seen in the sediment accumulation and in changes in the plant cover of the land. The characteristics of the Mediterranean vegetation during this period were similar to those of today, although during the moist period, the richness of vegetation was higher than in the dry period.

It can be concluded that there are plant species in Israel, some of them in the semi-arid zone, which have adapted to stress conditions of heat and dryness over the years, and can cope with a certain reduction in precipitation. Nonetheless, it is unclear whether these species will be able to survive an aggravation in heat and dryness conditions in the long range, due to climate change, especially an increase in dry periods, duration of heat loads, and increased frequency of drought years. Research studies have shown that a sharp decrease in precipitation in the south has already caused extensive changes in land cover and underlying biota, creating runoff and soil erosion.

Climate change also increases the likelihood of forest fires. According to JNF-KKL data, no increase in the number of forest fires or in the extent of forest area was observed in recent years. There are years during which the combination of weather conditions, along with other factors, such as arson, lead to an increase in the number of fires. Extreme days, especially during transition periods, or the lengthening of the dry season, bear a significant effect on the likelihood of forest fires, while the increase in temperature bears a lesser effect.

The impacts of climate change include the warming of surface water bodies. In recent years several species of blue-green algae began to appear in the Sea of Galilee. These algae produce new toxins and some of them fix atmospheric nitrogen. Until 1994, there was no massive appearance of nitrogen fixing species in the Sea of Galilee and their emergence is a warning sign for changes in the lake's environmental conditions. The blue-green algae prefer relatively high temperatures, which enable rapid growth and toxin productivity. Since these algae are thread algae which are not consumed by zooplankton, their concentration in the water remains high, making it more turbid. The reasons for the changes in species composition in the Sea of Galilee are not clear yet, but they can be attributed, among others, to global warming effects. The implications of this phenomenon include deterioration of water quality in the Sea of Galilee and reduction in the lake's biodiversity.

Climate change may also significantly impact on animal species. Higher temperatures and food availability shortages can contribute to a reduction in the body mass of birds and may have serious implications on bird populations' structure and species competition. Climate changes are among the factors that contribute to the spread and establishment of invasive tropical bird species in Israel. Research has shown that among the new bird species discovered in Israel in the years 1960-2002, tropical species tended to expand and establish their distribution more than the birds from northern origins.

The impacts of climate change on biodiversity also bear an economic cost. These costs include, for instance, damages to tourism due to adverse impacts on nature reserves, efforts to rescue and restore endangered species, loss of water resources in the Sea of Galilee due to water quality deterioration, damage to fishery in the Sea of Galilee, and restoration of forests after fire events.

6.2.6 Energy and Infrastructure

The energy sector contributes approximately 85% of Israel's total GHG emissions, originating from fuel combustion, in the various sectors of the economy. Energy production and the production of electricity are the main contributors to the emission of CO_2 (See section 4.7).

Israel's adaptation report points to the following potential impacts of climate change on energy:

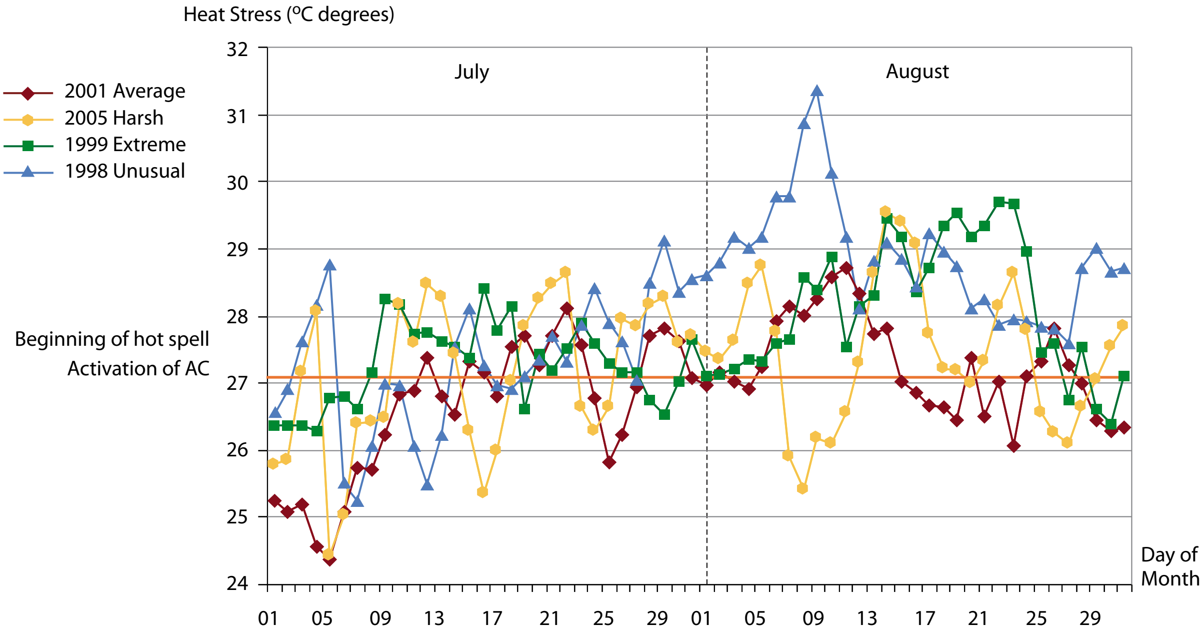
- Electricity demand is expected to grow by 3.2% per year, in a long-term average.
- An increase in peak demand for electricity is expected during heat and cold stress.

The IEC is currently preparing for increased energy demand, according to several climatic scenarios, determined by a statistical analysis of the differences between the heat stress in summer on national average, and a 27°C heat stress, which is the temperature at which air conditioners are operated (as of 1964-2006). The results of the statistical analysis indicate four possible scenarios for heat intensity in the summer: average, harsh, extreme, and exceptional (Figure 6.5). The probability for an average, harsh, extreme, or exceptional summer is 53.5%, 27.9%. 16.3% and 2.3%, respectively. The average summer was represented by the year 2001, in which a heat wave lasting 5 days was recorded, with the heat stress peaking at 28.71°C on a national average. The harsh summer is represented by the year 2005, in which a heat wave lasting 2 days was recorded, in which the heat stress peaked at 29.55°C on a national average. The extreme summer is represented by the year 1999, in which a heat wave lasting 11 days was recorded, with a peak heat stress of 29.7°C on a national average. The exceptional summer is represented by the year 1998, in which a heat wave lasting 13 days was recorded, with a peak heat stress of 31.36°C on a national average.

The summer heat stress increases the peak demand for electricity consumption, especially due to the intensive operation of air conditioners. The relation between the electricity consumption of household air conditioners and the heat stress in the third quarter of the year is depicted in Figure 6.6. For example, if in a given quarter there are 91 days, and in each day the average heat stress is 28°C, then the sum of differences will be 91*(28-27)=91.

Major parts of the infrastructure in Israel are located in the populated coastal area, which is vulnerable to climate change. Roads, railroad tracks, bridges and ports, industrial centers and power stations

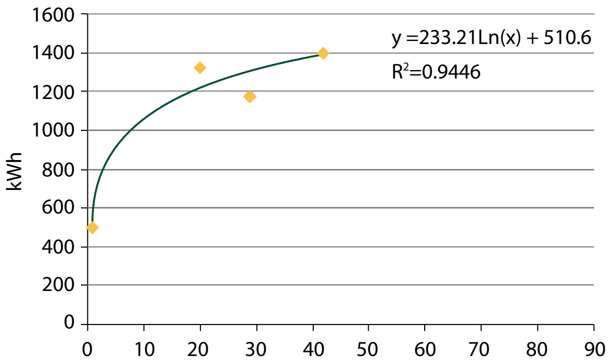
Figure 6.5 *The average daily heat stress during the months of July-August*



Source: IEC

are located in areas under threat of sea level rise and extreme events (such as floods). Damage to these facilities due to climate change impacts may bear great economic consequences.

Figure 6.6 *Electricity consumption and heat stress*



Source: IEC

6.2.7 Economy

Studies suggest that the economic burden of climate changes in the near future will be most significant in the southern Mediterranean basin, due to the structure of the economy of these countries and their geographical exposure to weather damages. Damage to water resources, especially, will affect all economic sectors. The vulnerability of the countries of the southern Mediterranean basin to climate change will vary according to the share of the climate-dependent sectors in the economy, such as agriculture, tourism, infrastructure, energy, and natural systems.

Although Israel's economy has experienced high growth rates along most of its history, climate change impacts could put an economic burden on the private, business and public sectors and slow down the country's development. The economic implications of climate change on different sectors were briefly described in previous sections.

One of the most vulnerable industries to climate change is the insurance business. Significant damages to public and private property can affect its profitability and its redemption abilities (the ability to pay installments on losses as a result of disasters).

6.3 Adaptation to Climate Change

Adaptation is defined as a change in a system's behavior in response to an external stimulus, such as a change in the climate system. Human systems can predict environmental changes, and respond accordingly, and so prepare for the expected changes. The reaction to climate change is on two levels: reaction by precursory actions, in anticipation of change (such as building planning and disaster insurance), and reaction to the change itself (such as migration from disaster areas, coastal nourishment, and enforcement of building regulations). These tools and methods for coping with anticipated and existing changes have been implemented for years in the wake of extreme climate events.

Sectors involved with land use, such as agriculture, have managed to cope with climate changes which have taken place gradually and consistently. The key to this success is to identify the signs of change, in order to prepare at the right time, in the right way. In the wake of climate change, which will increase the frequency and intensity of extreme events, it will be necessary to expand or adapt these tools to the new conditions. Climate changes which will occur at a faster rate will make timely adaptation more difficult. Also, extreme events will make adaptation more difficult and more expensive. In addition, it is unclear whether current tools for coping with climatic hazards will be effective or sufficient for dealing with the anticipated climate changes in the long term. For instance, different methods such as genetic alterations of crops and farm animals to reduce vulnerability to stress are only effective if climate changes are not drastic.

The extent of adaptation also depends on the attitude of the public and its willingness to accept the new technologies, or the food engineered by novel technologies (i.e., due to health concerns related to changes in the genetic diversity of plants and aesthetic features).

The need for precursory actions, whose purpose is to avoid the consequences of climate change, must be balanced with the need to respond to these consequences, in order to avoid unnecessary costs. Actions for coping with climate changes could lead to indirect results which should be understood and assessed during the planning process for these actions.

6.3.1 Preparation of a National Adaptation Plan

Since the impacts of climate change are already evident, and there is a real and actual danger of substantial damages in the short and medium terms, preparatory action must be taken. Adaptation to expected climate change is important in order to prevent large-scale economic and social damages, to develop innovative technologies, and to transfer them to countries at risk of climate change, including developed countries. In addition, preparatory action usually has environmental significance, which is important in itself. Therefore, the government of Israel has called for the preparation of an adaptation plan in 2010. By means of such a plan, decision makers will be able to assess the consequences and risks of climate change, and use the existing knowledge in the best possible way.

Based on international recommendations, effective national adaptation must include:

- Means to increase the scientific basis for decision making.
- Methods and tools to assess the adaptation actions.
- Education, training, and public awareness of the importance of adaptation.
- Technological development, effective use of resources and ecological innovation.
- Promotion of local adaptation approaches.
- Legislation and standards that promote environment-friendly adaptation actions.

6.3.1.1 Steps toward preparing Israel's adaptation plan

The aim of Israel's proposed climate change adaptation plan is to integrate preparations for climate change in the strategic planning systems of the various economic, social and environmental sectors.

In accordance with a government decision on the preparation of a climate change plan for Israel that will include both mitigation and adaptation measures, working groups on adaptation have been appointed which are concentrating on such areas as climate change models, the urban sector, agriculture, biodiversity, public health, drainage and runoff, water resources and economic and insurance aspects. The working groups are charged with bridging the gaps in existing knowledge on the impacts of climate change in Israel based on different scenarios, surveying available means for minimizing damage and vulnerability and identifying Israeli technologies for dealing with climate change that may assist other countries as well.

6.4 Recommended Actions to Prepare for Anticipated Climate Change

Since climate change seems evident and mitigation efforts may not entirely halt the ongoing processes, it is highly recommended that a series of actions be taken to monitor, moderate and prevent some of the global warming impacts. International studies, especially the Stern Review on the Economics of Climate Change, have suggested that early proper action can greatly reduce the heavy economic costs of climate change. Therefore, each suggested action should be analyzed in terms of its economic benefits vs. the alternative "no action" option, and feasibility should be estimated in the local context. In addition, an overall analysis of the suggested actions should be conducted in order to prevent negative synergistic impacts of actions or inefficient use of resources. The following section presents a list of suggested actions in major relevant fields.

6.4.1 Climate Monitoring and Database

- Establishment of a database which will concentrate data on climate change. This database should be accessible via internet to the public at large, and should include a complete description of existing data and means of obtaining these data. For example, in the field of atmosphere, a list of meteorological stations, the location of each station, the data measured by each station, the time period for which data exist, the time resolution of the measurements and their accuracy should be included, along with the details of the data holders and means of obtaining the data. It is crucial to allow easy and free access for researchers in the field.

6.4.1.1 Climate monitoring

- Overall administration of climate research in Israel, which will concentrate the existing studies and will draw the necessary conclusions and requirements.
- Providing high quality maintenance and improving the array of the monitoring stations throughout the country. Relevant measurements should include: air temperature, pressure data in an hourly resolution, hourly precipitation amounts, dust concentrations, altitude cross-sections of pressure, humidity, wind direction and speed.
- Running a long-range atmospheric model, at a high resolution (climate forecast). Taking part in a consortium for climate prediction in order to create an ensemble of predictions.

6.4.1.2 Hydrosphere

- Increase in the number of hydrological stations for surface water, which measure the quality and quantity of the water, including monitoring of all potential pollutants, and the flow speed in the channel.
- Sea level temperature measurements in a number of places along the Mediterranean coast, the Red Sea, the Dead Sea, and the Sea of Galilee, at different depths and hourly resolution.
- Measurements of the sea and lake levels and of salinity levels on a regular basis and at a higher resolution.
- Measurements of meteorological and marine data up to a hundred kilometers from the Israeli coasts.
- Measurements of sea level from satellites.
- High resolution aerial photos of specific sensitive areas. For instance, in agriculture, to locate damaged vegetation due to salination or damage to water bodies due to algae bloom or river delta pollution.

6.4.2 Water Resources

- Incorporation of the consequences of climate change (such as decreased water availability, rise in sea level, etc.) into the country's water economy plans, including changes in water abstraction and transport infrastructure as a result of reduced water supply. At present, Israel is considerably expanding its desalination capacity and is establishing new desalination plants along the Israeli coast in order to cope with the water shortage. In 2008, 150 MCM of desalinated water were supplied (7% of the total water supply). By 2020 desalination capacity is planned to reach 750 MCM.
- Sustainable administration, including flood management, aquatic system protection, and water infrastructure planning. Since many climate impacts are hard to predict, flexible management is required. This will enable the adaptation of preparatory actions to other stress conditions as well. An important tool for long-term planning is the use of different models which predict changes in water resources, in the wake of climate change.
- Integration of ecological models and hydrological models. In addition, as changes to present conditions occur, past and present conditions in empirical models could become irrelevant, or useless, in predicting the future. Approaches of mechanistic models and quantitative uncertainty analysis will become more important tools.
- Assessment of the price of water, so that it internalizes water supply, water usage, sewage treatment, and sewage disposal or reuse in order to encourage efficient use of water resources and effective management of the water economy. A sustainable water economy requires quantification of externalities in the determination of

operational, investment, and pricing policies. These changes lead to an increase in water prices, and means should be taken to ensure that this price increase will not affect the weaker segments of the population.

- Improvement in the adaptation and coping capabilities of water and sewage infrastructure during flood events.
- Conservation of water in light of climate change and population pressure on water resources. A campaign to promote water conservation and correct water consumption is already in place and is helping to prevent careless water use. It should be emphasized that water is an important economic and political resource, which should be used in an efficient, sustainable way, for the benefit of future generations. Water conservation campaigns should also encompass the school system and should use all forms of the media. Water savings may also be encouraged by changes in pricing and taxation.
- Optimal, high quality recycling of sewage. Effluents are currently providing more than 30% of the water consumption in agriculture and 17% of the total water consumption by all sectors.
- Moderation of floods by diverting urban surface runoff to infiltration areas and maintaining floodplains along rivers. Regulation of floodwater by the expansion of land conservation areas, flooding of more extensive agricultural areas while compensating farmers, and comprehensive management of drainage basins.
- Re-planning of water systems in urban areas in order to increase capacity.
- Improved water use efficiency in urban centers by installing water saving means in households.
- Development of dry gardening that uses water-thrifty plants, instead of flowers and lawns, which require large amounts of water. In addition, an irrigation regime should be put into practice according to season, soil quality, wind regime, etc. These actions could lead to a substantial savings in freshwater consumption.
- Re-assessment of freshwater pollutant lists and drinking water standards and assessment of the potential of climate change to impact on the character and extent of freshwater and aquatic systems pollution.
- Preparation of maps of anticipated land-use patterns for the coming decades (a map for each decade), to enable preparedness for the expected impacts of land-use on water quality, in addition to the consequences of climate change.
- Increased biological monitoring, mapping and collaboration between authorities and bodies responsible for water source management in order to evaluate the health of aquatic systems.

6.4.3 Agriculture

Crops

- Improvement of the quality of annual forecasts, development of models to predict crop growth, productivity, water and fertilizer consumption, models for pests, insects and plant diseases, and work plans derived from these in accordance with climate changes.
- Addition of variables which present the impacts on agriculture using statistical analysis, such as: frequency and strength of severe heat stress periods and freeze events, frequency of dry spells between rain events, and other events, which affect plant physiology. Improvement of the ability to identify significant trend changes in the relevant variables for climate change in statistical agriculture models.
- Increased use of effluents in Israel as a substitute for freshwater. Connection of all effluent reuse facilities to agricultural irrigation facilities in order to minimize the flow of treated wastewater to the sea. At the same time, it is important to irrigate crops with freshwater as well in order to neutralize soil salination and damage to soil fertility from reused water.
- Intensification of water conservation by increasing the use of crops which require lesser

amounts of water and whose added value per cubic meter of water is higher (such as wheat, chickpeas, sunflowers, cauliflower, lettuce and garlic), use of saline water, integration of vegetables between rows of orchards and improvement of water technologies in order to improve irrigation efficiency (e.g., pulse irrigation, recovered wastewater and drip irrigation systems).

- Genetic improvement and selection of crops resistant to heat stress, dryness, and cold, and to the increase in CO_2 concentrations. Biotechnology allows for the introduction of species more tolerant to salt and pests and for a general improvement in crop yields and quality.
- Improvement in greenhouse technology, including applying changes to the variety of crops, used inputs, and climate control systems.
- Changes in planting and harvesting dates and selection of a wider seasonal variety. Advancing the planting times of crops could help cope with the rise in temperatures. Nonetheless, not all crops are suitable for this procedure. For example, researchers have found that early seeding is not an effective adaptation measure for wheat and is only slightly efficient for cotton.
- Preference of spring and autumn crops, with a short growth period, in order to avoid the heat stress of midsummer. Winter crops could become more productive than summer crops.
- Compatibility between the efficient water use of the different crops and selection of suitable areas to grow those crops.
- Implementation of methods to reduce erosion and prevent soil loss, in addition to increasing the infiltration of water into the fields. The 'no-till' method allows the preservation of the soil and reduction of erosion since there is no soil inversion, and seeding takes place near the vegetation harvested the previous year.

Farm animals

- Improvement of existing climate control systems, improvement of planning and the materials used for livestock farms, shading and the use of sprinkler systems in order to relieve the farm animals of the heat stress.
- Selection of cattle species more resistant to heat conditions and pests, or genetic improvement of existing species (resistance to heat and pests, and effective food utilization), and timing breeding according to seasonal conditions.
- Development of methods to reduce and/or replace animal feed containing grains, including methods for recycling organic and industrial waste, which will be used as food for farm animals, instead of cereal crops.
- Development of methods to improve the nutrient quality of agricultural and waste by-products, such as straw.

6.4.4 Coastal Zone

- Incorporation of climate change implications in the land-use planning of the coastal area.
- Continuous monitoring of the rise in sea level along the coast.
- Enforcement to prevent the transfer of alien marine species by trade routes and indirectly (e.g., via bilge water, species arriving with algae, or mollusks, etc.).
- Assistance in the retreat of coastal ecosystems inland in the wake of sea level rise by removal of structures that could block the movement inland, or by a re-extension of the coastline by sand nourishment. Nonetheless, these actions are only possible in certain areas, due to the development of many coastal areas.
- Prevention of marine pollution from land sources in the Gulf of Elat in order to reduce the stress on the coral reefs.
- Continued monitoring of the changes to the coastal cliffs, by means of high resolution photogrammetric mapping on an annual basis. One of the more successful options is airborne laser mapping.
- Protection of the coastal cliff by such means as marine protections (detached breakwaters), in combination with sand nourishment. This combined solution requires continuous maintenance by sand nourishment, in order to prevent sand reduction from nearby beaches, as a result of the entrapment of sand by the breakwaters.

6.4.5 Public Health

- Education and information on potential health damages as a result of climate change.
- Training of health experts in the relevant areas.
- Urban planning to reduce the effect of the urban heat island, which increases heat stress, by means such as tree planting for shading.
- Preparatory actions in the area of air pollution, which will generally benefit the quality of the air, in addition to contributing to adaptations for climate changes: improvement of air pollution control systems, operation of an alert system for air pollution, limitations on car traffic in densely populated regions, improvement of public transportation and encouragement of car pools.
- Improved border control to prevent the entry of pathogens (including from farm and household animals).
- Increased monitoring of the environment and of various disease carrying vectors.
- Reassessment of clean water criteria (microbial criteria) and risks of water-borne diseases or of disease vectors related to water.
- Prevention of exposure to disease carrying vectors (such as mosquitoes and flies) by limiting their habitats.
- Improvement of the public health systems and their ability to respond to climate change and identification of the vulnerability of certain populations.
- Vaccinations against new or re-emerging diseases.

6.4.6 Ecosystems and Biodiversity

Biodiversity

- Incorporation of climate change implications in the management of natural reserves to allow for species migration. Establishment of ecological corridors between different reserves to enable the increase in the wealth of species and a genetic flow between the areas.
- Greater examination and focus on rare species and highly sensitive ecological communities which require large areas. Larger open spaces increase biological diversity.
- Allocation of conservation areas in the transition zones between the arid climate and the Mediterranean climate – in the northern Negev, in the Judean plain, and east Lachish.
- Allocation of resources for the establishment of a biodiversity monitoring plan, which will also examine climate changes.
- Treatment of invading species, which contribute to the reduction of local species diversity, and strengthening quarantine methods in ports and borders, through which exotic pest species could enter.
- Mapping the sensitivity of plants and animals to endemic and exotic pests, pathogens and parasites. Preparation of a database and improved monitoring in order to locate in due time pests, plant diseases and plant products, which could become harmful under future climate conditions, and improving means of treating these hazards.
- Broadening the scientific knowledge on a variety of strategies effective in the treatment of pests, and their assimilation in practice.

Forests

- Forest management which includes climate change implications under different scenarios, improved knowledge of the climatic requirements of different species, and assessment of the sensitivity and resistance of important species to stress conditions.
- Management of soil resources in the proximity of forests in order to better handle overpopulation and desertification.
- Avoidance of over-exploitation of forest resources.
- Planting of trees resistant to dry conditions and genetic improvement of plant species to allow them to cope with higher temperatures and dryness stress. Such action could help respond

to the potential expansion of the desert northward.

- Increasing the CO_2 sequestration by forestation and prevention of soil destruction.
- Thinning of forests in order to adapt the number of trees to the habitat conditions. Thinning (reduction in transpiring green foliage per unit area) will allow the water to properly disperse between weeds, flowers, groundwater, etc. Experience during drought years in the past has taught that forests duly thinned survived the drought period, compared to un-thinned forests. Preparedness for forest thinning, including the preparation of an action plan based on knowledge regarding the density of forests in practice, compared to the tree density required, according to the age of the forest and the nature of the habitat.
- Proper understanding of forest health (i.e., drying of trees, damage from forest pests, and defective development of forest trees) as a primary means for planning and taking administrative actions to ensure the resistance and development of the forests in the anticipated dry periods. A more intensive monitoring plan than is currently implemented is required to follow climate dependent processes in the forest.
- Preservation of soil and water resources in the forest. Preservation of water in rainfall areas in the Mediterranean region of Israel, collection of surface runoff water in arid areas, soil preservation actions for the rehabilitation and stabilization of river beds and slopes, as well as planning and maintenance of roads, may increase the resistance of forest vegetation to reduced precipitation and prevent soil erosion damages. In case the Mediterranean region of Israel will be exposed to the climatic conditions which currently exist in the northern Negev region, it will be necessary to shift the afforestation, water management and soil resources models, which are currently undertaken in the south, northward.
- Actions which could improve the resistance of forests to anticipated fires are improvements in grazing management, treatment of areas bordering built areas, maintenance of forest paths, upgrading the fire engine system and improvement of the training system, implementation of plans to monitor fires in forest areas, and cleaning forests of potential fire hazards, or execution of controlled fires to prevent the accumulation of fire hazards.

6.4.7 Energy and Infrastructure

- Development and usage of solar energy facilities to deal with the burden on the conventional energy infrastructure as a result of the increased need for air conditioning and for a reduction in GHG emissions.
- Energy costing to reflect the carbon cost.
- Increased energy efficiency in cities through use of air passageways and insulation measures in building, in order to relieve the heat or cold stress, and implementation of policies to encourage the efficient use of energy in building, transport, and electricity production.
- Planning and building regulations adapted to the anticipated implications of climate change. Preparations of risk assessments for vulnerable infrastructures, such as roads, railroad tracks, bridges and ports, in areas under threat of extreme events (such as floods). Strengthening and protection of existing infrastructures, and construction according to worst case scenarios of extreme weather events (according to a higher sensitivity threshold of the infrastructure).
- Reduction of industry's dependence on rare resources.
- Siting of industrial centers far from areas sensitive to weather damages.

6.4.8 Economy

Insurance companies could prepare for climate change in three ways. The first is adaptation to the adverse effects of climate change on their profitability and on their redemption capacity. An extensive analysis of the potential impacts of climate change assists individuals, governments and private companies to moderate the economic losses. Secondly, insurance companies could work toward improving the scientific research on the

Table 6.1 *Summary of vulnerable sectors and adaptation options*

Vulnerable Sector	Possible Impacts	Adaptation Options
Water Resources	• Reduction in water availability in aquifers and surface water bodies • Deterioration of water quality • Increased probability of flood events	• Expansion of desalination capacity • Efficient water use and effective water economy management • Improved modeling • Increased public awareness and change of consumption patterns • Enhanced water quality and quantity monitoring and modeling • Reassessment of water quality standards • Enhanced collaboration of authorities and relevant institutions • Improved wastewater and drainage infrastructure • Enhanced management of the land-use interface in flood-sensitive areas
Agriculture	• Shortage in water supply for agriculture • Damages to crop productivity due to water deficiency and extreme climate conditions • Changes in crop growing seasons • Salination and erosion of soil • Reduced productivity of farm animals • Shortage in fresh animal feed • Increased risks of pests and farm animal diseases	• Increased use of treated effluents in agriculture • Efficient use of water and better adjustment of crop location to water availability • Better modeling and forecasts • Technological improvements in irrigation and cultivation methods and implementation of cultivation methods that prevent soil loss, such as the "no till" method • Genetic improvements in crops and farm animals • Expansion and adjustment of crop varieties • Adjustment of planting and harvesting dates • Improvement of climate control systems in livestock farms • Development of substitutes for grains in animal feed • Selection of cattle species resistant to heat and pests and adaptation of animal husbandry methods
Coastal Zone	• Coastal retreat • Sand removal • Damages to coastal infrastructure and tourism • Salination of the coastal aquifer • Damages to the coastal cliff • Increased probability for the invasion of marine alien species • Coral bleaching in the Red Sea	• Incorporation of climate change implications into land-use planning • Enhanced monitoring of sea level and coasts • Adaptation of coastal infrastructure • Use of sea protections and sand nourishment techniques • Enhanced international trade control in order to prevent invasion of exotic marine species • Prevention of sea pollution in order to reduce stress on coral reefs

Vulnerable Sector	Possible Impacts	Adaptation Options
Human Health	• Increased incidence of parasitic and infectious diseases • Increased thermal stress • Increased risk of damages from extreme weather events	• Enhanced control and monitoring of disease carrying vectors and risk assessment • Training of health experts • Improvement and adaptation of health systems to climate change risks • Public education • Improved urban planning to reduce heat stress and air pollution
Ecosystems & Biodiversity	• Loss of plant species in the semi-arid region due to desertification • Damage to local animal species populations • Changes in species composition in the Sea of Galilee • Damages to nature reserves • Increased likelihood of forest fires	• Incorporation of climate change implications in the management of conservation areas and the establishment of ecological corridors • Research, monitoring and mapping of species vulnerability to climate change impacts • Enhanced management of forest resources along with their human interface • Forest thinning • Genetic improvements in forest tree species • Selection of resistant tree species for afforestation
Energy & Infrastructure	• Increased energy demand due to harsher heat stress, particularly during peak heat waves • Damage to infrastructure in vulnerable areas	• Use of renewable energy to meet increased energy demand • Increased energy efficiency • Adaptation of building regulations to new climatic conditions • Identification and protection of vulnerable infrastructure and industries • Enhanced resource management
Economy	• Damage to public and private property • Increased costs for goods and services • Higher burden on the insurance industry	• Cost benefit analysis of adaptation action vs. inaction in selected fields • Economic incentives that promote adaptation to anticipated climatic changes • Risk analysis for the insurance industry

impacts of the anticipated changes and the means to cope with them, and assist in the funding and development of projects to promote clean technologies and energy-efficient construction. Lastly, insurance companies could grant economic incentives, such as discounted premiums for those insured who will prepare in due time for the expected changes and hence reduce the losses expected as a result of climate change.

6.4.9 Israel as a Center of Knowledge for Climate Change Adaptation

Based on its rich experience in developing cutting-edge technologies and effective management systems in such fields as water management, recycling and reuse of treated wastewater, seawater desalination, desert agriculture and afforestation, the challenges presented by climate change may well serve as a lever to position Israel as a regional and global center of knowledge on adaptation to climate change.

A number of factors combine to make Israel a potential center of excellence on adaptation to climate change, including:

- Israel's existing research capacities in such areas as effluent reuse, irrigation with marginal water, development of drought-resistant crops, desert afforestation and soil preservation.
- Israel's know-how in such fields as water saving in the urban, agricultural and industrial sectors.
- Israel's research and development of innovative technologies in such areas as drip irrigation, leakage prevention, and more.

Israel has checked the feasibility of establishing an information and knowledge center for adaptation to global climate change, based on its broad experience and knowledge in a wide variety of relevant fields, in terms of both management and technology. The establishment of such a knowledge center in Israel may facilitate the collection of information on climate change in Israel and the Mediterranean region, may create climate forecasts together with other countries in the region, may bring together Israel's scientific activities on climate change and may assist in the transfer of Israeli technologies which deal with climate change to countries which currently face the need to adapt to climate change.

7 Forecast and Mitigation Options

Reduction of GHG emissions is an especially difficult challenge in Israel, a country undergoing economic growth against a backdrop of continuous increases in both population and energy consumption. In order to meet the challenge, special emphasis has been placed in recent years on assessing GHG emissions under different scenarios while identifying the steps necessary to reduce these emissions in an economically viable manner.

Within this process, the MoEP commissioned two studies: a survey of GHG emissions in Israel, future forecasts and mitigation options (hereafter referred to as the Heifetz study) and a carbon abatement cost curve for Israel that quantifies a range of measures across sectors (hereafter referred to as the McKinsey study). Although the general scope of the studies is similar, they tackle different reference periods and use different methodologies and analysis scales.

This chapter reviews the two studies separately and then compares the two studies in terms of objectives, methodology and estimated national and sectoral mitigation potential. Finally, an ongoing work, prepared by the S. Neaman Institute, Technion, is briefly presented which relates to implementing the conclusions of both studies.

7.1 The Heifetz Study

In May 2007, the MoEP commissioned A. Heifetz and Co. in cooperation with DHV Company to assess Israel's GHG emissions, prepare an emission forecast until 2025 and examine the abatement potential for that period. The resulting study, published in January 2009, quantified Israel's abatement potential via mitigation measures in the relevant sectors (energy, transport, industry, waste, etc.), using a detailed cost/benefit analysis.

In addition, the study surveyed the views of parties to the Kyoto Protocol regarding the second commitment period, reviewed and analyzed Israel's mitigation alternatives as a non-Annex I party (voluntary commitment versus the CDM), and presented operational recommendations for mitigation policy. The study was accompanied by an interdisciplinary committee, which consisted of experts from key ministries, from the power utility and from the manufacturing sector.

The first part of this chapter focuses on the emission forecast and mitigation potential presented in the Heifetz study.

7.1.1 GHG Emissions Forecast

In order to estimate the scope of GHG emissions in the coming decades in Israel, the Heifetz study constructed a baseline forecast termed the business as usual scenario (BAU). Thereafter, mitigation options in the different sectors were reviewed, analyzed and compared with the BAU scenario in order to fully comprehend Israel's mitigation potential.

7.1.2 Business as Usual Scenario

According to the BAU scenario, the forecast for domestic demand, supply and growth presupposes that Israel's economy will continue its current development course, with similar growth mechanisms and a similar level of government intervention. This scenario assumes a sequence of future actions that stem from approved government decisions with no special actions that diverge from these decisions. The calculation of GHG emissions for the base year (2006) and the forecast for the following years up to 2025 are based on the 1996 IPCC guidelines. As the energy sector is the major sector with regard to GHG emissions in Israel, the study mainly focused on foreseen developments in this sector.

7.1.2.1 Estimates for the energy sector

The estimate for growth in the energy sector is based on:

- **The Master Plan for the Energy Sector 2002-2025** - This plan, prepared in 2002, predicted the development of the energy sector up to 2025. The plan is divided into consumption sub-sectors and fuel types. The Heifetz study was based on this master plan, with required adjustments and data updates, when possible.
- **The Development Plan for the Electricity Industry 2007-2030** - This plan was prepared in 2007 and predicted the development of the electricity industry in terms of demand and supply until 2030. The plan specifies the anticipated introduction of new power plants and the introduction of natural gas for electricity production. In addition, it takes account of policy decisions relating to the ratio of natural gas to coal in power plants and the ratio of renewable energy from total electricity production.
- **The Master Plan for Natural Gas** – This plan, prepared 2003, predicts the introduction rate of natural gas, the quantity and the targets for 2010 and 2015. The introduction of natural gas has been delayed by two years, but it is anticipated that the plan will be fully realized with prioritization for the use of natural gas in the electricity industry.
- **Past data** – CBS data regarding supply and demand of energy sources in Israel.

7.1.2.2 Estimates for other sectors

The estimate for the growth rates of the waste sector is based on the MoEP forecast, which took into account recent changes in landfill-related legislation.

Estimates for the other sectors are based on CBS data for the last 7 to 15 year trends.

7.1.2.3 Demographic and macro-economic data

- **Population Growth Forecast** - Population growth is a central factor in estimating future GHG emissions, since it generates growth in production, which leads to increased GHG emissions. Therefore, without limiting demand, population growth would eventually lead to increased demand by the various sectors and to an increase in total production and kilometers traveled. As of December 2007, Israel's popula-

Table 7.1 *Population estimates*

	2006	2010	2015	2020	2025	Average growth rate
Population (millions)	7.2	7.7	8.4	9.1	9.9	1.70%

Source: Heifetz Study

tion stood at 7.25 million. Between 2002 and 2007 the population grew at an average rate of 1.8%. However, long-term forecasts predict an average growth rate of 1.7% until 2025.

- **Macro-Economic Development and Consumption** - Macro-economic development, and consumption patterns (including consumption of energy, waste and animal products by households) are strongly linked to GHG emissions. Therefore it is important to understand the major macro-economic trends and integrate them into the GHG emissions forecast.
- **GDP Data** -The average growth rate for the OECD economies for the years 1996-2006 was 3.2% per year. It is assumed that Israel's GDP growth rate will gradually decline from 4.3% per year to the OECD level. Therefore the forecast assumes an average growth rate of 3.8% for the years 2010-2025, which equals an average annual increase of 2% in GDP per capita.

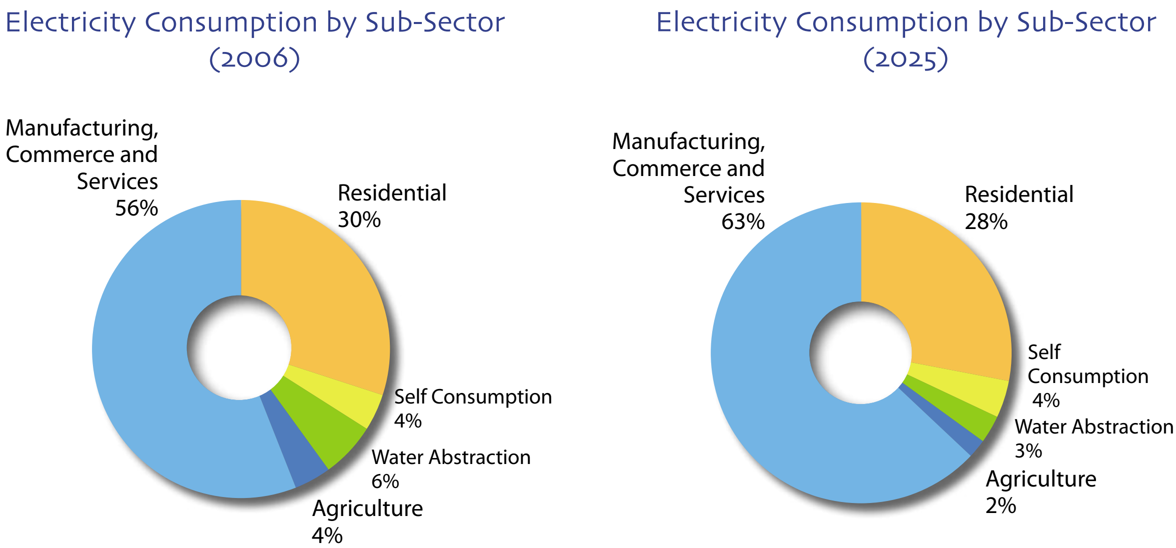
7.1.3 Fuel Forecast in the Energy Sector

The energy sector is responsible for 85% of Israel's GHG emissions. The following table presents the fuel types, by sub-sector, in the energy sector, for which CO_2, CH_4 and N_2O emissions were calculated.

Table 7.2 *Fuel types by sector*

Sub-Sector	Fuel Type
Energy (electricity production and oil refining)	Coal, natural gas, residual fuel oil, diesel oil, kerosene
Manufacturing and construction	Natural gas, residual fuel oil, diesel oil, kerosene, petroleum coke, oil shales, liquefied petroleum gas, naphtha
Transport	Gasoline, diesel oil, kerosene
Residential buildings	Diesel oil, liquefied petroleum gas
Commercial and institutional	Residual fuel oil, diesel oil, liquefied petroleum gas

Figure 7.1 *Electricity consumption by sub-sector (2006 and 2025)*



Source: 2006 IEC report

7.1.3.1 Generation of electricity

Energy production in general and electricity generation in particular are the main factors in the emission of CO_2, the major GHG gas. In 2006, electricity generation by the IEC totalled 50,372 GWh, of which 70% was generated by coal, 18% by natural gas, 6% by residual fuel oil and 6% by residual fuel oil and diesel oil.

The forecast for electricity demand till 2025 is based on three sources: MNI, IEC and a study by Eco-Energy Ltd. According to these sources, the growth rate of electricity demand is estimated at 3.2 to 3.6% per year.

Data on fuel consumption include fuels used by the IEC and other electricity producers, which sell electricity to the IEC, produce electricity for auto-consumption or sell electricity to other factors. Table 7.3 presents the evolution of fuel use in electricity generation between 2000 and 2006.

The MNI prepared its forecast for electricity generation by coal and natural gas based on the Development Plan for the Electricity Industry (2007-2030).

Table 7.3 *Fuels used for electricity generation*

Year	Diesel Oil (1000 tons)	Residual Fuel Oil (1000 tons)	Coal (1000 tons)	Natural Gas (BCM)
2000	591	2424	10,307	
2001	235	2233	11,566	
2002	415	1937	12,202	
2003	413	2003	12,610	
2004	337	1465	12,717	1.2
2005	679	1125	12,694	1.7
2006	617	943	12,665	2.3

Source: CBS 2006

Table 7.4 *Forecast for electricity generation and fuel consumption by coal and natural gas*

Year	Electricity Generation		Fuel Quantity	
	Coal (GWh)	Natural gas (GWh)	Coal (1000 tons)	Natural gas (BCM)
2011	32,321	30,574	11,560	5.8
2012	33,058	32,822	11,831	6.2
2013	32,051	35,687	11,484	6.7
2014	39,040	31,226	13,811	5.8
2015	43,326	29,609	15,167	5.5
2016	43,333	32,287	15,169	6.0
2017	43,333	34,987	15,169	6.6
2018	43,334	37,694	15,170	7.0
2019	47,626	36,204	16,527	6.8
2020	51,909	34,794	17,882	6.5
2021	51,922	38,033	17,887	7.0
2022	51,922	40,861	17,886	7.6
2023	51,923	43,775	17,887	8.0
2024	51,923	46,829	17,887	8.8
2025	51,923	49,878	17,887	9.2

Source: Heifetz Study

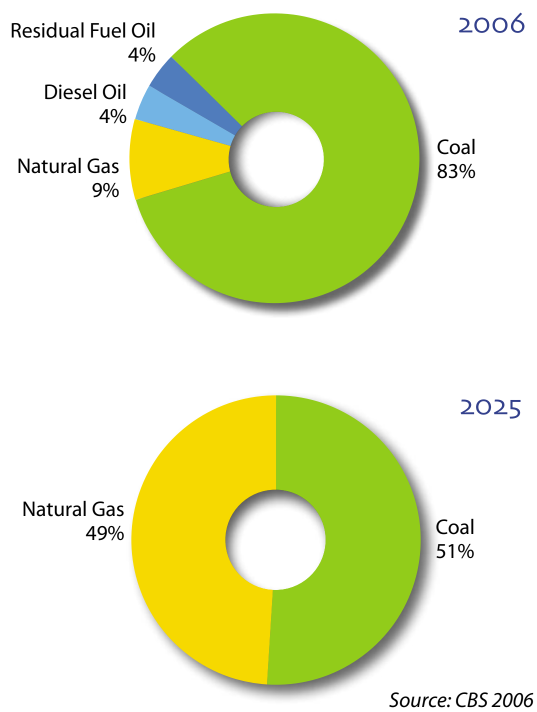
General Assumptions:

- The forecast takes into account the establishment of two coal-fired power plants, D and E in the years 2014-15 and 2019-20, respectively.
- The development plan assumes that at least 50% of energy production will be based on coal. Accordingly, the forecast predicts that for 2011-2025, on average, 55% of the energy production will be based on coal, whereas 45% will be based on natural gas.
- The average growth rate of electricity generation was set at 3.5% per year.
- According to the MNI, the plan should be revised as follows:
    - Some of the fossil fuels should be replaced by renewable sources, such as wind, solar and biomass.
    - The government decided on targets of 2% renewable capacity by 2007, 5% by 2016 and 10% by 2020.
    - The government decided on publishing a tender for two solar power stations in Ashalim in the Northern Negev.
    - In 2007 only 0.1% of electricity generation was based on renewable sources.
    - The MNI forecast assumes that by 2030 only 6.5 % of electricity generation (1500 MW) will be based on renewable sources. The current study assumes that the MNI assumption is most realistic and therefore incorporated it in its BAU scenario.
    - A 20% reduction in electricity demand by 2030 by promoting an energy conservation and efficiency policy.

7.1.3.2 Forecast of developments in residential buildings

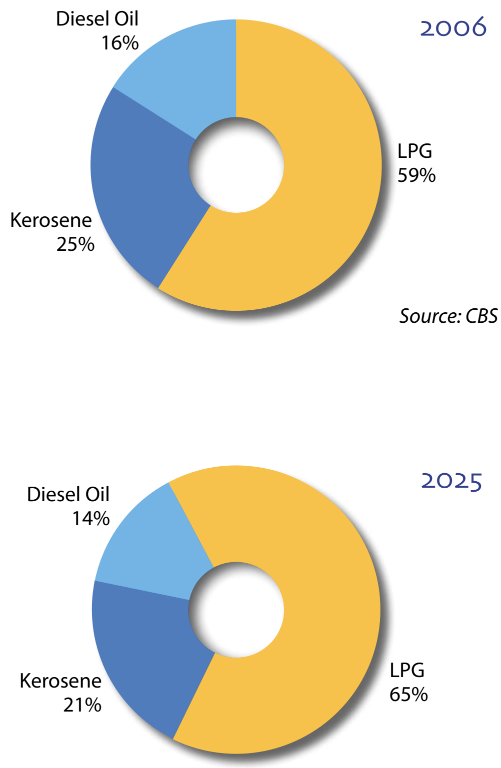
Estimated fuel consumption in residential buildings is based on the Master Plan for the Energy Sector, updated by CBS data for the years 2002-6. In 2006, residential buildings consumed 300,000 tons of various fuels. The predicted annual growth rate of fuel consumption in residential buildings is 3.4% (twice as much as the predicted population growth rate). Accordingly, total consumption will reach 570,000 tons by 2025.

Figure 7.2 *Electricity production by fuel (2006 and 2025)*



Source: CBS 2006

Figure 7.3 *Fuel consumption in residential buildings (2006 and 2025)*



Source: Master Plan for the Energy Sector

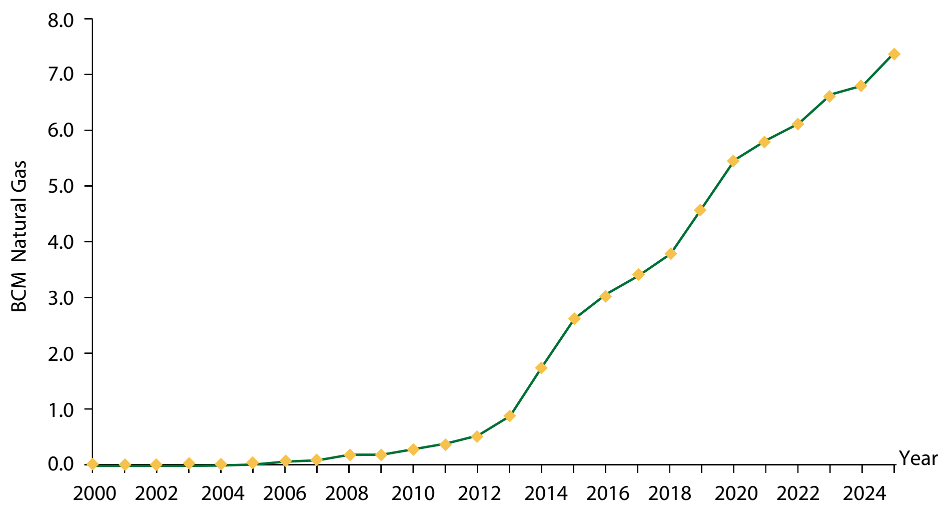
7.1.3.3 Fuel consumption in the manufacturing, construction, commercial and institutional (MCCI) sub-sectors

As in the residential buildings sub-sector, the fuel consumption forecast in the MCCI sub-sectors is based on the Master Plan for the Energy Sector, updated by CBS data for the years 2002-6. In addition, updated data regarding the introduction of natural gas were incorporated into the forecast.

The predicted average annual growth rate for natural gas consumption is 25%, due to its late and slow initial introduction. In 2025, the forecast predicts a consumption of 7.4 BCM of natural gas in these sub-sectors.

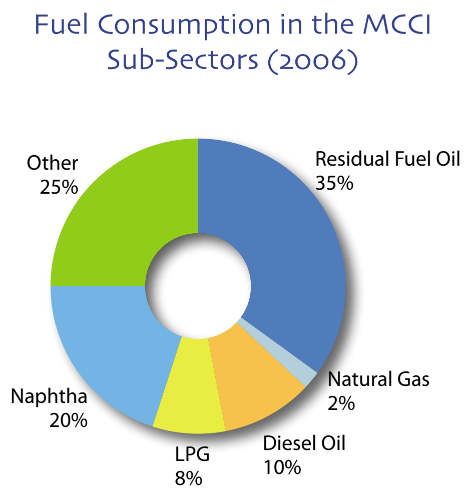
For the rest of the fuels, an average growth rate of 1.4% was assumed, with total consumption of 3.7 million tons in 2006 and 4.8 in 2025. The distribution of consumption into the various fuels is presented in Figure 7.5.

Figure 7.4 *Predicted evolution of natural gas consumption by the MCCI sub-sectors (excluding electricity generation) (BCM)*

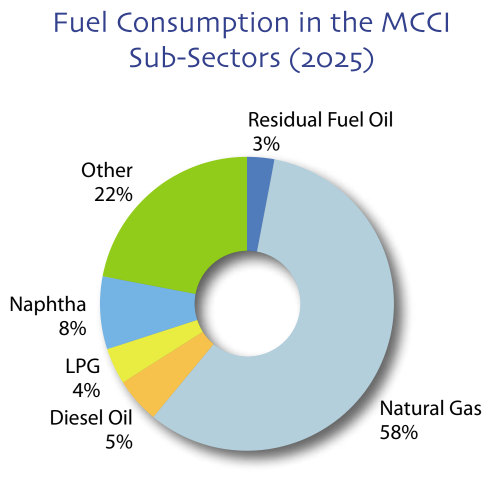


Source: Master Plan for the Energy Sector and Natural Gas

Figure 7.5 *Fuel consumption in MCCI sub-sectors (2006 and 2025)*



Source: CBS



Source: Master Plan for the Energy Sector

As seen in the figure, the main difference between 2006 and 2025 is the increased natural gas consumption at the expense of residual fuel oil and naphtha.

7.1.3.4 Fuel consumption in the transport sub-sector

In the last 20 years, there was a substantial increase in the number of private vehicles in Israel and the kilometers traveled. Consequently, fuel consumption and GHG emissions from the transport sub-sector increased as well.

The increase in private vehicles in Israel is affected by economic cycles. The number of motor vehicles in Israel reached 2.2 million in 2006, an increase of 3.2% from 2005. Private cars increased during that year by 3.5%. From 1990 the number of vehicles increased on an annual average by 4.9%, partially, due to the large immigration wave to Israel in the 1990s. The growth rate in the total number of vehicles from 2000 to 2006 was 2.9%. According to the 2008 master plan of the MOT, the number of vehicles in 2020 will reach 2.7 million, with an average annual increase rate of 3.4%. The motorization level in Israel in 2006 stood at 306 vehicles per 1000 inhabitants vs. 302 in 2005. This level is low relative to developed countries, such as the United States (783), Japan (662), and Great Britain (406). Therefore, it is assumed that the potential for increase in Israel's motorization level is high and will continue to exceed the population growth rate.

Kilometers traveled in Israel increased at an average annual rate of 2.9%. This indicator is affected by road capacity, demand for participation in various activities, economic cycles, car maintenance, and the alternative cost of public transportation. Since the growth in number of vehicles is higher than the growth in road capacity, it is predicted that the kilometers traveled will decrease in the long run.

Table 7.5 *Vehicles and drivers in Israel (1990-2006)*

Year	Motor Vehicles (thousands)				Drivers (thousands)
	Total	Of which:			
		Buses	Trucks and Commercial Vehicles	Private Vehicles	
1990	1,015	9	154	803	1,669
2000	1,831	12	310	1,397	2,679
2004	2,038	11	345	1,567	3,033
2005	2,107	12	351	1,626	3,116
2006	2,176	13	354	1,685	3,198
Growth rate from 1990 (%)	4.9	2.3	5.4	4.7	4.1
Growth Rate from 2000 (%)	2.9	1.0	2.3	3.2	3.0

Source: CBS

Table 7.6 *Kilometers traveled in Israel*

Kilometers traveled (millions)	1990	2000	2004	2006
Total	**18,688**	**36,482**	**39,869**	**43,242**
Of which: Private Vehicles	12,170	22,800	24,683	26,436
Trucks	4,842	10,216	11,119	11,489
Buses	565	814	804	822

Source: CBS

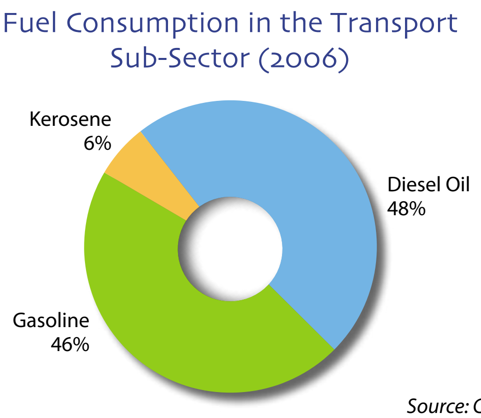
Table 7.7 *Railway services in Israel*

	1990	2000	2004	2006
Length of railway lines	830	926	815	905
Seats	-	11,854	23,981	29,928
Number of passengers (1000)	2,524	12,698	22,898	28,351
Kilometers traveled - passenger trains (1000)	-	3,812	7,093	8,238
Kilometers traveled - freight trains (1000)	-	1,498	1,662	1,635

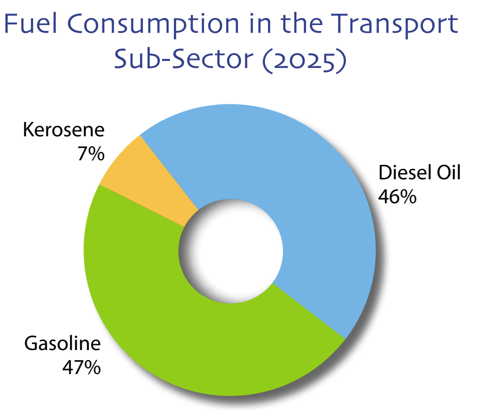
Source: CBS

The forecast for fuel consumption in the transport sub-sector is based on the Master Plan for the Energy Sector, updated by CBS data for the years 2002-6. In 2006 the transport sub-sector consumed 4.6 million tons of fuel (not including kerosene that is used for civil aviation). According to the forecast, fuel consumption is predicted to grow at an annual average rate of 2% and reach 6.6 million tons by 2025, without a significant change in the fuel mix.

Figure 7.6 *Fuel consumption in the transport sub-sector (2006 and 2025)*



Source: CBS



Source: Master Plan for the Energy Sector

7.1.3.4.1. Data limitations

According to the IPCC guidelines, fuel consumption for international aviation and marine transport was not included in the calculations.

In recent years tax benefits have been granted for the purchase of "green" cars (hybrid, electric, natural gas, etc.). Although the number of "green" cars is on the increase, it is still small. However, vehicle producers are in the process of developing new "green" models and therefore their market is predicted to significantly grow in coming years. Due to their high prices, the BAU scenario did not take the introduction of "green" cars into consideration.

According to the tax reform that came into force in 2004, tax rates for diesel oil and gasoline were set to be equal by 2009. Since the Master Plan for the Energy Sector was prepared in 2002, it did not account for these changes. Therefore, the BAU scenario was adapted according to the foreseen changes.

Forecasts regarding the impacts of future transport policy on the mix of kilometers traveled between private and public transportation and between motorized and railway transport were not available. Therefore, the BAU scenario was based on the forecast for fuel consumption, adjusted by the foreseen growth in the number of vehicles.

The following table summarizes the forecast for fuel consumption by the energy sector.

Table 7.8 *Total fuel consumption forecast in selected years*

Thousand tons (Except for Natural Gas -BCM)	2006	2010	2015	2020	2025	Average annual change (%)
Fuel Combustion - electricity						
Coal	12,665	12,009	15,167	17,882	17,887	1.8
Heavy Fuel Oil	943	205	181	201	201	-7.8
Diesel Oil	617	244	192	277	277	-4.1
Natural Gas	2.3	5.0	5.5	6.5	9.2	7.6
Fuel Combustion - not including electricity						
LPG	398	445	512	591	683	2.9
Refinery Gases	146	177	182	189	197	1.6
Diesel Oil	2,378	2,613	2,824	3,078	3,346	1.8
Gasoline	2,143	2,299	2,532	2,796	3,089	1.9
Light Fuel Oil	120	81	38	24	15	-10.4
Heavy Fuel Oil	1552	1255	730	579	441	-6.4
Naphtha	762	908	940	973	1,008	1.5
Kerosene	1,066	412	469	528	592	-3
Other Oil Products	596	663	876	1,044	1,174	3.6
Oil Shales	452	446	450	455	459	0.1
Natural Gas	0.1	0.3	2.6	5.5	7.4	27.1

Source: Heifetz Study

7.1.4 Calculation Methodology for GHG Emissions in the Energy Sector

GHG emissions were calculated according to the IPCC guidelines. The emissions up to the year 2025 were calculated using a weighted-average coefficient that includes the characteristics of each fuel type.

For each sub-sector, different emission factors were used for the relevant fuel types, according to the ratio of consumption to emission. Therefore, the calculation of total CO_2 emissions accounts for the anticipated fuel mix changes in the various sub-sectors along the years.

According to the Development Plan for the Electricity Industry, a new coal-fired power plant, Project D, will start operating in 2014. This plant is designed to use super critical technology, with higher efficiency than the current technology resulting in 8% reduction in CO_2 emissions. The plan has met with opposition from the MoEP and environmental groups.

7.1.5 Emissions Forecast for the Energy Sector

The energy sector releases CO_2, CH_4 and N_2O emissions from fuel combustion. The following table presents an estimate for the total emissions by sector of CO_2 for the years 2006-2025.

The results show a 67% increase in CO_2 emissions in the energy sector from 2006 to 2025. The increase mostly stems from increases within the three major sub-sectors: energy industries (49%), transport (43%) and manufacturing and construction (250%).

Table 7.9 *CO_2 emissions in the energy sector by sub-sector (thousand tons)*

Year	Energy Industry	Manufacturing & Construction	Transport	Commercial & Institutional	Residential	Total
2006	41,693	5,700	14,501	385	858	63,137
2007	44,042	5,717	14,824	386	890	65,859
2008	43,432	5,796	15,164	388	921	65,700
2009	42,474	5,700	15,489	390	958	65,011
2010	41,583	5,809	15,804	392	994	64,583
2011	40,886	6,454	16,114	394	1,029	64,877
2012	42,187	6,533	16,423	395	1,063	66,602
2013	43,790	7,188	16,731	394	1,098	69,201
2014	46,697	8,764	17,041	386	1,135	74,022
2015	48,776	10,196	17,354	381	1,172	77,880
2016	49,878	11,178	17,671	388	1,212	80,326
2017	51,085	11,761	17,993	395	1,253	82,487
2018	52,034	12,547	18,319	402	1,295	84,597
2019	54,714	14,136	18,651	410	1,338	89,248
2020	57,163	16,198	18,988	417	1,384	94,150
2021	58,124	16,788	19,331	425	1,430	96,098
2022	59,273	17,380	19,680	433	1,478	98,245
2023	60,025	18,574	20,036	441	1,528	100,604
2024	61,578	18,768	20,398	450	1,580	102,773
2025	62,331	19,964	20,767	458	1,634	105,153

Source: Heifetz Study

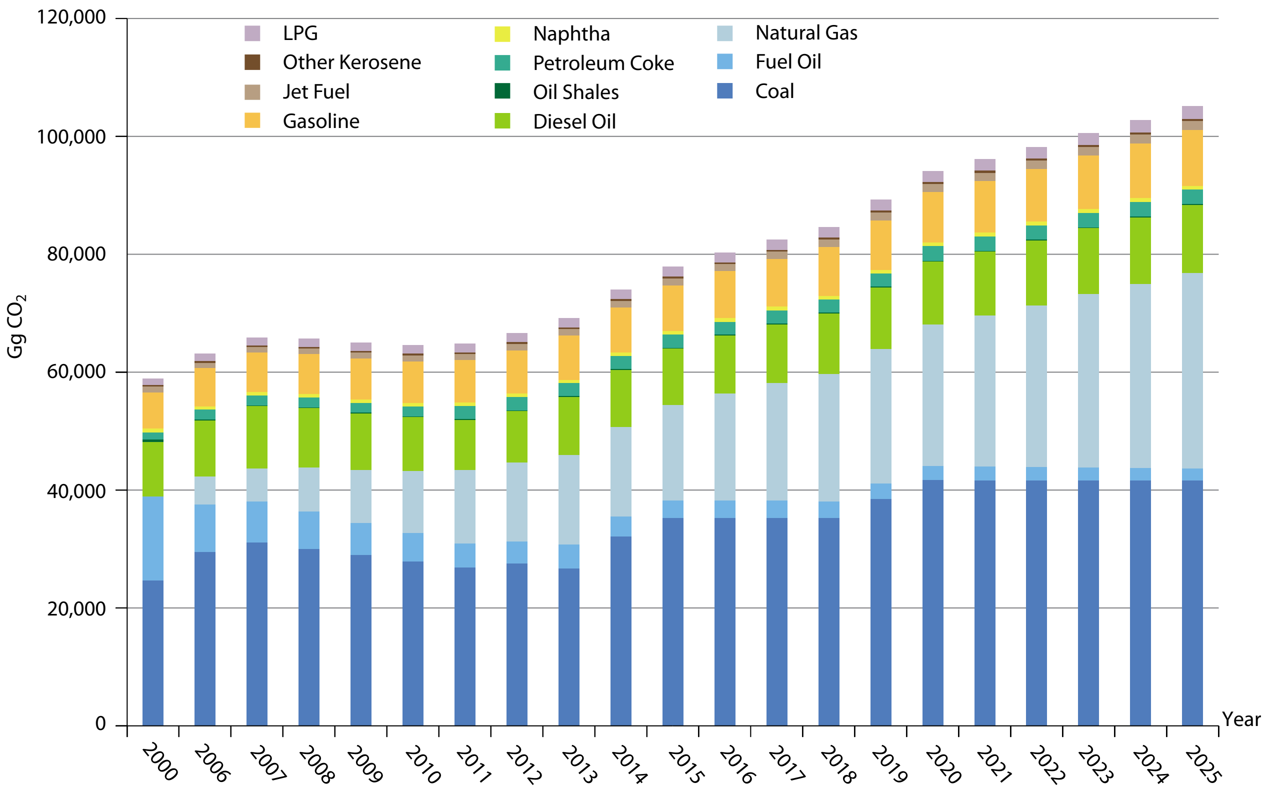
The contribution of the different fuel types to the total emissions is presented in Figure 7.7.

As can be seen in Figure 7.7, the contribution of fuel oil to CO_2 emissions is decreasing along the reviewed years, whereas the contribution of natural gas is on the increase. This trend is mostly due to the transformation of the heavy fuel oil power plants to natural gas.

As to the non-CO_2 emissions from the energy sector, Table 7.10 presents the predicted evolution of CH_4 and N_2O emissions for the years 2006-2025.

As can be seen in the table, a gradual increase in emissions of both CH_4 (77% increase) and N_2O (49% increase) is predicted between 2006 and 2025.

Figure 7.7 *Evolution of CO_2 emissions by fuel in the energy sector*



Source: Heifetz Study

Table 7.10 *Evolution of non- CO_2 emissions in the energy sector*

Year	N_2O (1000 Tons)	CH_4 (1000 Tons)
2006	0.67	3.5
2007	0.76	3.6
2008	0.73	3.65
2009	0.69	3.60
2010	0.66	3.71
2011	0.63	3.70
2012	0.63	3.84
2013	0.66	3.96
2014	0.72	4.18
2015	0.77	4.39
2016	0.78	4.60
2017	0.81	4.68
2018	0.84	4.90
2019	0.89	5.05
2020	0.94	5.40
2021	0.97	5.50
2022	0.98	5.70
2023	0.98	5.90
2024	0.99	6.00
2025	1.00	6.20

Source: Heifetz Study

7.1.6 Projected Emissions from the Industrial Processes Sector

Emissions from the industrial processes sector include emissions from chemical or physical transformation of various materials in the manufacturing industry.

GHG emissions by process are detailed in Table 7.11.

The Heifetz study related only to emissions of direct GHGs. The following section reviews the foreseen developments in this sector and the projected emissions.

- **Cement** – Cement production is the second largest source of CO_2 emissions after fuel combustion. CO_2 is emitted in the production of clinker, an intermediate product of the cement production process. Currently there is only one producer of cement, which uses "dry", "semi-dry" and "wet" production lines. The producer plans to increase the number of production lines and, therefore, emissions are predicted to

Table 7.11 *GHG emissions from industrial processes*

Direct GHG	Industrial Processes
CO_2	Cement production Lime production Use of soda ash
N_2O	Production of nitric acid
CH_4	Ethylene production
Indirect GHG	
NO_x	Production of nitric acid
SO_2	Production of cement and sulphuric acid
NMVOC	Road pavement, production of glass and other chemicals

grow. The following table presents a forecast of CO_2 emissions from clinker production for the years 2006-2025.

Table 7.12 *CO_2 emissions from clinker production*

Year	CO_2 (1000 tons)
2006-2010	2,265
2011-2019	3,043
2020-2025	3,550

Source: Heifetz Study

Lime – Lime is used in the construction industry and in various manufacturing industries. It is produced in rotary kilns in the process of heating the limestone to high temperatures, which releases CO_2. Lime production emitted about 134 thousand tons of CO_2 in 2003 and 158 thousand tons in 2007 - an annual growth rate of 4.2%. This rate was assumed for the rest of the study period.

Soda Ash – Soda ash is used in various industries, such as glass, soap, paper and water purification. In 2000, 17 thousand tons of CO_2 were emitted from this source. Since new data were not available, emissions were set at this level for the rest of the study period.

Nitric Acid - The production process of nitric acid emits N_2O as a byproduct. Nitric acid is produced in five production lines in Israel, already registered as CDM projects. Therefore, mitigation due to these projects is not considered in the study. The N_2O emissions from this source amounted to 2.4 thousand tons in 2006 and are predicted to grow to 2.5 thousand tons by 2025.

Ethylene – Ethylene is produced in the chemical industry in a process that emits CH_4. Ethylene production is a minor source of CH_4 emissions in Israel. In 2008 emissions stood at 0.2 thousand tons and are predicted to remain at this level for the rest of the study period.

7.1.7 Forecast for Emissions from the Agriculture Sector

The agriculture sector emits CH_4 and N_2O. The study included the following emission sources: domestic livestock - enteric fermentation, manure management and agricultural soils.

7.1.7.1 Domestic livestock - enteric fermentation and manure management

Methane is produced in the digestion process of livestock, mostly during enteric fermentation of ruminants. The quantity of methane emission depends on the animal species, sex, age, weight and quality of consumed food. Part of the organic nitrogen in the manure undergoes nitrification and denitrification processes, which release N_2O into the atmosphere.

An average methane emission factor was calculated according to IPCC guidelines based on the number of milking cows, other cattle, sheep, goats, camels, horses, donkeys, swine and poultry in 2006.

The estimate for N_2O emissions relates only to storage and manure management processes. Due to lack of data, N_2O emissions were calculated according to an average ratio of N_2O/ CH_4 emissions during five milestones of the study period.

A forecast regarding the number of animals was constructed according to the 2007 inventory.

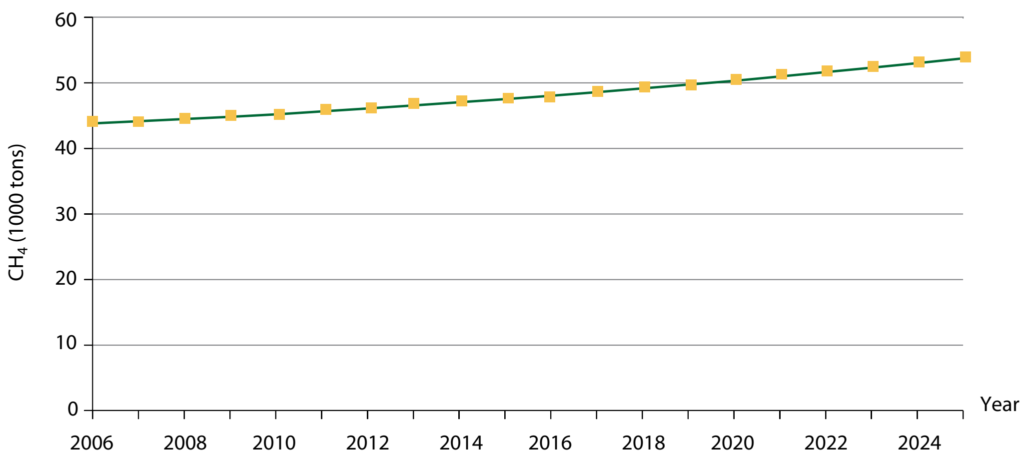
The projected CH_4 and N_2O emissions from enteric fermentation and manure management are presented in Figures 7.8 and 7.9.

Table 7.13 *Projected evolution of livestock (1000)*

	1990	2000	2006	2010	2015	2020	2025
Cattle	332	364	398	422	455	490	528
Poultry	23,930	32,318	41,135	46,545	56,908	69,580	85,072
Sheep and Goats	490	442	532	602	702	820	957
Swine	-	13	20	27	37	51	70

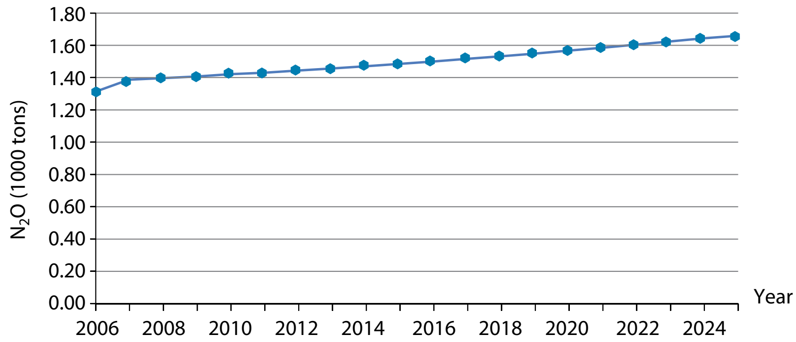
Source: Heifetz Study

Figure 7.8 *Projected CH_4 emissions from enteric fermentation*



Source: Heifetz Study

Figure 7.9 *Projected N_2O emissions from manure management*



Source: Heifetz Study

In conclusion, as can be seen from the figures, CH_4 is projected to grow by 23% and N_2O by 29% during the study period. The relatively moderate increase in emissions is due to the projected gradual increase in the number of livestock animals in that period.

7.1.7.2 Agricultural Soils

Nitrification and denitrification processes are responsible for N_2O emissions from soil. Crop fertilization causes an increase in N_2O emissions from soils. Since data were not available for this source, emissions were assumed to be constant for the study period.

7.1.8 Projected Emissions from the Waste Management Sector

The waste sector includes CH_4 and N_2O emissions from domestic and industrial wastewater treatment and emissions of CH_4 from municipal waste landfilling. CH_4 is produced from the decomposition of organic matter in both wastewater and landfilled solid waste. N_2O is produced, mainly in domestic wastewater, during nitrification and denitrification of nitrogen, which originates from protein consumed by humans.

7.1.8.1 Calculation methodology for GHG emissions in the waste sector

The calculations of emissions in the waste sector were performed according to the IPCC methodology. Emissions of N_2O from domestic wastewater treatment were based on the predicted population size for the reviewed period and the current average protein consumption per capita (42 kg), which was assumed to be constant for the entire study period.

Methane emissions from domestic and industrial wastewater in 2006 were calculated according to the IPCC guidelines and were adjusted for the rest of the study period according to the foreseen population and industrial growth rates, respectively. Methane emissions from municipal waste landfilling assumed a constant ratio of dissolved organic carbon and used the estimates of the MoEP and other sources to produce a forecast on solid waste generation and treatment for the study period. It should be noted that collection of methane in landfills and emissions from abandoned landfills were not taken into consideration in the calculation.

Table 7.14 *Projected evolution of solid municipal waste*

	2006	2010	2015	2020	2025	Average Annual Change (%)
Generated waste (million tons)	4.7	5.5	6.6	8.1	9.8	4.0
Landfilled waste (million tons)	3.6	4.1	4.3	4.4	4.9	2.1
% of controlled landfilling	77	75	65	55	50	-2.8

Source: Heifetz Study

Figure 7.10 *Projected CH_4 emissions from landfilling of solid municipal waste*

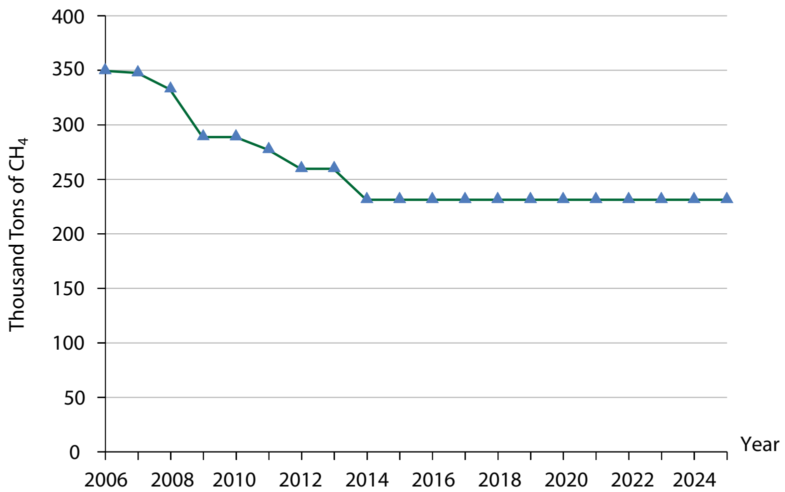


Figure 7.11 *Projected CH_4 emissions from the treatment of domestic and industrial wastewater*

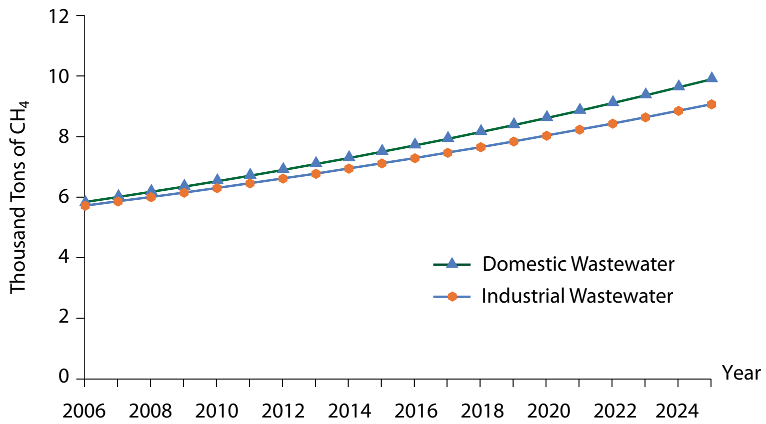
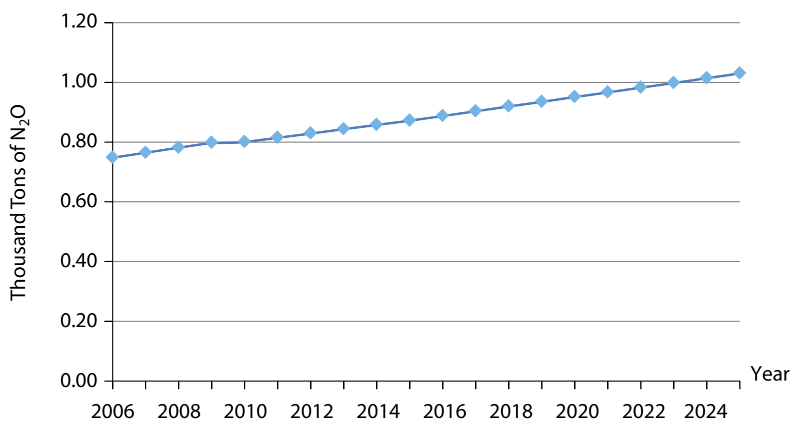


Figure 7.12 *Projected N_2O emissions from the treatment of domestic wastewater*



Source for graphs: Heifetz Study

Figure 7.10 presents the forecast for CH_4 emissions from municipal waste landfilling. Methane emissions from domestic and industrial wastewater are displayed in Figure 7.11. The projected N_2O emissions from the treatment of domestic wastewater are presented in Figure 7.12.

According to the forecast, N_2O emissions are predicted to grow at a rate of 38% from 2006 to 2025.

The data show that CH_4 emissions from wastewater treatment are expected to grow at rates of 69% for domestic wastewater and 58% for industrial wastewater between 2006 and 2025.

7.1.9 Projected Emissions from Land Use and Forestry

The land use and forestry sector relates to emissions and removals of CO_2 from natural sources. The biological activity in plants causes CO_2 emissions, on the one hand, and removals on the other hand. The rate of emissions and removals is dependent on the vegetation type: conifers, broad-leaved trees, shrubs, etc. The methodology for calculating the balance between emissions and removals from forests is based on the IPCC guidelines. An average annual growth rate of forest area (1%) was assumed based on information received from the KKL-JNF. The following table presents the projected evolution of forest area from 1990 to 2000.

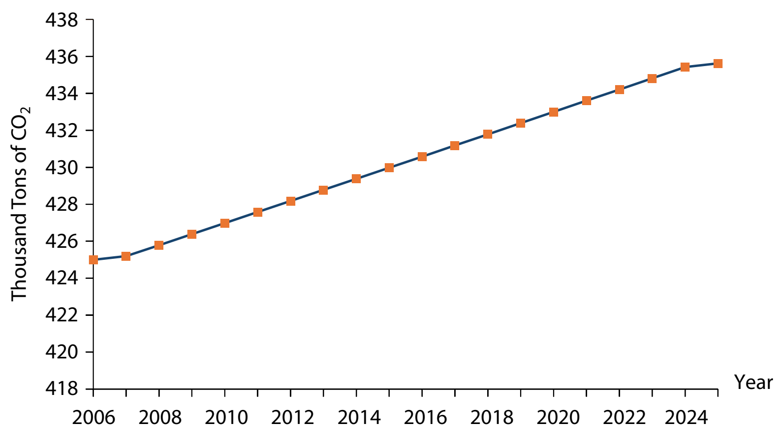
The net removals of CO_2 by forests are presented in Figure 7.13. The total removals in 2025 are estimated at 436 thousand tons.

Table 7.15 *Evolution of forest area in Israel (1000 dunams)*

	1990	2000	2004	2005	2006	% change from 1990	% change from 2000
Forested Area	756	856	852	853	849	0.7	-0.3

Source: Heifetz Study

Figure 7.13 *CO_2 removals by forests*



Source: Heifetz Study

7.1.10 Summary of the BAU Scenario

The previous sections presented the forecast for the relevant trends in the five different sectors and the derived emissions under the BAU scenario. The following table summarizes the foreseen emissions from all sectors until the year 2025.

From the table it can be seen that without any mitigation action, GHG emissions are predicted to grow by 63% until 2025 relative to the year 2000, whereas, emissions per capita are expected to grow by 11% in the same period.

Figure 7.14 presents the emissions by gas type. From 2006 to 2025, CO_2 emissions continue to grow (66%) and dominate the GHG emissions. Simultaneously, N_2O emissions are expected to grow by 13% and CH_4 emissions are expected to decrease by 24%, whereas both their shares of the total emissions remain minor.

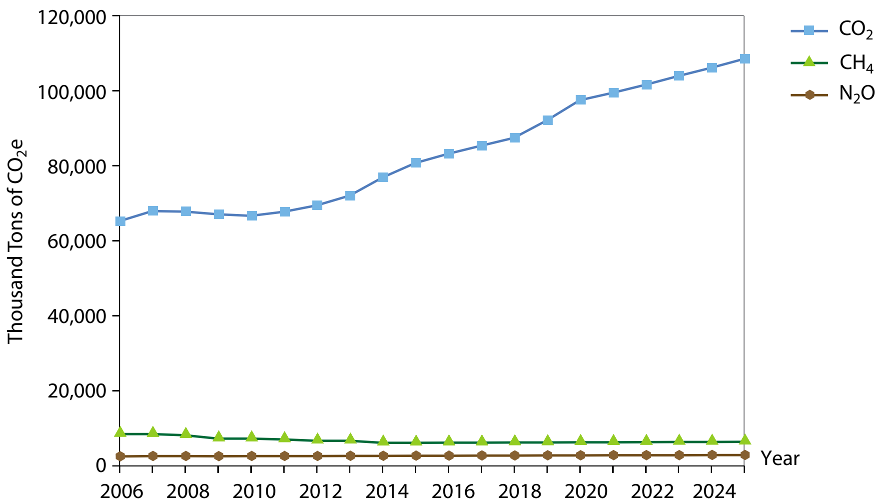
Figures 7.15-7.17 present the distribution of emissions by sector for CO_2, CH_4 and N_2O for the years 2006 and 2025.

Table 7.16 *Summary of CO_2-eq emissions from all sectors*

	2000	2006	2010	2015	2020	2025
Total emissions CO_2-eq (1000 tons)	72,436	76,499	76,824	89,868	106,870	118,003
Emission index (2000=100)	100	105	106	124	148	163
Population (1000)	6,366	7,117	7,542	8,115	8,688	9,262
Emissions per capita	11.4	10.7	10.2	11.1	12.3	12.7

Source: Heifetz Study

Figure 7.14 *GHG emissions by gas*



Source: Heifetz Study

Figure 7.15 *Total CO_2 emissions by sector*

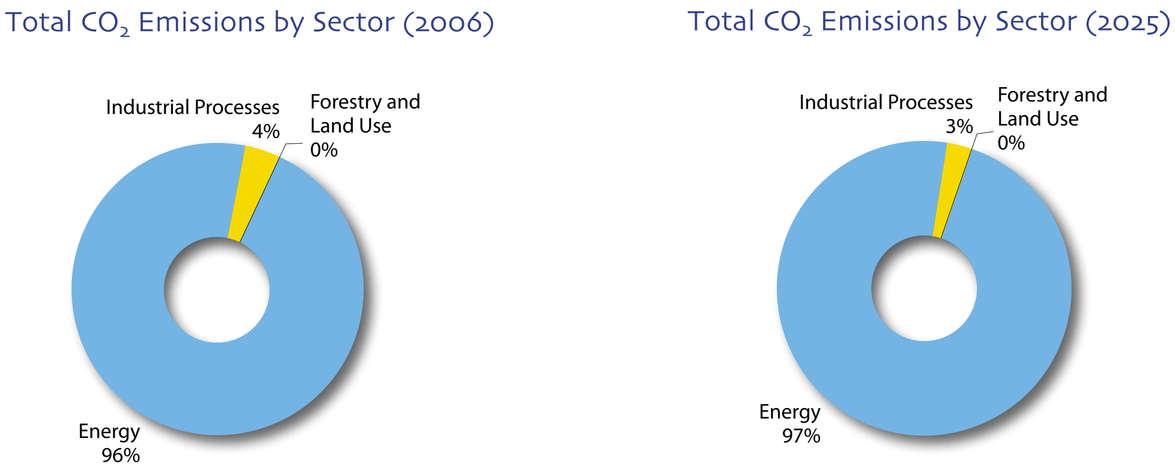


Figure 7.16 *Total CH_4 emissions by sector*

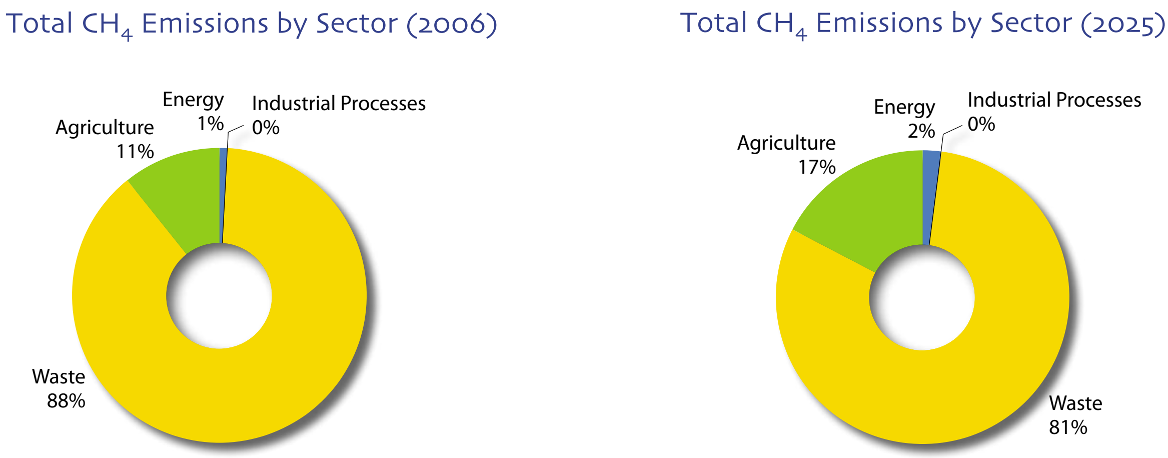
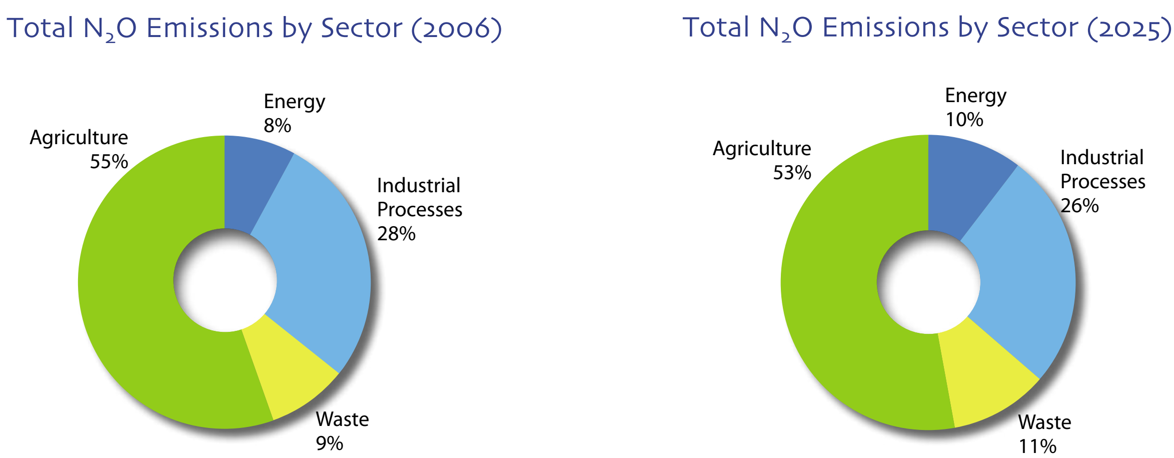


Figure 7.17 *Total N_2O emissions by sector*



Source for graphs: Heifetz Study

From the series of figures it can be seen that in general, no major changes are expected in the distribution of emissions by sector between 2006 and 2025. Nevertheless, the share of the agriculture sector in methane emissions is expected to slightly increase at the expense of the waste sector.

7.1.11 Mitigation Options

7.1.11.1 Renewable energy

At the end of 2005, total electricity capacity stood at 10,010 MW, of which only 15 MW (0.15%) originated from renewable energy (wind and solar). The following section presents the potential for renewable energy in Israel regarding wind and solar energy.

Wind Turbines

Current estimates regarding Israel's wind energy capacity are in the range of 200 - 600 MW. Only one wind farm, built in 1993 in the Golan Heights, currently operates in Israel, with 6MW capacity and with only 8 out of its10 turbines active. This wind farm has passed its planned lifetime and uses relatively old technology with lower efficiency than most modern technology in the field.

Assumptions for a cost benefit analysis:

- Cost of kWh - $0.1
- Efficiency relative to coal – 25%
- Lifetime – 25 years

Solar Energy

Israel is the one of the most advanced countries in developing and utilizing solar energy. About 4% of the country's energy demand is met by solar water heaters, whereas all new residential buildings are required since 1976 to install solar water-heating systems. Solar energy is divided into thermal solar and photovoltaic technologies.

Thermal solar technology

This technology is based on solar receptors that capture solar energy and transfer it into thermal energy (heat). Israel recently published a bid for establishing two solar power plants in the Negev desert (Ashalim) with a capacity of 250 MW at a cost of $650 million. These power plants will use solar tower technology that includes a solar field with mirrors that concentrate the solar energy towards a solar thermal heater on the top of a power tower. Two working instances of this technology are in operation in Israel – at the Weizmann Institute and in a pilot in Dimona.

Assumptions for a cost benefit analysis:

- Cost of kWh - $0.2
- Efficiency relative to coal – 25%
- Lifetime – 25 years

Table 7.17 *Cost / benefit ratio – wind energy*

Potential (MW)	Net cost NIS (millions)	Savings of CO_2 eq. (million tons)	NIS cost per saved ton of CO_2 eq
1,000	2,292	46	50

Source: Heifetz Study

Table 7.18 *Cost / benefit ratio – thermal solar energy*

Potential (MW)	Net cost NIS (millions)	Savings of CO_2 eq. (million tons)	NIS cost per saved ton of CO_2 eq
2,000	20,625	91	226

Source: Heifetz Study

Photovoltaic technology

Photovoltaic technology transfers solar energy (light) directly into electric energy. This technology is considered more expensive than the thermal solar energy and uses silicon chips, which are produced by a limited number of countries. Two applications are currently in use in Israel:

- Solar farms
- Solar roofs

Solar farms

The MNI issued a bid for the establishment of a solar farm with a capacity of 15 MW and an extension option of an additional 15 MW. The project is evaluated at $70 million.

Assumptions for a cost benefit analysis:

- Cost of kWh - $0.3
- Efficiency relative to coal – 30%
- Lifetime – 25 years

Solar roofs

The installation of solar panels on roofs is mostly the responsibility of the public and therefore the analysis focused on the potential implementation of this technology by the public. The generated electricity from small-scale solar panels is not used in Israel for self consumption by households but is sold to the government via the IEC at a subsidized rate, so that an economic analysis must relate to the investment in solar panels and the derived income from the investment. An analysis by the Ziegelman Institute revealed that the expected payback period for this technology is 15 years with an average return rate of 2-3% per year, a return rate which is currently not attractive for private consumers. Although some private companies achieve better efficiency and higher rates of returns, this technology is not currently economically feasible for the economy as a whole.

Table 7.19 *Cost / benefit ratio – photovoltaic energy*

Potential (MW)	Net cost NIS (millions)	Savings of CO_2 eq. (million tons)	NIS cost per a saved ton of CO_2 eq
500	11,000	27	403

Table 7.20 *Cost / benefit ratio – energy-conscious building design*

Savings			NIS cost per saved ton of CO_2 eq
kWh (millions)	NIS (millions)	CO_2 eq. (million tons)	
10,462	2,092	9	(236)

Table 7.21 *Cost / benefit ratio – efficient lighting*

Saving potential (millions kWh)	Net Cost NIS (millions)	Savings of CO_2 eq. (million tons)	NIS cost per saved ton of CO_2 eq
3,046	609	3	(236)

Source for tables: Heifetz Study

7.1.11.2 Efficiency[2]

GHG emission abatement can also be achieved via improvement in energy consumption efficiency and enhanced demand management. The following section reviews the main possible efficiency measures in Israel:

- Energy-efficient buildings
- Efficient lighting
- White (efficient) appliances
- Green roofs
- Energy demand management

Energy-conscious building

Energy-conscious building design attains energy savings by several means that are largely enforced by binding standards. They include:

- Insulation of ceilings, floors and walls
- Shading of windows
- Air flow optimization

Assumptions for a cost benefit analysis:

- Analysis is based on the American LEED standards which include some environmental components.
- Applications from a similar climate region, such as California, to Israel showed that LEED standards added 2% to the total construction cost, of which 0.7% were dedicated to energy saving.
- Minimal annual savings of 26 kWh per meter.
- By 2025, 483 million square meters are planned to be built in Israel.
- Average cost per square meter - NIS 3000.
- Application of building standards – starting from 2010 for new buildings only.

Efficient lighting

Most light fixtures in Israel use incandescent light bulbs which are much less efficient (1/7) and have a shorter life time (1/12.5) than PL bulbs. Although PL bulbs are very expensive, replacing the traditional bulbs by PL bulbs may still yield 80% saving.

Assumptions for a cost benefit analysis:

- Distribution of electricity consumption in Israel: 28% - residential sector, 28% - public and commercial sectors, 21% - manufacturing industry and 23% - other.
- 10% of the total electricity consumption in the residential, public and commercial and manufacturing sectors is for lighting purposes.

White appliances

In an effort to reduce inefficient use of energy by the public, Israel recently mandated the energy ranking of major domestic appliances, including refrigerators, air conditioners, dishwashers, washing machines, baking ovens and clothes dryers. Table 7.22 presents the potential electricity savings from replacing inefficient appliances by high-ranked efficient appliances.

Assumptions for a cost benefit analysis:

- The calculation is based on IEC rates and consumption hours.
- The supply of appliances is based on past CBS data.
- The distribution of appliances by energy ranking for air conditioners and refrigerators was determined by various empirical data sources. For other appliances a conservative approach was applied with an arbitrary distribution.
- A representative model and operating habits were used for the calculation.
- The rate of growth in appliance sales – 1.7% per year.

Standby losses

Standby losses relate to the consumption of appliances in a standby position. These appliances include, for example, television sets, air conditioners, microwaves, digital clocks, monitors, etc.

2 The cost / benefit analysis for the efficiency measures is not cumulative and relates only to the year 2025

Table 7.22 *Energy savings from purchases of white appliances*

Appliances	Purchases in 2008 (thousand)	Energy savings (%)
Dishwashers	70	18
Refrigerators	240	20
Clothes dryers	70	17
Washing machines	250	20
Air conditioners	70	4
Baking ovens	240	24
Total	**940**	**17**

Source: Heifetz Study

Table 7.23 *Cost / benefit ratio – white appliances*

Savings			NIS cost per saved ton of CO_2 eq
kWh (millions)	NIS (millions)	CO_2 eq. (million tons)	
7,041	1,408	6	(238)

Source: Heifetz Study

Assumptions for a cost benefit analysis:

- An average appliance consumes 44 kWh per year in this state.
- All current appliances will be replaced by standby-efficient appliances, which consume 8.8 kWh per year.
- Data for savings per capita (IEC and CBS data).

Green roofs

Roof gardens decrease the amount of required energy for cooling/heating the top floor in buildings by 30% versus flat roofs without any covering except for thermal insulation and sealing layer as required by building standards. Additional benefits of roof gardens include: absorption of CO_2 by vegetation, prevention of flooding and filtration of water pollutants.

Table 7.24 *Cost / benefit ratio – standby losses*

Savings			NIS cost per saved ton of CO_2 eq
kWh (millions)	NIS (millions)	CO_2 eq. (million tons)	
986	197	1	(236)

Source: Heifetz Study

Table 7.25 *Cost / benefit ratio – green roofs*

Savings			NIS cost per saved ton of CO_2 eq
kWh (millions)	NIS (millions)	CO2 eq. (million tons)	
1,523	284	1.3	0

Source: Heifetz Study

Table 7.26 *Cost / benefit ratio – reduction of electricity consumption*

Savings			NIS cost per saved ton of CO_2 eq
kWh (millions)	NIS (millions)	CO_2 eq. (million tons)	
5,915	(1,183)	5	(237)

Source: Heifetz Study

Assumptions for a cost benefit analysis:

- 3.2 million dwellings in Israel in 2025.
- The size of an average apartment is 100 square meters.
- The response for this measure will reach a maximum of 1% from 2014 to 2025.
- The maintenance cost is 10% of the original cost (between several dozen to several hundreds of NIS per square meter).

Reduction of electricity consumption

In addition to the above mentioned methods there are other ways to reduce electricity consumption. The most important is energy demand management via the generation of public awareness. It is assumed that by 2025 Israel will reduce 5% of its electricity consumption under the BAU scenario, as a result of a public campaign for energy saving.

Assumptions for a cost benefit analysis:

- The cost of the campaign will be 20% of the total savings of this method.

7.1.11.3 The Transport sector

In 2006, the transport sector was responsible for 19% of total GHG emissions in Israel. Under the BAU scenario, an annual growth of 2% is expected in this sector, leading to an emission of 20.8 million tons of CO_2 eq in 2025.

The mitigation measures in this sector include:

- Technological improvements
- Reduction of kilometers traveled
- Green vehicles
- Traffic management

Technological improvements

Technological improvements are designed to improve vehicles' efficiency and to reduce their GHG emissions. The MOT is updating the requirements for new imported vehicles, based on European and American standards. Technological improvements mostly focus on clean alternative energy. It is assumed that although technological improvements are foreseen in the long run, the derived reduction in gasoline and diesel oil consumption is not expected to be significant during the study period.

Reduction of mileage

Private vehicles make up 78% of the motorized vehicles in Israel. From 2000, the kilometers traveled by private vehicles have increased at an average annual rate of 2.9%, whereas in 2006 they reached 27,063 million kms. The BAU scenario estimates that they will grow to 47,820 by 2025. The current study considered several measures for mileage reduction:

- Standards and regulations - Reduction of parking spaces, parking limitations, regulation to reduce business travel, closing certain zones for private vehicles.
- Taxes and fees - Congestion fees, vehicle pollution tax, fuel tax, taxing of parking benefits for employees, taxing emissions from municipalities.
- Transportation demand management - organized transportation to workplaces, public education, and traffic-reduction policy.
- Public transport - Development of an efficient system of public transportation.

In order to significantly reduce mileage in the coming years, a mix of these measures is required. Accordingly, the researchers constructed a model that estimates the mitigation potential from reduction of private vehicle mileage.

Assumptions for the mileage model:

- The average number of passengers in a private vehicle and a bus is 1.4 and 40, respectively.
- A 15% rate of diversion from private vehicles to public transportation is assumed in 2025 (65% to buses and 35% to trains).
- 10,042 million passenger kilometers will be saved in 2025.
- The distribution of emissions by fuel type are presented in Table 7.27
- Based on the reviewed assumptions, the potential emission abatement is 1.1 million CO_2 eq in 2025.
- A minimal investment of NIS 4.3 billion in the bus fleet is required in order to accommodate the passengers diverted from private vehicles. As a result of the diversion, an increase in mileage of buses is expected in parallel to the decrease in mileage of private cars. Total savings will reach 9% relative to BAU.
- An additional saving of NIS 1.5 billion is expected from the decrease in the necessary investment in road infrastructure as a result of the mileage reduction.
- Other significant indirect costs and benefits, such as investments in train infrastructure and time saving for passengers, were not taken into consideration.

Table 7.27 *GHG emissions by vehicle type*

Vehicle Type	Grams CO_2 eq/ passenger km
Private car	158.6
Train	43.0
Bus	53.2

Source: Heifetz Study

Table 7.28 *Cost / benefit ratio – mileage reduction*

CO_2 eq abatement in 2025 (1000 tons)	1,094
Bus purchase offset by the reduction in infrastructure investments NIS (millions)	2,736
Cost benefit ratio (NIS/ ton emission)	351

Source: Heifetz Study

Green Vehicles

In 2008, Israel's government adopted a set of decisions to encourage the use of environmental friendly vehicles and fuels (i.e., "green vehicles"). These decisions mostly include economic tools that assist the penetration of these measures into the Israeli market.

Assumptions for the cost benefit analysis of green vehicles:

- Based on international and local research, the following table shows the GHG emission rates of green vehicles relative to gasoline vehicles with an internal combustion engine:

Table 7.29 *GHG emissions by private vehicle type*

Type of private vehicle	Emissions (%)
Gasoline	100
Hybrid	59
Electric	36
Natural gas	80

Source: Heifetz Study

- An average saving in emissions of 46% relative to gasoline vehicles was assumed.
- According to the BAU scenario, gasoline consumption in 2025 is expected to reach 3,089 thousand tons.
- Green vehicles will constitute 15% of the vehicle inventory in 2025.
- 1 ton of gasoline emits 3.074 tons of CO_2 eq.

Therefore, the estimate for the savings potential in GHG emissions in 2025, as a result of using green vehicles, totals 652.5 thousand tons.

Traffic management

A reduction in road traffic would enable more efficient use of fuels and would contribute to emissions abatement. The possible measures in this category may include:

- Systems for planning and management of road congestion
- Automation and placement of road signs
- Monitoring and control traffic systems

However, better traffic flow may also increase private car traffic and consequently cause an increase in overall GHG emissions from transport. Due to the unclear conclusion regarding this measure, it was excluded from the analysis.

7.1.11.4 Other measures

Many other measures were also considered in the study but were not included in the economic analysis:

- Nuclear energy
- Carbon capture and storage (CCS)
- Solar air conditioning
- Cogeneration
- Energy towers

The following section provides a brief review of these measures.

Nuclear energy

Nuclear energy is considered an efficient and inexpensive substitute for coal. However, due to the complex and controversial nature of this topic, it was decided not to include it in the current mitigation analysis.

The cost estimation of nuclear energy is very complex and includes several elements:

- Establishment cost - This cost is estimated at NIS 1.5 billion for a capacity of 1000 MW.
- Production cost - The cost of production depends on the varying prices of uranium.
- Operating cost - This is the major and most expensive cost of this technology. The highest cost component of operation is the removal of nuclear waste. Other substantial costs include employment and insurance costs.
- Lifetime - The lifetime of a nuclear plant ranges between 40 to 60 years. The cost of the nuclear plant depends on its lifetime and on the cost of its demolition at the end of lifetime. The demolition must be performed in a controlled manner and with great care and depends on many factors, such as location and size. Hence demolition is a very expensive process.

The current study examined examples from other countries and found that in most cases the cost of nuclear energy was equal to or less than the cost of coal energy. Table 7.30 presents the estimated cost benefit ratio for nuclear energy.

CCS

The CCS technology is aimed at the collection and burial of CO_2, emitted from electricity generation in coal power plants, in order to prevent its release into the atmosphere. This technology has several applications although its effectiveness and safety have not yet been fully tested. In addition, its application requires extensive land reserves

Table 7.30 *Cost / benefit ratio – nuclear energy*

Saving potential (millions kWh)	Net Cost NIS (millions)	Savings of CO_2 eq. (million tons)	NIS cost per saved ton of CO_2 eq
3,000	14,137	970	15

Source: Heifetz Study

and is probably very expensive. Therefore it was excluded from the analysis.

Solar air conditioning

It is estimated that air conditioning systems use 45% of the capacity of electricity generation in Israel, whereas in office buildings and shopping malls 65% and 60% of electricity consumption, respectively, are used for air conditioning purposes. The MNI initiated a pilot study for the installation and operation of a solar air conditioning system in the southern city of Elat.

Although solar air conditioning technology was developed in the 1970s, it has not advanced, mainly due to its high costs and space considerations. For example, an air conditioning system for an area of 800-1000 square meters requires 500 m^2 of roof space for solar receptors, at a cost of about $220,000. The MNI estimates the saving potential of this technology at 800 MW, but the current study could not find sufficient support for its cost benefit analysis and hence it was excluded from the overall calculation.

Cogeneration

Cogeneration, or combined heat and power, harnesses the unused heat in the generation process of electricity. The highest efficiency in the standard process stands at 55%, while the cogeneration process increases efficiency to 89%. Cogeneration technology depends on many factors, of which the main one is the availability of natural gas. The MNI estimated the cogeneration potential at 3000 MW, 15% of the installed capacity in 2025. This potential requires 5 BCM of natural gas, 30% of the planned quantity for 2025. The high uncertainty regarding the relevant variable costs and benefits for the Israeli economy and the availability of natural gas led to the decision not to include this technology in the analysis.

Energy towers

Energy towers are massive systems for the generation of artificial wind. Their application suits areas with warm and dry air, which they use for cooling along with a water sprinkling system. The cooled air moves down the tower and operates turbines, which generate electricity. The main advantages of this technology are:

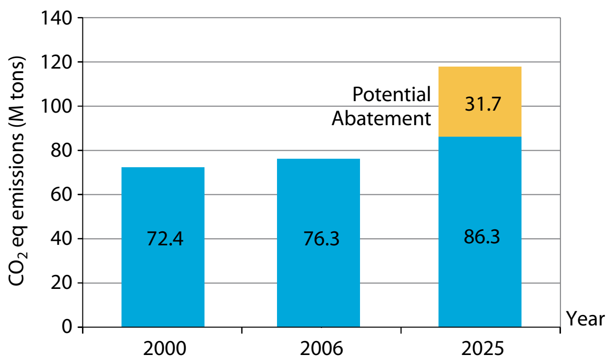
- There is no need for direct sunlight and therefore the towers are active 24 hours a day.
- The space required for these towers is 15 times smaller than a parallel solar power station.
- The cost is as low as the cost of a coal power station.
- The technology enables seawater desalination at half the standard cost.

Although its advantages are of high value, this technology was not fully tested yet and therefore was excluded from the analysis.

7.1.11.5 Summary

The following section summarizes the abatement potential of the examined measures in the energy (renewables and efficiency) and the transport sectors.

Figure 7.18 *Emissions of CO_2 eq and potential abatement*



Source: Heifetz Study

Table 7.31 *Summary of mitigation potential*

Mitigation Options	Savings potential of CO_2 eq. (million tons)	NIS cost per saved ton of CO_2 eq
Wind Energy	1.8	50
Solar energy	3.6	226
Energy-conscious building	8.9	(236)
Efficient lighting	2.6	(236)
Appliance efficiency	6.7	(238)
Green roofs	1.3	0
Reduction of electricity consumption (5%)	5.0	(237)
Reduction in mileage and fuel consumption (transport)	1.7	351
Total	**31.7**	

Source: Heifetz Study

Table 7.32 *Emissions per capita under BAU and mitigation scenarios*

	BAU CO_2 eq Emissions (tons)			Mitigation CO_2 eq Emissions (tons)
	2000	2006	2025	2025
Emissions per capita	11.4	10.7	12.7	9.3

Source: Heifetz Study

- As shown, in the year 2025, under the BAU scenario, total expected emissions reach 118 million tons of CO_2 eq, whereas potential abatement measures total 31.7 million tons.
- Emissions per capita are expected to grow from 11.4 tons in 2000 to 12.7 in 2025 (+11%) under BAU or decrease to 9.3 tons (-18%) under the mitigation scenario.
- Under BAU, a 63% increase in emissions is expected from 2000 to 2025. Applying the surveyed mitigation measures will drop the increase to 19% (27% less than expected emissions under BAU).

7.2 McKinsey Cost Curve for the Abatement of Greenhouse Gas Emissions in Israel

Following the results of the Heifetz report and as part of Israel's efforts to prepare for combating climate change, the MoEP commissioned McKinsey & Company to further assist in estimating the potential GHG abatement in Israel and evaluate the sectoral costs involved in realizing this potential. The report, published in November 2009, provides Israel's government and other stakeholders with a quantitative database to inform the debate around abatement targets and policy and facilitate international comparisons. Preparation of the report was accompanied by discussions, consultations and workshops with the participation of more than 100 experts and stakeholders from various fields and ministries. This part of the mitigation chapter presents the McKinsey report, highlighting the methodology and results of Israel's abatement cost curve and the abatement potential in the major sectors.

7.2.1 Methodology

McKinsey's methodology analyzes over 200 technical measures (levers) aimed at reducing GHG emissions across 10 sectors, with the results integrated into a single cost curve. The cost of implementing these levers is calculated using McKinsey's globally recognized methodology, adjusted to take account of the specific characteristics of the Israeli economy. The abatement cost curve quantifies Israel's abatement potential in ten sectors and its associated costs.

The evaluation includes three principal stages (Figure 7.19):

1. Evaluation of the quantity of GHG emissions expected up to 2030, based on existing programs and expected regulation, without the implementation of new GHG abatement programs. This evaluation is known as the "Business as Usual" (BAU) emission scenario and constitutes the reference basis for present and future emission abatement.

2. Identification of a range of technical levers for GHG emission abatement. For each lever, the GHG abatement potential and the costs of implementation are examined.

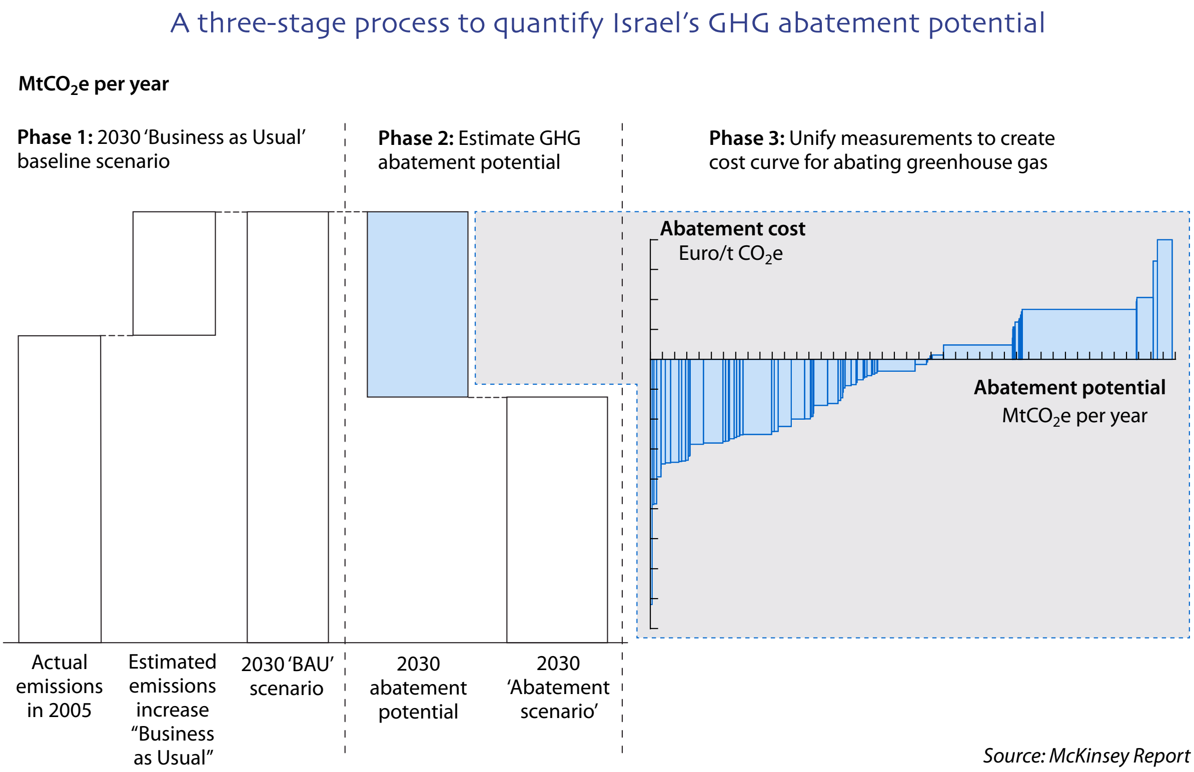
3. Integration of all of the levers in order to create the GHG abatement cost curve for Israel. This curve clearly presents the potential for GHG abatement in Israel's economy and the costs which accompany that abatement, thus enabling a broad overview, at the level of the individual sector and that of the entire economy.

7.2.1.1 Construction of the business-as-usual emissions scenario

The BAU scenario reflects the likely growth of GHG emissions in Israel from 2010 to 2030, taking into account government policy and regulations as of 2009. This scenario serves as a baseline for comparing other reviewed abatement scenarios.

For the purpose of the BAU scenario, Israel's economy was grouped into ten sectors: electric

Figure 7.19 *The process of quantifying Israel's GHG abatement potential*



Source: McKinsey Report

power; buildings (subdivided into residential and commercial); transport; chemicals; cement; petroleum and gas; other industries; waste; agriculture; and forestry. The likely emissions from each sector were calculated taking into account fuel consumption, electricity consumption, and process-related emissions (such as emissions from chemical processes). The likely growth in emissions between 2005 and 2030 was factored in, taking into account forecasted economic changes (GDP growth, population growth, new technologies, etc.); operational changes (such as the development of the gas industry); and the more efficient use of energy.

7.2.1.2 Subsequent analysis of the technical abatement levers

The levers appropriate to Israel's economy were first identified, followed by an analysis of their abatement potential and cost of implementation. The levers reviewed included power generation technologies that use renewable energy; alternative fuels; and energy efficiency levers - for example, levers that improve insulation in buildings or reduce electric power consumption. The majority of levers analyzed used commercially-proven technologies. Only a few, newer technologies in the final stages of development were included, whereas, technologies in the early stages of development were excluded.

The analysis focused on abatement levers that were expected to cost less than €100 /tCO_2eq in 2030.

7.2.1.3 Analysis of abatement potential and costs

The abatement potential of each of the levers was calculated as the total emissions that would be prevented through the use of the lever over the course of one year. For example, the abatement potential of switching to energy-saving light bulbs - compact fluorescent lamps (CFLs) - was calculated as the difference between the total emissions from CFLs and incandescent light bulbs over a year.

The cost of implementation of each of the levers was also calculated in relation to BAU practices. The annual cost of each lever is the cost of the initial investment or capital expenses (including financing costs, and capitalized over the life span of the lever at an annual interest rate of 4%), plus the annual current operating expenses, less the annual savings captured by using the lever. For example, the cost of using energy-saving bulbs was calculated as the annual added cost of purchasing the bulbs compared with using incandescent bulbs, less the annual savings gained from using less electricity.

The overall abatement cost is defined as the cost (in Euros) required for the abatement of one ton of GHGs. The abatement cost of a lever is therefore the implementation cost divided by the GHG emissions prevented by the use of the lever (€/tCO_2eq).

It is important to note that the abatement costs are calculated as costs to society as a whole and remain constant whether they are subsidized by the government, transferred to the consumer, or borne by industry. In addition, the abatement costs represent only direct costs. In other words, they include most of the costs related to the implementation of the levers, but do not include any indirect, additional costs and/or benefits.

7.2.1.4 Integration of the levers into the abatement cost curve

The cost curve takes account of the abatement impact each lever has on the entire economy. For example, it takes account of the impact electric vehicles (EVs) will have on power supply. This provides an integrated view of Israel's abatement potential and the overall direct cost of capturing that potential.

The order in which the levers are implemented can impact the abatement potential. For example, levers which reduce demand for electricity also reduce the amount of power generated, which in turn reduces the abatement potential in the power industry that would otherwise result from changing the fuel blend (i.e., by using more renewable energy).

Abatements are allocated to the industry that implements the lever. For example, the switch to energy-saving light bulbs saves emissions from electric power generation. However, the abatement is allocated to the buildings sector where the bulbs are used, not the power sector.

For the purpose of the analysis, certain assumptions were made about factors such as future electricity costs, fuel costs, technology costs, and learning curves. Where necessary, insights gained from other countries were adapted for Israel. Data unique to Israel's economy were also factored in.

The abatement potential of behavioral change is not included in the cost curve, but analyzed separately. This is because behavioral change is hard to predict, and the associated abatement potential and cost are hard to quantify. For example, it is difficult to attribute a direct cost to the economy of turning down the air conditioning in shops, as it is difficult to predict the extent to which this might deter people from shopping.

7.2.2 Main Findings

With the current growth trajectory (BAU), Israel is expected to double its GHG emissions between 2005 and 2030

As presented in Figure 7.20, in the absence of mitigating action, Israel's GHG emissions are expected to double from 71 $MtCO_2eq$ in 2005 to 142 $MtCO_2eq$ in 2030. This growth is higher than other developed countries, primarily due to Israel's relatively high growth in population and GDP per capita. In per capita terms, this represents a growth in emissions from 10.2 tons per capita in 2005 to approximately 14.3 tons in 2030. For comparison, under a BAU scenario, 2030 emissions per capita would be 23 tCO_2eq in the United States, 10.7 tCO_2eq in Western Europe, and 11.3 tCO_2eq in China.

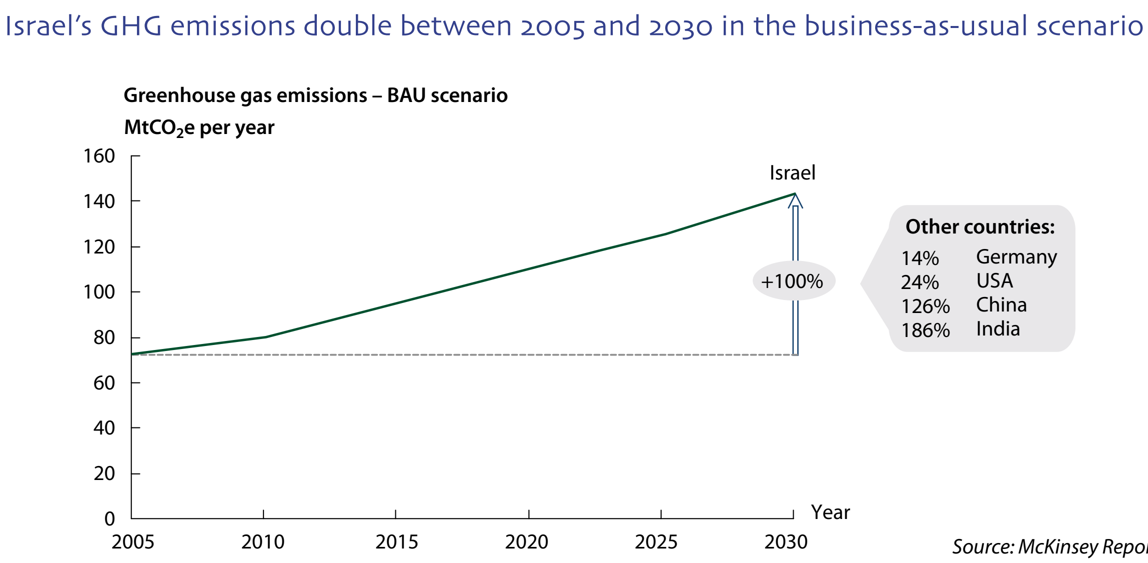
Israel could reduce its expected emissions growth by two-thirds through adopting the technical abatement measures identified in the study

The analysis suggests an abatement potential of 45 $MtCO_2eq$ if all the examined technical abatement levers would be applied. This corresponds to approximately two-thirds of the expected GHG emissions growth between 2005 and 2030 and approximately one-third of total BAU emissions expected in 2030. Technical abatement levers are defined as measures that do not lead to significant changes in lifestyle or standards of living.

A set of behavioral changes could achieve further abatement of approximately 7 $MtCO_2eq$

Whereas the abatement cost curve has to do with technical levers for emission reduction, there is an additional emission abatement potential which can be achieved by behavioral changes. Unlike technical changes, behavioral changes are likely to result in lifestyle changes – for example, switching from a vehicle with an internal combustion engine

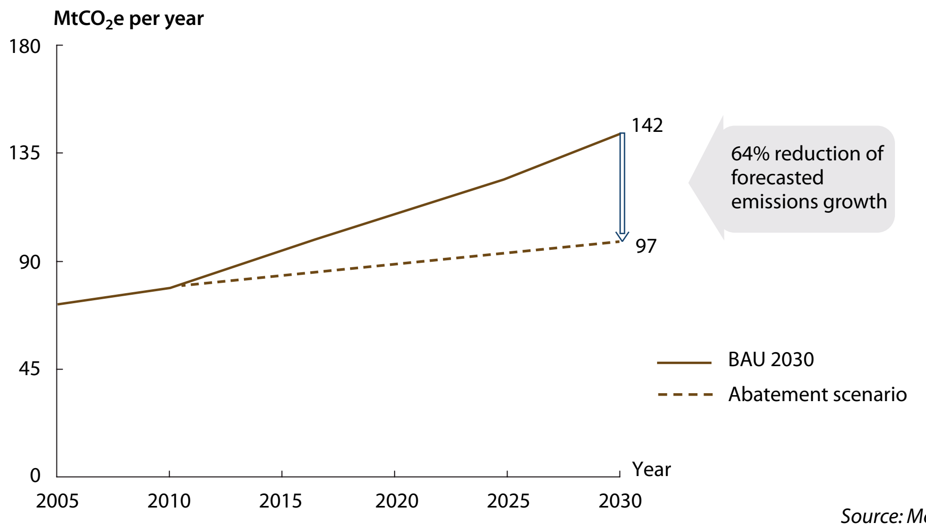
Figure 7.20 *GHG emissions BAU scenario (2005-2030)*



Source: McKinsey Report

Figure 7.21 *GHG emissions abatement scenario (2005-2030)*

The abatement scenario reduces expected emissions by two-thirds

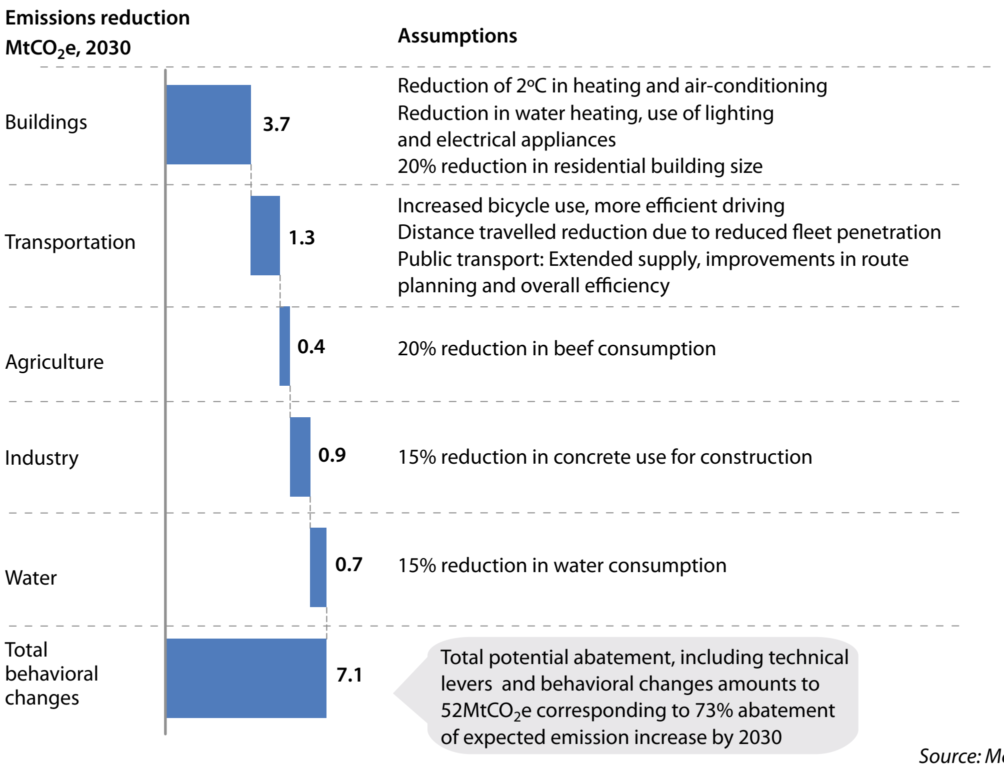


Source: McKinsey Report

to a bicycle or adopting energy-saving patterns of driving.

Based on the feedback of expert panels, a specific set of behavioral changes was modeled, which in an optimistic case could enable further abatement of approximately 7 $MtCO_2eq$ in 2030. Examples of the selected behavioral changes include reduced use of lighting, increased use of public transport, increased use of bicycles, increased average building temperature, and reduced meat consumption. The abatement potential from behavioral change is not included in the cost curve but analyzed separately (Figure 7.22).

Figure 7.22 *Effects of behavioral changes on GHG emissions*



Source: McKinsey Report

Most of the abatement measures fall into two categories – low carbon energy sources and improved energy efficiency

Examples of levers to reduce emissions from the use of energy include shifting from fossil fuels to renewable energy for power generation (25% of total generation in 2030); shifting from coal to gas in power generation (36% of total generation in 2030); and shifting from fossil fuels to biofuels in the transport sector. Examples of levers to improve energy efficiency include using energy-efficient light bulbs, improving vehicle fuel consumption, and using more efficient electrical appliances (air conditioners, refrigerators, etc.).

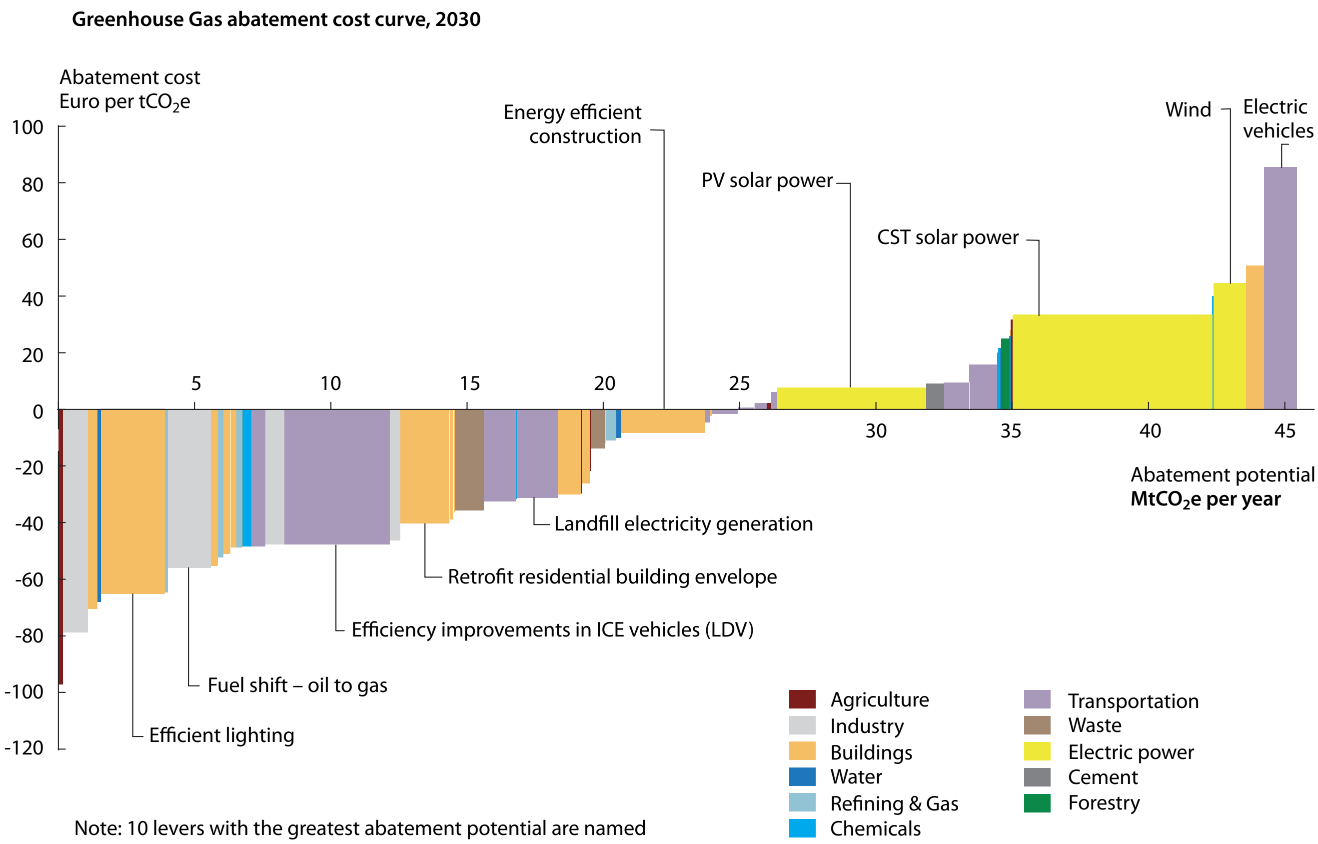
Some 8% of the abatement potential does not fall into these two categories. This potential is primarily related to waste treatment and agriculture.

Three broad measures account for most of the abatement potential:

1. **Higher energy efficiency in the buildings sector** - higher energy efficiency means lower electricity consumption (and, to a lesser degree, lower fuel consumption) in residential and commercial buildings. Sectoral analysis shows that it is possible to reduce electricity consumption by some 24% by 2030 in the buildings sector relative to the BAU scenario through a combination of low-energy lighting, energy-efficient white appliances, and improved insulation.

2. **The use of renewable energy for power generation** - Israel's electric power industry relies almost exclusively on fossil fuels, and particularly coal. Production of 1 kWh of power from fossil fuels emits 660 gCO_2 in 2010 and 720 gCO_2 in 2030. Sectoral analysis shows that by 2030, 25%

Figure 7.23 *Israel GHG abatement cost curve (2030)*



Source: McKinsey Report

of Israel's electricity could be generated from renewables - that is, wind energy, photovoltaic (PV) energy, and concentrated solar thermal energy. GHG emissions per 1 kWh would then fall by 26% to approximately 500 gCO_2 in 2030.

3. **Vehicle emission abatement** - Improved internal combustion engines (ICEs), hybrid vehicles, and EVs are likely to reduce fuel consumption by 2030 and hence GHG emissions from vehicles. (The abatement potential of EVs depends on the fuel mix used in electric power generation.) By adding alternative fuels, there is a potential to cut GHG emissions in the transport sector by approximately 38%.

Implementing 10 measures with the greatest abatement potential would capture 65% of the total abatement potential

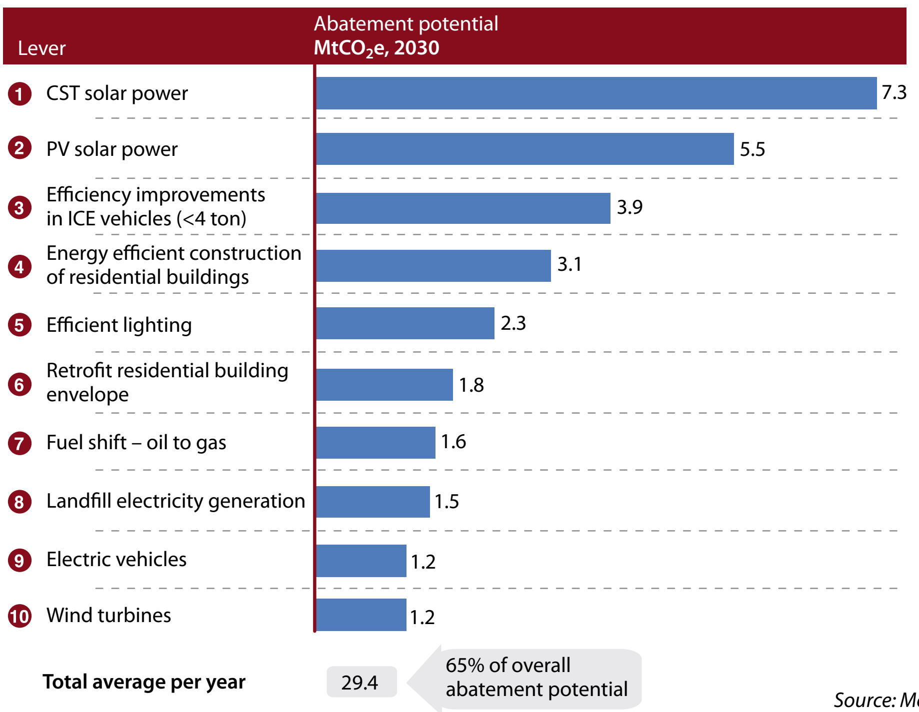
Implementing the ten measures with the largest abatement potential captures 65% of the total abatement potential in 2030. These measures include a change in the fuel mix, increased energy efficiency, and more energy-efficient vehicles. Total abatement from the ten major levers is approximately 30 $MtCO_2eq$ in 2030. The average annual investments required to implement these measures are approximately NIS 1 billion between 2011 and 2030. These investments are returned in their entirety in the form of energy savings.

These 10 levers are:

1. High penetration of concentrated solar thermal power generation.
2. High penetration of solar photovoltaic power generation.
3. Improved fuel efficiency of internal combustion engine vehicles.
4. Increased energy efficiency in new buildings as a result of improved planning and insulation.
5. Use of efficient lighting and lighting control systems.
6. Retrofit of residential buildings with improved insulation in order to improve heating and cooling efficiency.
7. Industry fuel transition - fuel oil to gas.
8. Use of landfill gas for electricity generation.

Figure 7.24 *The 10 principal abatement levers*

Ten levers capture 65% of the abatement potential



Source: McKinsey Report

9. Increased penetration of electric vehicles and plug-in hybrids (assuming low-carbon power fuel mix).

10. Use of wind turbines for power generation.

Israel's overall emission abatement potential is limited in comparison to other countries

The analysis indicates lower abatement potential in Israel (32%, compared to BAU) than in many other countries (average of around 50%). One of the reasons for this is the low feasibility of many abatement levers in Israel, including hydroelectric power, biomass, and carbon capture and storage. The feasibility of nuclear power in Israel is still unclear. Another limiting factor is the absence of a large, heavy manufacturing sector (petrochemicals, steels, metals and mining), in which significant abatement potential is usually found.

The total net cost to the economy of implementing all technical measures would be approximately zero in 2030

Many of the abatement measures examined are net profit positive to the economy, i.e., they are beneficial to the economy as a whole. Analysis of the abatement curve characteristics shows that approximately 60% of the levers, which account for more than 50% of the abatement potential, are net profit positive to Israel's economy. An example of a net profit positive lever is energy efficient lighting, for which the increased upfront cost of the light bulbs is more than compensated for by the savings in power consumption cost. Moreover, should all measures be implemented, savings from the net profit positive abatement measures would cancel out the costs of the others.

However, several implementation barriers need to be overcome for otherwise, it would be expected that net profit positive levers would already be pursued under a BAU scenario. The two main factors preventing the implementation of the net profit positive measures are the financing hurdles and rapid payback requirements. The upfront investment needed, particularly in the buildings and transport sectors, can be significant, and most consumers would like a return on their investment within two years. In addition, in many cases, the consumer or company reaping the benefit of lower energy bills is not the one making the upfront investment. Construction companies, for example, have limited incentives to insulate homes beyond the level required in building codes, since home owners and tenants will be the ones to enjoy lower energy costs.

Realizing Israel's abatement potential requires action

Realizing Israel's abatement potential would require changes in policy, regulation, industry conduct and public conduct.

The Israeli government could consider taking four key steps to realize the described potential:

1. Establish ambitious national GHG abatement goals as a government policy.

2. Formulate Israel's Low Carbon Growth Plan (LCGP) – a national abatement plan that defines the levers, the mechanism and the timing of implementation.

3. Translate the national abatement plan into detailed operational measures including measures to incentivize financing of the upfront investments.

4. Establish a central body to monitor progress in implementation and provide a database for making ongoing political and technical decisions.

Realizing the potential is possible, but imposes numerous challenges

Implementing the abatement measures will raise many different challenges, which can be divided into three principal types:

1. **Structural bottlenecks** - numerous barriers currently prevent the implementation of the abatement levers. For example, solar power plants require planning permission, but current planning and zoning processes could slow or even prevent the establishment of such plants.

2. **Agency costs** - the cost curve describes the cost of implementing the abatement levers to the economy as a whole. In many areas, however, agency costs are an issue. In other words, although the economy might benefit, the individual or organization that has to pay for the implementation might not. For example, insulating an office block

will benefit the economy, but represents an extra construction cost for the builder who will not reap the benefits of lower electricity bills enjoyed by the tenants. Overcoming these "market failures" is a major challenge.

3. **Capital** - implementing the abatement levers requires considerable investment - approximately €3.3 billion between 2011 and 2015. This rises to approximately €11 billion between 2026 and 2030. The increased investment over the years results from changes in the rate of assimilation of technologies and the decrease in costs over the years. Between 2011 and 2030, the investment represents about 1% of average GDP. The ability to reduce the cost of raising that capital will impact the extent to which the levers are implemented.

7.2.3 Analysis of the "Halfway" Situation – Emissions in Israel in 2020

In order for the analysis to provide a complete picture, the effect of the abatement scenario on Israel's emissions in 2020 was examined as well. Analysis of the BAU scenario shows that GHG emissions in Israel are expected to reach approximately 109 MtCO_2eq in 2020. This compares with 88 MtCO_2eq in 2020 in the emission abatement scenario, a reduction of some 20% (Figure 7.25).

Analysis of the costs accompanying the abatement scenario in 2020 and construction of the cost curve show that the average abatement cost in that year is negative and totals approximately €6 /tCO_2eq (Figure 7.26).

The ten main abatement levers cut emissions by approximately 8 MtCO_2eq in 2020 compared with the BAU scenario. This represents approximately 40% of the total abatement potential - a lower percentage than what could be achieved in 2030.

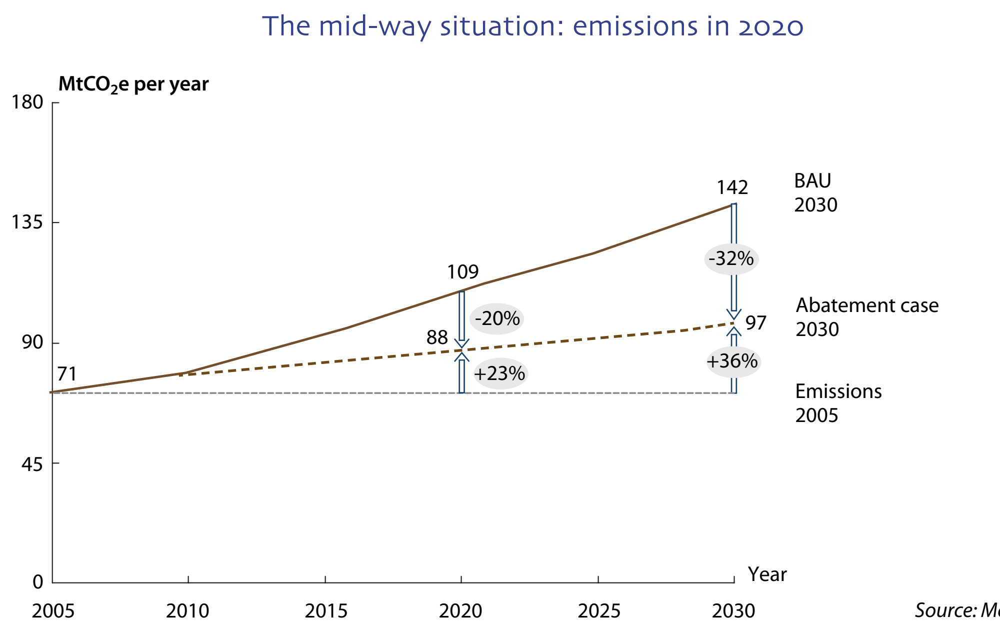
Reasons why the 2020 abatement cost curve differs from the 2030 curve:

1. Some measures cost more - some levers cost more in 2020 than in 2030 because they are still relatively immature and have not completed the learning curve which will help reduce the cost of the levers by 2030. The abatement cost of EVs, for example, exceeds €200 /tCO_2eq in 2020. By 2030, the cost falls to approximately €85 /tCO_2eq as a result of a sharp drop in the cost of EV batteries, followed by a reduction in the price of the EVs.

2. Commercialization - some levers will not be widely implemented in 2020 due to their high cost. PV power generation is a case in point.

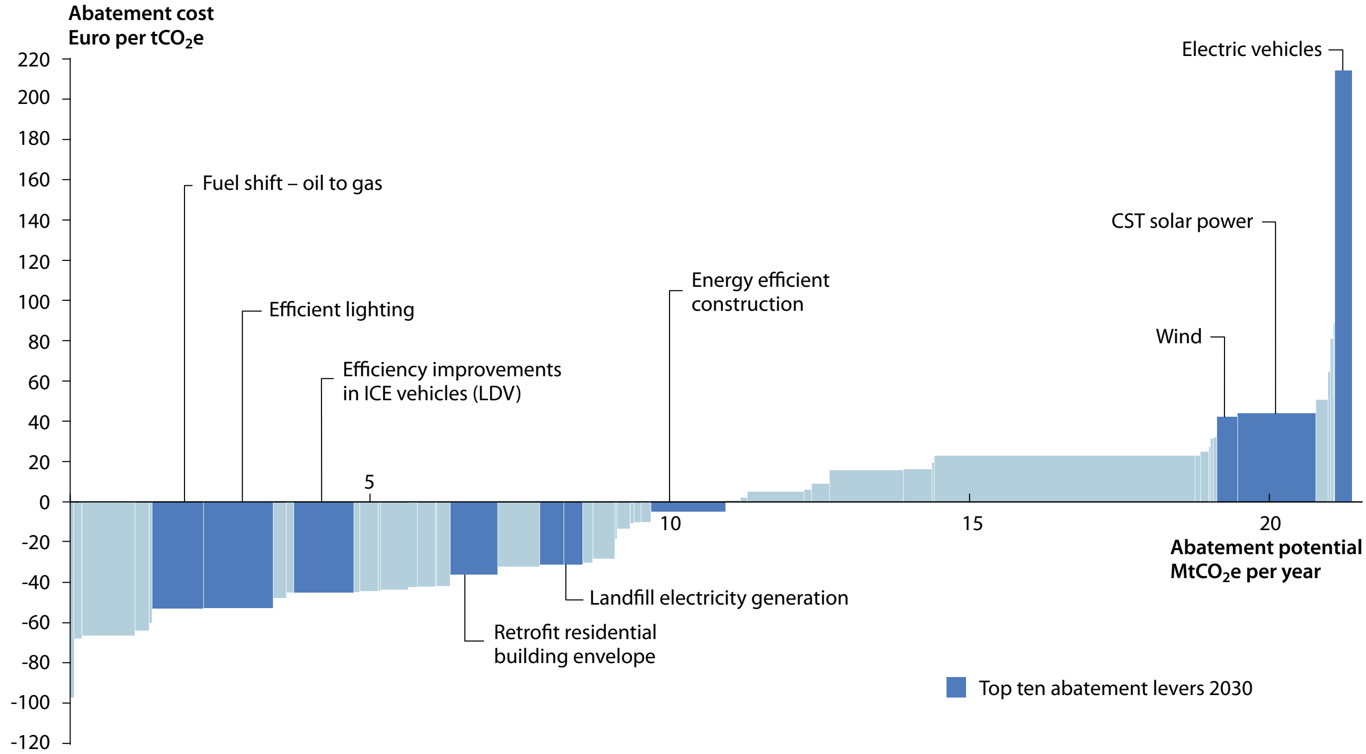
Due to these factors, the abatement potential in 2020 is 20% of the total emissions for that year, compared with 32% in 2030. The average cost of abatement in 2020 is higher too.

Figure 7.25 *GHG emissions abatement scenario (2005-2020)*



Source: McKinsey Report

Figure 7.26 *Israel GHG abatement cost curve (2020)*



Source: McKinsey Report

7.2.4 Abatement by Sector

7.2.4.1 Electricity generation

In the BAU scenario, emissions from the electric power sector rise by 94% between 2005 and 2030

In the BAU scenario, GHG emissions from the electric power sector rise from some 38 $MtCO_2eq$ in 2005 to 74 $MtCO_2eq$ in 2030, an increase of approximately 94% (Figure 7.27).

Emissions from the electric power sector fall by 14 $MtCO_2eq$ in 2030 in an abatement scenario that uses solar and wind power in the generation mix

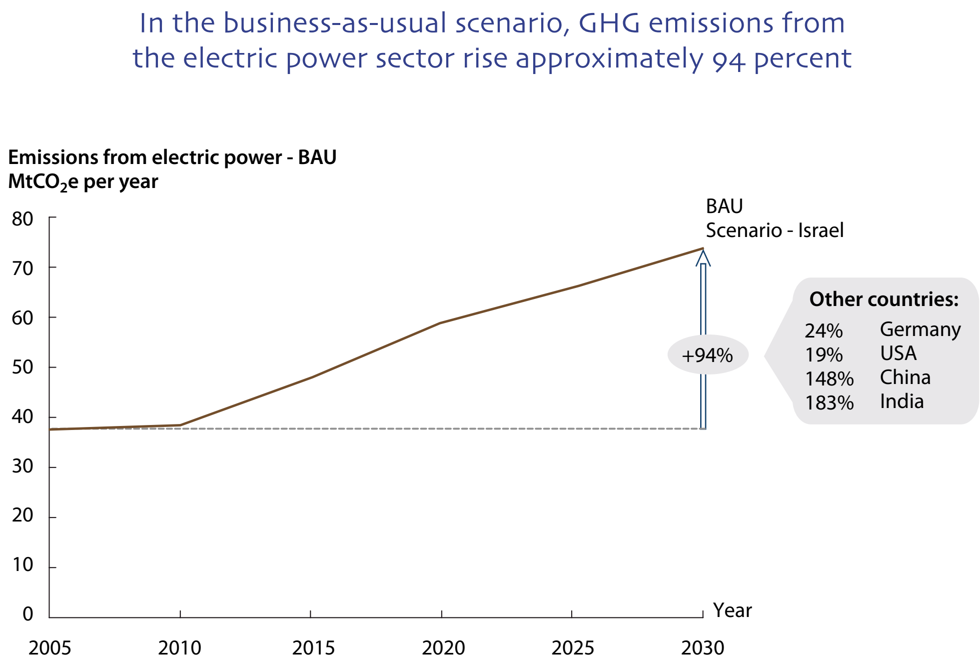
The analysis was performed in two stages. Initially, all levers for reducing demand for electric power were analyzed and summarized and a peak demand and supply forecast was built. Various scenarios to increase capacity were then constructed using different fuel mixes (i.e., different ratios of gas, coal, renewable energy, etc.). For each scenario, the effect on total emissions and generation costs was examined, as well as the possible barriers to implementation.

The emissions forecast for each of the scenarios is shown in Figure 7.28. Reducing demand for electric power, and assuming that 2.5 TWh will be met by cogeneration, lowers emissions from the electric power sector from approximately 73.5 $MtCO_2eq$ to approximately 59.5 $MtCO_2eq$, a fall of 14 $MtCO_2eq$. Changing the fuel mix in the various scenarios further reduces abatement by 2030 from between 4 $MtCO_2eq$ (in the "10% renewable energy plus coal" scenario) to more than 24 $MtCO_2eq$ (in the "nuclear energy plus 15% renewable energy" scenario).

Israel's emission abatement cost curve is based on the "25% production from renewable energy" scenario

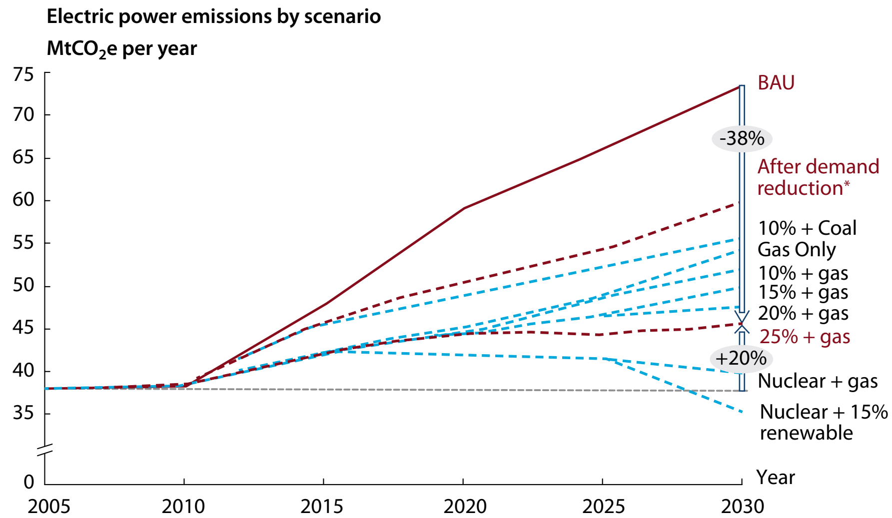
In deciding on a single scenario that represents the abatement potential in the electric power sector, the McKinsey study used an "ambitious, imple-

Figure 7.27 *GHG emissions from the electric power sector in the BAU scenario (2005-2030)*



Source: McKinsey Report

Figure 7.28 *GHG emissions from the electric power sector in various fuel-mix scenarios (2005-2030)*



* Including 2.5 TWh cogeneration production

Source: McKinsey Report

mentable" scenario – a scenario with the highest abatement potential that is technologically feasible and whose implementation is dependent on Israel alone. Based on these considerations, of the scenarios that include renewable energy, the 25% scenario has the greatest abatement potential, and is therefore the one to be integrated into the overall cost curve.

As mentioned earlier, the 25% renewable energy scenario reduces emissions by 14 $MtCO_2eq$. This, together with the reduction in demand, causes a 38% drop in emissions from the electric power sector in 2030 compared with the BAU scenario, and lowers total emissions growth in the sector to 20% compared with 2005 (as against 94% growth in the BAU scenario).

The average abatement cost of the electric power sector in 2030 is approximately €24/ tCO_2eq

Producing 25% of electric power from renewable sources requires the installation of some 4GW of PV, some 2GW of concentrated solar thermal (CST), and some 0.85GW of wind facilities., About one-half of the abatement (7.3 $MtCO_2eq$) results from electric power production by CST, at an abatement cost of €33 /tCO_2eq; PV contributes an abatement of some 5.5 $MtCO_2eq$ at a cost of €7.5 / ton; wind production contributes an abatement of some 1.2 $MtCO_2eq$ at a cost of some €45 /tCO_2eq. The total emission abatement potential from the electric power sector in 2030 is approximately 14 $MtCO_2eq$, at an average cost of some €24/tCO_2eq.

7.2.4.2 The buildings sector

The buildings sector includes energy consumption in all residential, commercial, and public buildings

The buildings sector quantifies GHG emissions from lighting systems; electrical and electronic appliances; various elements used for heating, cooling, and air conditioning; water heating devices; and other appliances that consume energy and cause GHG emissions in buildings. It includes both residential buildings, such as apartments and private homes, and commercial and public buildings, such as warehouses, schools, shopping malls, hotels, hospitals, etc.

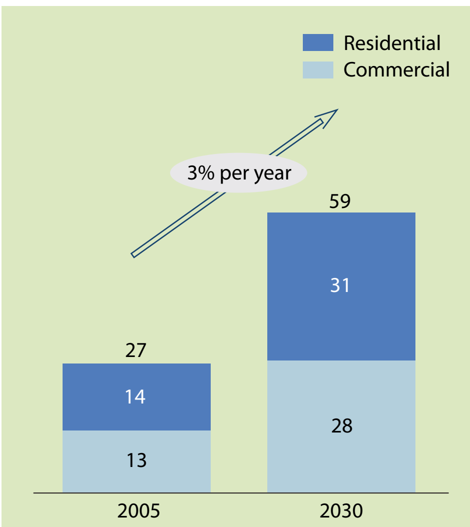
Improved energy efficiency in the buildings sector has a knock-on effect on other industries - for example, on the supply and demand of cement. This is accounted for in the relevant industry sectors.

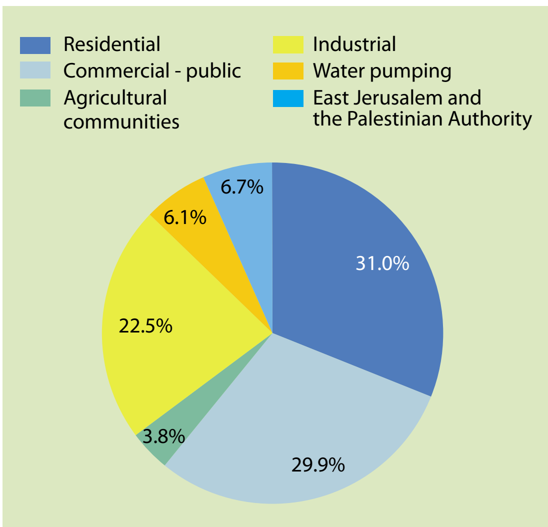
Increased efficiency of energy use in buildings

Buildings account for some 60% of total electric power consumption in Israel (Figure 7.29).

Most GHG emissions in the sector are indirect - that is, from the use of electric power rather than the combustion of fuel or gas. Accordingly, reducing demand for electric power is the central means of reducing GHG emissions.

Figure 7.29 *Electricity demand in the buildings sector (2005, 2030)*





Source: McKinsey Report

Lighting, electrical appliances, and air conditioning/heating consume most electricity

Residential buildings and public/commercial buildings differ in their patterns of power consumption. In both sectors, however, lighting, electrical appliances, and air conditioning/heating are responsible for at least 75% of total consumption.

In the BAU scenario, emissions from the buildings sector rise by approximately 81% in 2030

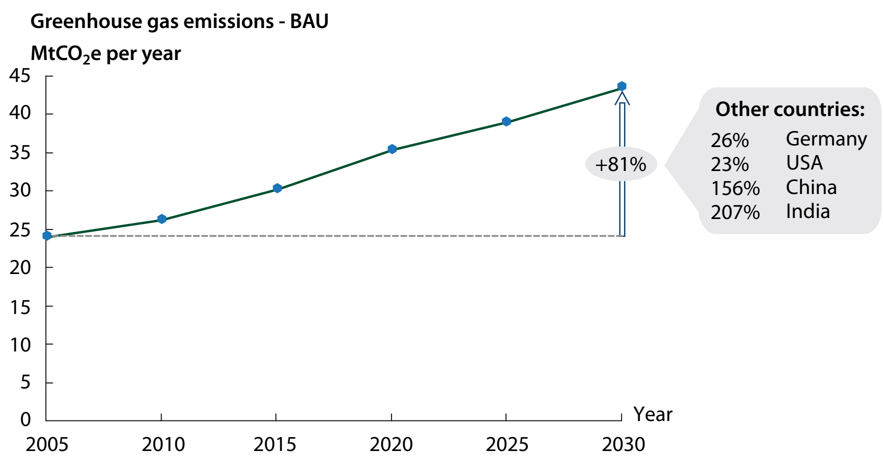
In 2005, GHG emissions from the buildings sector were 24 MtCO_2eq. In the BAU scenario, this rises to 44 MtCO_2eq in 2030 - an 81% increase (Figure 7.30). This increase results from the relatively high increase in Israel's population, which leads to growth in the residential and commercial buildings sectors. This, in turn, leads to growth in the use of air conditioning, heating, and ventilation, and higher demand for light bulbs and electrical and electronic appliances.

Five principal groups of emission abatement levers exist in the buildings sector

Almost all the emission abatement potential lies in reducing demand for electric power using 20 different levers. These fall within five main categories:

1. **New, energy-efficient construction methods such as "green construction"** - the total abatement obtained from this group of levers is 3.9 MtCO_2eq, which represents 38% of total abatement in the sector.
2. **Renovation / Improvement of existing buildings in order to increase the efficiency of energy use** - the total abatement obtained from this group of levers is 2.9 MtCO_2eq, which represents 28% of total abatement in the sector.
3. **Improvement of air conditioning, heating and ventilation systems** - the total abatement obtained from this group of levers is 0.7 MtCO_2eq, which represents 7% of total abatement in the sector.
4. **Improvement of lighting in buildings, including replacement of existing light bulbs with energy-efficient bulbs and installation of lighting control systems** - the total abatement obtained from this group of levers is 2.3 MtCO_2eq, which represents 23% of total abatement in the sector.
5. **Improvement of energy consumption of white goods and electronic appliances** - the total abatement obtained from this group of levers is 0.6 MtCO_2eq, which represents 5% of total abatement in the sector. The potential is limited as the BAU scenario already captures government efforts in this area.

Figure 7.30 *GHG emissions in the buildings sector in the BAU scenario (2005-2030)*



Source: McKinsey Report

An additional group of abatement levers improves existing water heating systems. However, due to the high percentage of solar water heaters already in use in Israel, the abatement potential is not significant.

In the abatement scenario, GHG emissions in the buildings sector fall by approximately 24%

Emissions fall by 24% by 2030 compared with the BAU scenario if all levers are implemented, and will be 38% higher than in 2005 (Figure 7.31). The potential is slightly lower than the global average due to three factors: the limited abatement potential in water heating; the fact that the BAU scenario assumes the abatement potential from the introduction of more energy-efficient appliances has already been captured; and the assumption that fewer major buildings renovations are likely in Israel compared with the global average.

Most of the abatement levers in the buildings sector are net profit positive to the economy

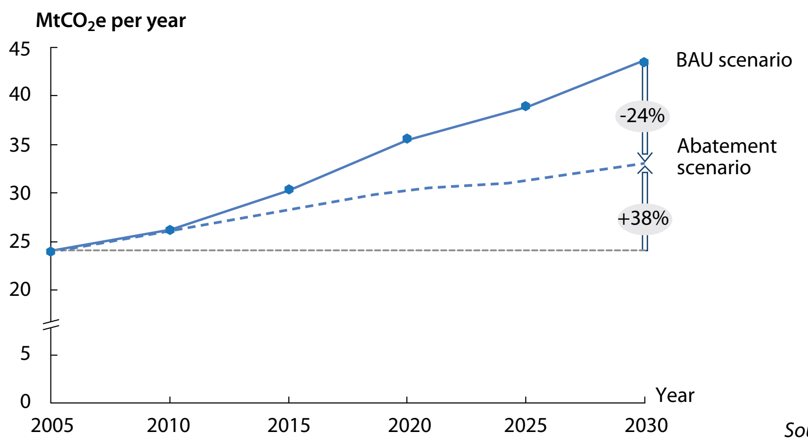
An overwhelming majority of levers in the buildings sector cost curve are net profit positive to the economy (Figure 7.32).

There are significant barriers to capture the abatement potential

Due to the long lifetime of an average building, energy-efficient measures such as renovations impact emission levels for decades to come. Hence, decisions made today - such as setting construction and insulation standards - have long-term impact and cannot be easily reversed or improved given the investments involved. Accordingly, there are a number of significant barriers and challenges which block the way to implementation of the abatement levers in this sector:

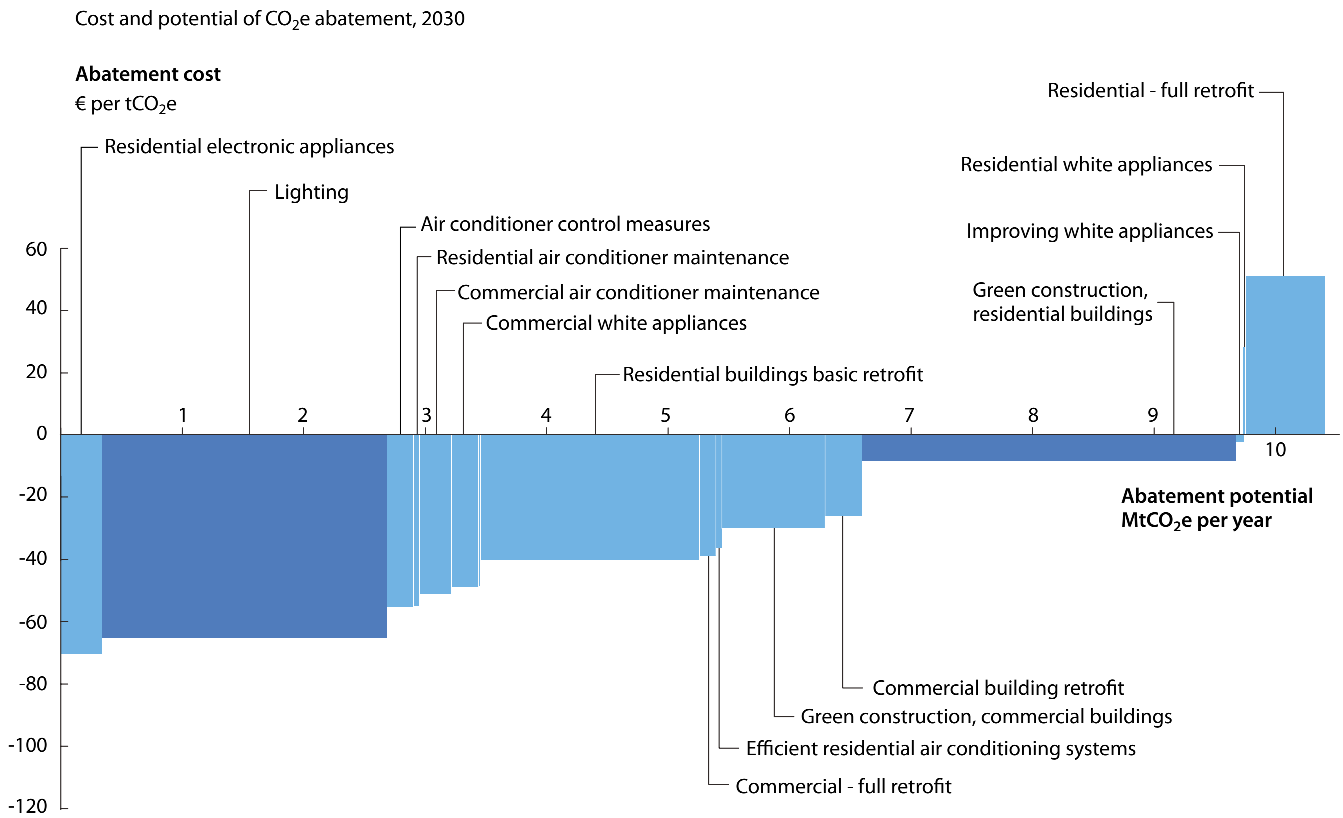
- Much depends on the decisions made by thousands of consumers rather than a small number of large organizations or interested parties. This makes implementation more difficult.
- Many of the abatement levers require considerable capital investment that will take several years to recoup in the form of lower operating costs.
- Consumers are often reluctant to make large investments that will not yield returns in the short term.
- Those who bear the costs of implementation are often not the beneficiaries. For example, "green" construction methods are extra expenses for the contractor or asset owner, but the beneficiaries are the tenants who enjoy lower energy bills, but who may not be willing to pay a rent premium for the benefit.
- Many tenants of residential units and offices are not aware of the amount of energy used in buildings or the amount wasted. This does not encourage them to take relatively easy energy-savings steps such as replacing incandescent light bulbs with more efficient ones.

Figure 7.31 *GHG emissions in the buildings sector in the abatement scenario (2005-2030)*



Source: McKinsey Report

Figure 7.32 *GHG abatement curve for the buildings sector (2030)*



Note: The graph represents an estimation of the maximum GHG abatement potential of each of the technical levers at an economic cost below € 100/ton CO_2e if all levers were to be fully implemented. It does not represent a prioritization of the various levers.

Source: McKinsey Report

7.2.4.3 Transport

The transport sector is responsible for 18% of greenhouse gas emissions in Israel

Emissions from the transport sector in 2005 were approximately 12 $MtCO_2eq$, accounting for 18% of all emissions in Israel that year. These emissions included 11 $MtCO_2eq$ from fuel combustion in vehicles and an additional 1 $MtCO_2eq$ from fuel refining and distribution to petrol stations. (In the overall cost curve, emissions from the refining process are included in the refining sector rather than transport.)

In the BAU scenario, emissions double between 2005 and 2030 because of more cars on the road

In the BAU scenario, emissions from the transport sector increase from about 12 $MtCO_2eq$ in 2005 to 25 $MtCO_2eq$ in 2030. This takes into account existing technology improvements that give rise to lower fuel consumption as well as the retirement of older and less efficient vehicles in favor of more efficient ones. Today, there are no firm plans to use alternative fuels (biofuels) in Israel, and they are therefore not included in the BAU scenario.The increase in emissions stems from more cars on the road. Although the distance traveled per vehicle is not assumed to change significantly, there will be more cars due to population growth. The total number of kilometers driven in Israel therefore doubles.

Abatement in the transport sector is achieved by a variety of means

The technical abatement levers in the transport sector can be divided into five main groups:

1. **Improvements to vehicles with internal combustion engines** (ICEs) - The fuel consumption of vehicles with ICEs can be significantly improved through technological improvements.

The calculations only take into account technological improvements that exist today and can be implemented relatively easily.

2. **Hybrid vehicles** - Hybrid vehicles combine electric engines with an ICE engine. They are also engineered so that aerodynamic drag, rolling resistance, and weight are all reduced. Batteries for the electric engine are charged while the vehicle is in motion.

3. **Plug-in hybrid electric vehicles (PHEVs)** - There are plans to introduce a new type of hybrid vehicle in Israel, the PHEV with rechargeable batteries. The ICE charges the battery while the vehicle is in motion, but the vehicle relies primarily on the electric engine. The battery can also be charged by plugging into the grid. Consequently, its emissions are lower than those from other hybrid vehicles.

   The abatement potential of both types of hybrid vehicle depends upon how much the electric engine is used. This in turn will depend upon where the car is driven (urban or rural areas), and whether the PHEV battery can be charged from the grid.

4. **Electric vehicles (EVs)** - EVs run on batteries that give the vehicle considerable range. Today, prices for EV batteries are high, raising the price of EVs relative to ordinary vehicles. The expectation is that battery prices will drop in the coming decade due to technological improvements in the production process, making EVs more competitive. The MOT expects relatively more EVs to be driven in Israel than elsewhere in the world as a result of its current efforts to install the necessary infrastructure under the terms of the "Better Place" initiative. The abatement potential of EVs depends upon the GHG emissions from electric power generation.

5. **Alternative fuels (biofuels)** - Alternative fuels release CO_2 when burned. But whereas emissions from fossil fuels are net additions of CO_2 to the atmosphere, the CO_2 released from biofuels becomes part of a natural cycle that entails no net additions. Therefore, it is commonly accepted that the use of alternative fuels enables GHG abatement. The abatement potential depends on the raw materials used in the production of biofuels and the level of emissions that can result from land-use change as a result of increased crop production.

In the abatement scenario, hybrid and electric vehicles will constitute 45% of new vehicles in 2030

In the abatement scenario, 55% of new vehicles in 2030 are ICE vehicles and approximately 45% are hybrids, PHEVs, and EVs. The assumption is that the ratio between gasoline-powered and diesel-powered vehicles will remain constant over the years.

From 2016, heavier vehicles (over four tons) will be equipped with improved powertrain and non-powertrain systems. Even under the BAU scenario, a large proportion of commercial vehicles include some improvements due to high vehicle expenses in the commercial sector relative to the private sector.

In the abatement scenario, emissions fall by 38%

The abatement scenario reflects an abatement potential of approximately 38% by 2030, or 10 $MtCO_2eq$ (Figure 7.33). Vehicles weighing up to four tons are responsible for 28% of the abatement and vehicles over four tons an additional 2%. Switching to biofuels will enable abatement of a further 8%.

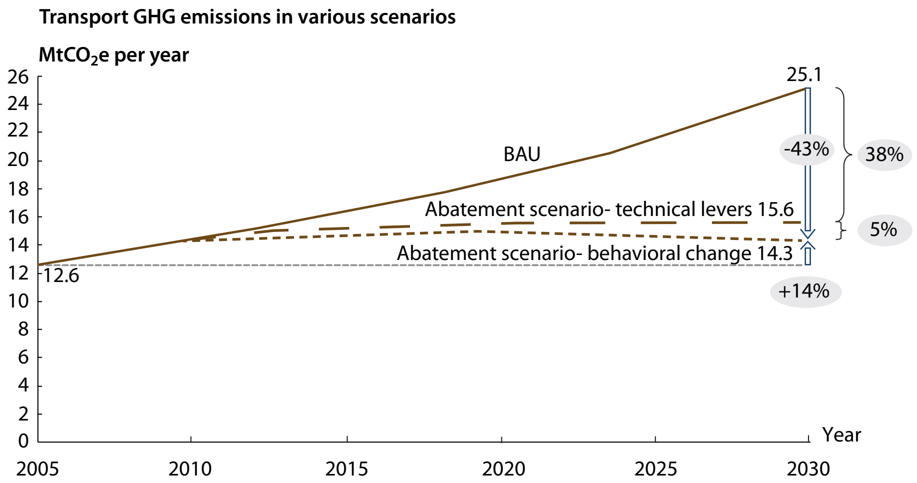
Most levers in the transport sector are net profit positive

The levers in the transport sector deliver cost savings as a result of lower fuel consumption despite the additional investment required for purchasing new vehicles. The greatest abatement potential lies in improvements to ICE vehicles. The abatement potential of EVs is achieved at a relatively high cost. Alternative fuels enable abatement at next to no cost.

Abatement potential lies in behavioral change as well as the technical levers

Abatement potential lies in behavioral change as well as the technical levers described above. The former could reduce emissions in the transporta-

Figure 7.33 *GHG emissions in the transport sector in the abatement scenario (2005-2030)*



Source: McKinsey Report

tion sector by an additional 5%, or approximately 1 $MtCO_2eq$, but these reductions are not incorporated into the overall cost curve.

7.2.4.4 The industrial sector

The industrial sector accounts for 30% of greenhouse gas emissions in Israel

Emissions from the industrial sector reached approximately 21 $MtCO_2eq$ in 2005, representing 30% of all emissions that year. These comprised 4 $MtCO_2eq$ from the chemicals industry, 4 $MtCO_2eq$ from the cement industry, 3 $MtCO_2eq$ from the petroleum and gas industry, 2 $MtCO_2eq$ from the water industry, and 9 $MtCO_2eq$ from other parts of the sector.

There are three types of GHG emissions in the industrial sector:

1. **Process emissions** – emissions released from processes in the cement and chemicals industries. In Israel, they are related to the production of clinker, ethylene, nitric acid and soda ash. They constitute around 15% of total emissions in the industrial sector (approximately 3 $MtCO_2eq$ in 2005).
2. **Direct emissions from fuel combustion** - burning fuel in various processes accounts for around 32% of total emissions in the industrial sector (approximately 7 $MtCO_2eq$ in 2005). Half of these emissions are in the petroleum and gas industry.
3. **Indirect emissions from electricity consumption** - These emissions constitute around 53% of total emissions in the industrial sector (approximately 11 $MtCO_2eq$ in 2005). Their level is determined both by power consumption and the fuel mix used in power generation.

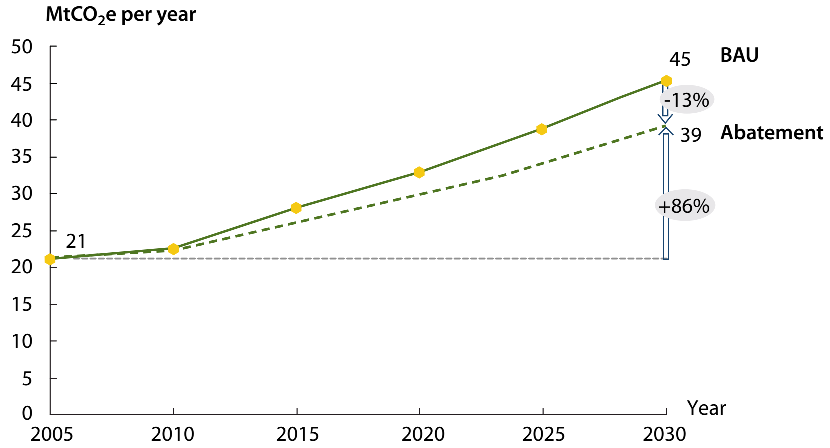
In the BAU scenario, GHG emissions rise by 115% between 2005 and 2030

In the BAU scenario, emissions rise to approximately 45 $MtCO_2eq$ in 2030 from about 21 $MtCO_2eq$ in 2005 - an annual growth rate of 3.1% and a 115% rise over the full period. The annual growth rate is lower than GDP growth due to the more efficient use of energy factored into the BAU scenario. The increase in emissions is distributed by industry as follows: chemicals 5 $MtCO_2eq$; cement 7 $MtCO_2e$; petroleum and gas 13 $MtCO_2eq$; water 5 $MtCO_2eq$; other industries 15 $MtCO_2eq$.

13% of emissions, relative to the BAU scenario, can be abated in 2030

The abatement scenario reduces emissions approximately 6 $MtCO_2eq$, or 13%, from the 2030 levels of the BAU scenario (Figure 7.34). Some industries are already highly efficient compared

Figure 7.34 *GHG emissions in the industrial sector in BAU and abatement scenarios (2005-2030)*



Source: McKinsey Report

with those in other countries in terms of energy use. In addition, some abatement levers are not likely to be suitable for application in Israel before 2030 (CCS in the chemical sector, for example). As a result, the abatement potential in Israel's industrial sector is relatively low.

In the industrial sector there are some general abatement levers and some industry-specific ones

General levers include:

1. Cogeneration through the use of steam turbines reduces emissions by approximately 1 $MtCO_2eq$ in 2030 and captures savings of some €74 million that year.
2. Improving motor systems in plants cuts electricity consumption by 20% and emissions by 1 $MtCO_2eq$ by 2030.
3. Switching from fuel oil to gas for energy production cuts emissions by around 1.5 $MtCO_2eq$ by 2030, as well as costs.
4. Efficient construction in industrial zones cuts emissions by around 0.5 $MtCO_2eq$ by 2030.

Levers for specific industries include:

1. In the chemicals industry, emissions can be reduced by 0.1 $MtCO_2eq$ by 2030, through upgrading technologies in ethylene plants.
2. Increasing the efficiency of chemical processes in the chemicals industry reduces emissions by 6%.
3. In the cement industry, reducing the quantity of clinker through the use of substitutes such as metal alloys cuts emissions by some 0.7 $MtCO_2eq$ by 2030.
4. Two abatement levers cut emissions in the water sector by around 0.3 $MtCO_2eq$ in2030 :
   - Improving energy efficiency in existing desalination plants, as sea water desalination accounts for the majority of the forecasted rise in electricity consumption in the water industry over coming years.
   - Improving existing water systems to reduce leaks since reducing the number of leaks in existing water systems increases water supply while reducing the need for desalination.
5. Abatement levers in petroleum refining and gas production have a potential of 0.9 $MtCO_2eq$ in 2030 through improved planning and maintenance of the gas grid.

7.2.4.5 The waste sector

The total abatement potential in the waste sector is estimated at 5 $MtCO_2eq$ through the use of five main levers

The abatement levers in the waste sector cut CH_4 and N_2O emissions. These emissions can be reduced by decreasing the quantity of waste in landfills through recycling or using some of the waste for fertilizer; producing energy from decomposed waste products - for example, collecting the gas emitted from landfilled waste for electricity generation; and burning methane that is naturally produced in landfills.

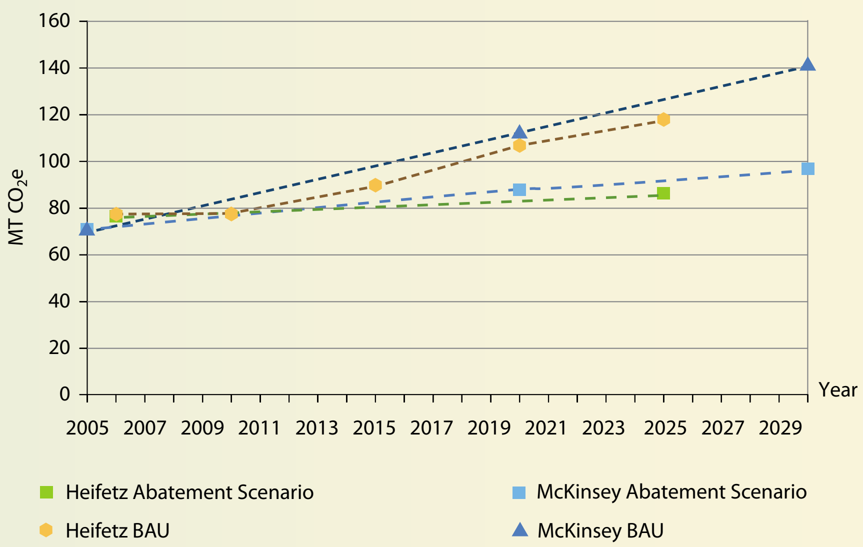
The abatement levers in the waste sector include:

1. Recycling - reducing the quantity of landfilled waste makes it possible to reduce the total quantity of waste which is likely to emit GHGs, as well as to reduce additional emissions which would be required for the production of new materials.
2. Using waste for fertilizing - fertilizing soil through the use of organic waste helps reduce emissions by reintroducing some of the gases into the soil.
3. Using waste for electric power generation - some 1.5 million tons of organic waste per year can be used for electric power generation in Israel by utilizing the methane from waste and preventing its release to the atmosphere. Given a production coefficient of approximately 1 MWh per ton of waste, the annual generation potential is some 1.5 TWh.
4. Burning accumulated gas - burning gases accumulated in small landfill sites that cannot be collected efficiently but nevertheless pollute the atmosphere. The emission abatement potential is achieved by transforming the methane in the process into a less potent gas - CO_2.
5. Direct use of gas for industrial purposes - methane from landfill sites can be piped to local industries, enabling both abatement and the efficient use of the gas. The abatement potential is limited, however, because of the need for geographical proximity to landfill sites.

7.3 Comparison of the Heifetz and McKinsey Studies

Since the Heifetz and the McKinsey studies essentially tackle a similar set of questions, it is important to understand their similarities and differences. The following table provides a comparison between the Heifetz and McKinsey studies with respect to the objectives, methodology, scenarios and conclusions.

Table 7.33 *Comparison of the Heifetz and McKinsey studies*

Theme	Heifetz	McKinsey
Objectives	• Review emissions in Israel • Build emission forecast for the Israeli economy • Examine abatement potential by abatement measures • Review international views of the Kyoto parties • Examine application mechanisms (voluntary vs. CDM)	• Build emission forecast for the Israeli economy (second opinion) • Examine sectoral abatement potential (combined abatement levers) • Enable international comparability of the study results (by using the abatement cost curve methodology)
Methodology		
Method	• IPCC	• McKinsey's abatement cost curve methodology
Base year	• 2006	• 2005
Target year	• 2025	• 2030
Data	• Based on fuel and electricity consumption and process related emissions	• Based on fuel and electricity consumption and process related emissions
Emission forecast assumptions	• Existing ministerial programs, regulations and trends and projected developments in the IPCC sectors	• Existing ministerial programs, regulations and projections for GDP, population growth, new technologies and operational developments
Cost evaluations	• Cost / benefit analysis of each abatement measure	• Analysis of 10 economic sectors in three phases: ◆ Build BAU scenario ◆ Analyze technical abatement levers ◆ Integrate measurements to create the cost curve
BAU Scenario	63% emission increase by 2025 to 118 million tons CO_2eq and 12.7 tons per capita	100% emission increase by 2030 to 142 million tons CO_2eq and 14.3 tons per capita
Figure 7.35 Abatement Scenario vs. BAU		

Theme	Heifetz	McKinsey
Abatement scenario		
Emission growth reduction	• Mitigation measures may decrease emissions growth by 76% (2006-2025)	• Mitigation measures may decrease emissions growth by 64% (2005-2030)
Abatement potential	• 2025 potential CO_2 savings 31.7 M tons.	• 2030 potential CO_2 savings 45 M tons.
Behavioral changes	• Included	• Excluded
Major abatement measures (M tons)* **	• Energy-conscious buildings (8.9) • White appliances (6.7) • Solar (3.6) • Wind (1.8) • Efficient lighting (2.6) • Green roofs (1.3) • Electricity demand management (5) • Mileage reduction (1.7)	• Energy-conscious buildings (4.9) • White appliances (0.6) • Solar (12.8) • Wind (1.2) • Efficient lighting (2.3) • Efficient vehicles (3.9) • Fuel shift (1.6) • Landfill electricity generation (1.5) • Electric vehicles (1.2)
Conclusions and recommendations	• Limited abatement potential for Israel • Efforts should concentrate on the energy, transport and building sectors • Many of the abatement measures are net profit positive to the economy • Realizing the abatement potential requires action	• Limited abatement potential for Israel • Efforts should concentrate on the energy, transport and building sectors • Net cost of implementing all technical abatement measures would be around zero in 2030 • Many of the abatement measures are net profit positive to the economy • Realizing the abatement potential requires action

* The McKinsey abatement measures refer to 67% of the mitigation potential

** The discrepancy between the McKinsey and Heifetz abatement measures stems, among others, from different reference years and different assumptions regarding BAU measures and learning curves.

7.4 Implementation of the Heifetz and McKinsey Studies

According to the Heifetz study, BAU emissions in 2020 are expected to reach 106.8 Mt CO_2eq. According to the McKinsey report, BAU emissions in 2020 are expected to reach 109 Mt CO_2eq.

A 20% emission reduction goal, as announced by Israel's President in Copenhagen and adopted in a government decision (See Chapter 5) therefore translates into a reduction of 22 Mt of CO_2eq, which will drop emissions to 87 Mt CO_2eq in 2020 (compared to the McKinsey BAU scenario).

In accordance with a March 2010 government decision to formulate a national action plan for the reduction of GHG emissions, an interministerial committee, headed by the director-general of the Ministry of Finance, was set up to specify the steps required for the implementation of such an action plan, including regulation, removal of barriers, cost benefit analysis, economic incentives and more, and to submit recommendations to the government by the end of 2010.

Four working teams are now focusing on the most promising areas of emission reduction potential in Israel:

- Energy efficiency
- Renewable energy
- Green building
- Transportation

The process is being facilitated by a team from the S. Neaman Institute, Technion – Israel Institute of Technology, which is assisting the working groups to determine the policy tools that should be implemented to attain Israel's emissions reduction target by:

- Addressing the main "policy umbrellas" which may allow goal achievement.
- Reviewing the main policy tools planned or implemented in various countries to reduce GHG emissions.
- Surveying the barriers to the implementation of GHG reduction measures in Israel.
- Developing a computable general equilibrium (CGE) economic model to assess the cross-effects of the different policy tools.

In May 2010, the S. Neaman Institute presented its preliminary interim report on the remaining gaps and implementation barriers and the mix of policy measures needed to reach Israel's intended targets.

8 Financial Contribution, Technology Transfer and International Cooperation

8.1 Financial Contribution

In addition to local activities on mitigation and adaptation (See Chapters 6 and 7), Israel participates in and contributes to various environmental international activities which directly and indirectly relate to climate change. The following table presents Israel's contribution to international environmental conventions and protocols during 2009.

Table 8.1 *Israel's contribution to international environmental activities (2009)*

Convention/Protocol	Topic	2009 Contribution
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	Control of transboundary movements of hazardous wastes	$ 21,959
Convention on the Conservation of Migratory Species of Wild Animals (CMS)	Conservation of migratory species of wild animals	€ 16,628
Convention on Biological Diversity (CBD)	Sustaining the diversity of life on Earth	$ 54,172
Convention on Wetlands of International Importance (Ramsar Convention)	Conservation of wetlands of international importance especially as waterfowl habitats	CHF 17,917
Vienna Convention for the Protection of the Ozone Layer	Protection of the ozone layer	$ 2,518
Montreal Protocol on Substances that Deplete the Ozone Layer	Phasing out production of substances responsible for ozone depletion	$ 17,860

Convention/Protocol	Topic	2009 Contribution
United Nations Framework Convention on Climate Change (UNFCCC)	Combating climate change	$ 64,541
Convention for the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention)	Protection of the marine environment and the coastal region of the Mediterranean	€ 81,427
Kyoto Protocol to the UNFCCC	Emission reduction of GHGs	$ 48,472
Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA)	Conservation of African-Eurasian migratory water birds	€ 15,004
Mediterranean Wetlands Initiative (MedWet Initiative)	Protection of wetlands in the Mediterranean region	CHF 3,671
Convention on International Trade in Endangered Species (CITES)	Control of international trade in endangered species of wild fauna and flora	$ 21,678
United Nations Human Settlements Programme (UN-Habitat)	Promotion of sustainable urban development and adequate shelter	$ 10,000
United Nations Convention to Combat Desertification (UNCCD)	Combating desertification	€ 30,410
International Renewable Energy Agency (IRENA)*	Promotion of renewable energy worldwide	NIS 350,000
Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention)	Protection of the world cultural and natural heritage	$ 65,000
International Convention for the Prevention of Pollution from Ships (MARPOL), International Convention on Civil Liability for Oil Pollution (CLC), International Oil Pollution Compensation Fund (IOPC) Fund	Marine pollution prevention and compensation for oil pollution	-
International Whaling Commission (IWC)	Regulation of whaling	£ 21,934
Additional payments	**Topic**	**2009 Contribution**
World Meteorological Organization (WMO)	Annual membership	CHF 256,000
United Nations Environment Programme (UNEP)	Voluntary funding	$ 20,000
UNEP	Funding for course on management of water resources	$ 20,000
Multilateral Fund for the Implementation of the Montreal Protocol	Funding implementation activities in developing countries	$ 100,000
Organisation for Economic Cooperation and Development (OECD)	Project on household behaviour and environmental policy	€ 23,500
OECD (observers)**	Participation in OECD subsidiary bodies (environment)	€ 16,800

Source: MFA

* Annual membership for 2010 (Membership ratified in 2010)

** Invitation for full membership in May 2010

8.2 Technology Transfer and International Cooperation

8.2.1 International Cooperative Programs - MASHAV

Israel has a long history of international cooperation with respect to technology and know-how transfer and capacity building. MASHAV – Israel's Agency for International Development Cooperation, MFA, is responsible for the design, coordination and implementation of the State of Israel's development cooperation programs. In events of natural disasters, it provides humanitarian assistance and participates in reconstruction and rehabilitation efforts. Guided by the Millennium Development Goals (MDGs), adopted by the UN General Assembly, MASHAV's approach is to ensure social, economic and environmental sustainable development.

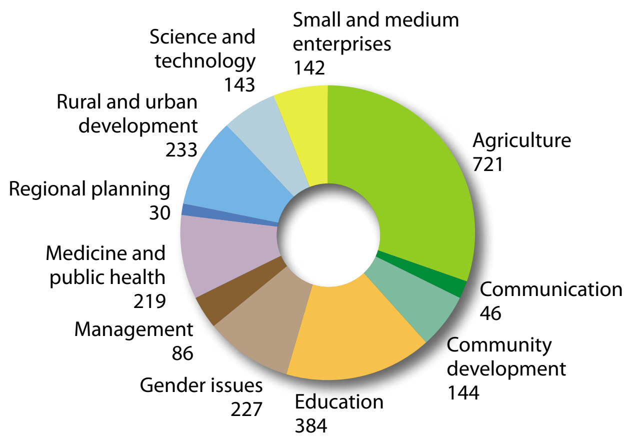
MASHAV draws its programs in accordance with current global challenges such as adaptation to climate change and food security. Its programs concentrate on human capacity building in developing countries by sharing Israel's own development experience and expertise, imparting know-how and transferring innovative technologies and tested methodologies adaptable to developing country needs.

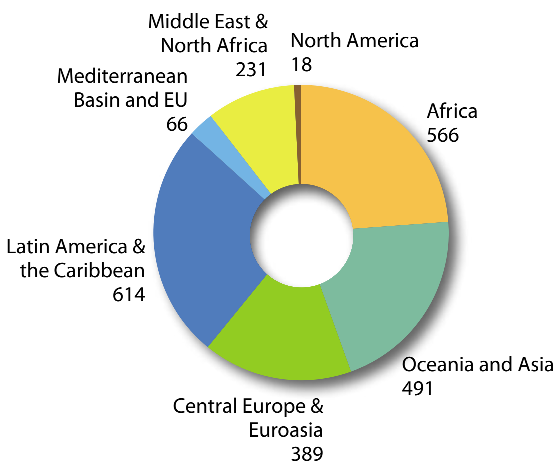
Since its establishment, MASHAV has promoted the centrality of human resource enrichment and institutional capacity building in the development process – an approach which has attained global consensus. MASHAV's philosophy is to encourage professionals from the developing world to find their own solutions to development issues and adapt them to the reality of their countries own specific needs and potential, guided by the international agreed principles of aid effectiveness such as demand driven programs, country ownership and improved coordination.

MASHAV's activities focus primarily on areas in which Israel has a comparative advantage including: agriculture and rural development; water resources management; micro-enterprise development; community development; medicine and public health; gender issues; empowerment of women and education.

MASHAV places special emphasis on the critical issues of climate change and its impact on agricultural activities and food production. Two important strategies to mitigate the effects of climate change are water management and making relevant technologies available to smallholder farmers. MASHAV's approach to agricultural development is based on harnessing science, technology and extension of applied research. The introduction of innovative technologies and the promotion of agricultural crop intensification and diversification are key elements in attaining food security in the face of climate change.

Figure 8.1 *Participants in MASHAV courses in Israel by topic and region (2009)*





Source: MFA

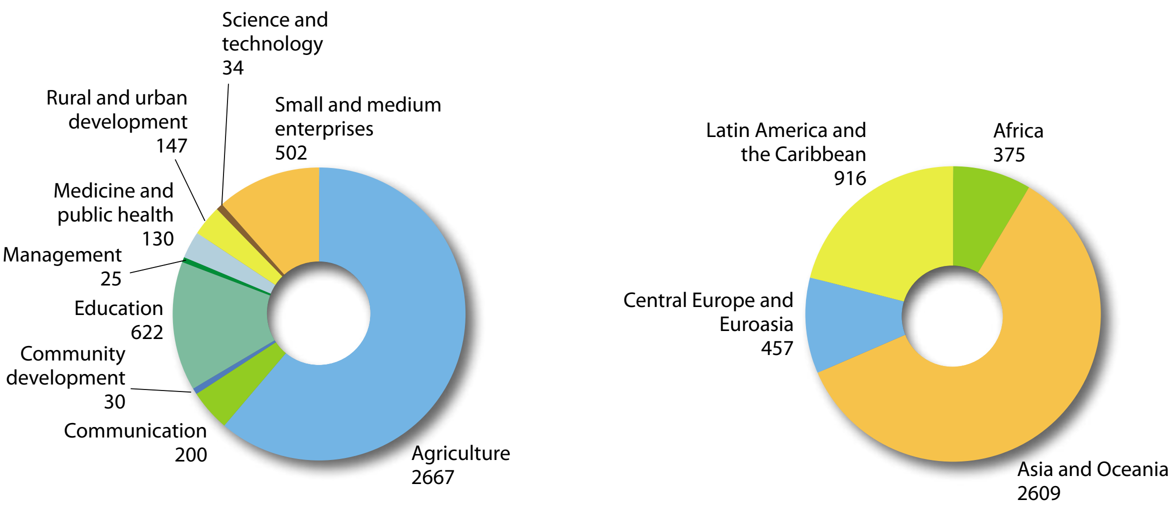
MASHAV shares the goals set by the international community for greater synergy among donor and partner countries. Towards this end, it has signed agreements in partnership with governments, civil society, international organizations and Jewish organizations in order to achieve maximum coordination of international development activities. Over 260,000 professionals from all over the world have taken part in MASHAV's programs in Israel and abroad over the past fifty-two years. A wide spectrum of short- and long-term consultancies, combined with on-site demonstration activities geared to the transfer of know-how and appropriate technologies, have become MASHAV's trademark.

In 2009, some 2,375 professionals from 110 countries participated in 99 courses offered in Israel, while 4,357 took part in 82 *in situ* courses offered in a total of 35 host countries. MASHAV experts were dispatched for 89 short-term consultancies and humanitarian medical missions to 31 countries, and eight long-term experts served on MASHAV demonstration projects in a total of seven countries worldwide.

The following section presents selected MASHAV activities relevant to climate change, especially in relation to adaptation to harsh conditions and scarce resources:

- MASHAV and USAID are cooperating in a joint program with Ethiopia's Ministry of Agriculture and Rural Development to assist the development of Ethiopia's agriculture. In 2005, an agreement was signed for a three-year program to provide technical support to accelerate the transfer and adoption of modern agricultural technologies and practices in Ethiopia. During 2008, with USAID budget assistance, MASHAV experts provided training and technical assistance in the fields specified in the agreement: capacity-building for farmers and water user groups, dairy herd improvement, small scale irrigation and water management, horticulture crop production, soil conservation and biotechnology.
- MASHAV takes part in the Millennium Village Initiative Project in the Tigray region of Ethiopia. The Initiative works directly with the national government, respective communities, non-governmental organizations, and the international donor community to show how rural Africa can extricate itself from extreme poverty and achieve the Millennium Development Goals (MDG) – while operating within the budget constraints established by international agreements for official development assistance. MASHAV's collaboration with the Millennium Village Initiative was officially launched in 2005

Figure 8.2 *In situ MASHAV courses by topic and by region (2009)*



Source: MFA

in order to bring about crop diversification, additional agricultural livelihoods, access to domestic and foreign markets and more efficient involvement of women in the development process through the creation of small entrepreneurships. MASHAV experts conducted a survey in the Tigray area (11 villages) to asses local needs in the fields of irrigation and water management, introduction of improved planting materials, orchard management and development of intensive and integrated horticulture based production systems, agribusiness development plans, development of integrated natural resources conservation and capacity building.

- In June 2009, Ethiopia, Israel, and Germany launched a three-year tripartite agricultural development project on "Enhancing Irrigation Efficiency and Water Management as a Tool for Adaptation to Climate Change" to enable Ethiopia to cope with climate change by enhancing small-scale irrigation development activities in different parts of the nation. Expected to benefit over 1,000 farmers, the pilot project will be implemented in the regions of Amhara, Tigray, Oromia, and South Ethiopia Peoples' States. Starting in 2006 MASHAV has been cooperating with MCI in Ghana in the fields of health and medicine and community empowerment. Providing training both in Israel and in Ghana, activities include, *inter alia*, upgrading local water supply systems.
- A local economic development program is being carried out by MASHAV and MCI, the Millennium Cities Initiative, together with UN-HABITAT in Kisumu, Kenya. *Inter alia*, the program addresses environmental development issues, including the utilization of solar energy for water supply and irrigation, technology for waste management and greening the city.
- Techo-agricultural Innovation for Poverty Alleviation – TIPA is a project based on the concept of the African Market Garden (AMG), which focuses on poverty reduction and crop productivity. Both TIPA and the African Market Garden specialize in horticultural production systems for small landholders, making use of the "Family Drip Irrigation System," which includes a mix of annual and perennial crops and a special low pressure drip irrigation system, and has been proved to significantly enhance yields and lower the risk of subsistence farmers in arid and semi-arid zones.
- In March 2006 an Agricultural Cooperation Agreement was signed between the Israeli and Indian Ministers of Agriculture. Within this framework, a Plan of Action was formulated and is being implemented by MASHAV in India. The first phase of the cooperation program (2009-2011), which takes place in Haryana, Maharashtra, Rajasthan and Gujarat States, focuses on the transfer of agricultural technologies including the establishment of demonstration centers in each one of the four States. In Rajasthan and Gujarat, agricultural practices focus on irrigation and water management including utilization of wastewater purification technologies for irrigation. MASHAV's professional training will take place both in India and in Israel, including courses and consultation missions.
- MASHAV operates a Consulting Center in Bishkek, Kyrgyzstan, which assists farmers interested in planning, financing and implementing improved systems, and supports former MASHAV demonstration farms in the region. Application of advanced technologies has resulted in diversification of crops and higher yields for local farmers.
- Within the framework of Uzbekistan's National Project on Sustainable Development of the Livestock Sector, a cooperation agreement was signed in 2007 between the UNDP and MASHAV to strengthen local capacity for sustainable livestock development in the country. The agreement includes transfer of Israeli know-how and new technologies, professional training programs, and the provision of high quality genetic materials and equipment for artificial insemination.
- The Xinjiang Sino-Israeli Demonstration Center for Arid Zone Agriculture was established in Northwestern China in 2003, following the joint cooperation of the Chinese Ministry of Agricul-

ture and the Israeli MFA. The project is operated by MASHAV and the People's Government of the Xinjiang Uygur Autonomous Region. The project's objective is to promote agricultural development in this water poor area by improving the efficiency of agricultural practices and engaging in commercial agricultural production. It provides training for agricultural staff and farmers in modern agricultural technologies in order to maximize crop yields and profitability under conditions of water scarcity. Two demonstration farms use greenhouse and open field crops for adapting methodologies, technologies and seed varieties for local needs.

- In 2005, an Implementation Agreement was signed for the establishment of the Philippines-Israel Center for Agriculture Training (PICAT). The main goal of this training center, which became fully operational in 2006, is to achieve a more efficient delivery of extension and outreach for the benefit of surrounding farmers. It also provides extension services to farmers in growing high value and off-season crops and in livestock raising and production. The project is jointly managed with the agricultural university in the area and serves as a demonstration site for advanced agricultural practices and the use of innovative Israeli agricultural technologies such as irrigation and fertilization.
- The Regional Agricultural Program, in which Egypt, Jordan, Israel, and the Palestinian Authority participate, is well into its second five-year phase. The unique program is being carried out under the sponsorship of the Danish International Development Agency (DANIDA) and encompasses a number of topics in the field of agriculture: small ruminants, dryland agriculture, saline and marginal water resources, post-harvest technology and marketing, and aquaculture. The program, which was established in 2000, includes on-site and regional training programs, meetings between experts, joint applied research and participation in international conferences. During 2008, courses were conducted in Israel on Quality Standards of Fresh Products, Reclaimed Waste Water and Milk Processing for women, in addition to several meetings of partner experts and of the program's steering committee.
- An Egypt-Israel-Japan Memorandum of Understanding was signed in 2006 between MASHAV, Japan's International Cooperation Agency (JICA), and the Ministry of Agriculture and Land Reclamation (MALR) of the Arab Republic of Egypt, on a Japan-Israel joint training program for Egypt. The purpose of the training is to support the "Mubarak Program" by providing agricultural courses in arid and semi-arid areas for extension officers and graduate settlers in newly reclaimed lands of the program. Some 80 participants took part in four courses during 2008 and an additional 80 Egyptian participants took part in the long standing bilateral training program.
- MASHAV runs, in cooperation with Jordanian partners, a beekeeping demonstration project near the city of Irbid, as bees provide essential services to many agricultural crops. The project involves upgrade of local bee stock, research and development, and training and demonstration activities geared at introducing improvements to the local beekeeping sector in the northern Jordan Valley. Further plans include extension and training activities for local beekeepers.
- In 2010, MASHAV and the German Federal Ministry for Economic Cooperation and Development signed a memorandum of understanding regarding development cooperation with emphasis on water management, agricultural development and public health. The memorandum relates to the achievement of the Millenium Development Goals through cooperation in the Middle East, Africa and Central Asia.
- In 2010, the United Nations Food Program (WFP) and MASHAV signed a Memorandum of Cooperation in the field of Water Management, including irrigation and drinking water systems in Nepal. The agreement aims at providing a framework for collaborative efforts on international programs and activities by identifying areas of common interest and priorities based on Nepal's development strategies.

8.2.2 International Cooperative Programs - KKL-JNF

In addition to government agencies, NGOs in Israel take an active part in international cooperation on climate change. *Inter alia*, Israeli NGOs were a prominent part of the official delegation of Israel to the UN Climate Change Conference in Copenhagen in 2009 and took an active part in the deliberations. An important organization in the fields of afforestation, land reclamation and water conservation is the KKL-JNF.

KKL-JNF has accumulated experience in such areas as:

- Managing open areas and forests in arid and semi-arid regions;
- Combating desertification;
- Developing and implementing advanced methods for harvesting water run-off in arid areas;
- Reclaiming rivers and streams;
- Conserving land through sustainable agriculture and research.

KKL-JNF shares its knowledge and experience with countries worldwide and has participated in and sponsored numerous international conferences and workshops demonstrating its technical experience and applied research.

Following are some of KKL-JNF's international co-operation activities in the fields of desertification, afforestation, water conservation and agriculture.

Desertification

- International Arid Land Consortium (IALC) – The Consortium was established in 1990 by KKL-JNF, the USA, Jordan, Egypt, the Palestinian Authority and five United States universities. Its aim is to further research and experiment in the field of arid area management and to support projects to prevent desertification in developing countries. Many of the Consortium's joint research projects involve KKL-JNF and Israel.
- In December 2008, a Conference on Combating Desertification was held at Sede Boker. Key officials from ministries of agriculture, environment and water, representing developing countries in Africa, Asia, Latin America, Eastern Europe and Central Asia, were invited to participate as guest lecturers and panellists. UNCCD focal points representing these countries also took part in the conference. The seminar was initiated by MASHAV together with KKL-JNF and the Center for International Cooperation of the MARD (SINDECO).

Afforestation

- KKL-JNF experts have been active in East Timor, helping to set up tree nurseries in order to rehabilitate forests that were damaged by the long war that raged in this region.
- KKL-JNF together with IUFRO (the International Union of Forest Research Organization) and the FCD (Forests to Combat Desertification Organization) sponsored an international conference in Jerusalem on Afforestation and Sustainable Forests in April 2007. The conference hosted 200 participants in the field of forestry from developing and developed countries.
- The first international conference on control of the eucalyptus gall wasp, organized by KKL-JNF and the Volcani Institute for Agricultural Research, took place in Israel in November 2008. During the conference, participants from twelve different countries learned from the Israeli experience on the use of non-pesticide management.
- A memorandum of understanding on cooperation in the fields of afforestation and soil conservation was signed with the States of Victoria and New South Wales (Australia). Particular areas of interest and knowledge exchange have focused on biological pest control.

Water

- A research and professional partnership agreement was signed between the government of Manitoba, Canada and KKL-JNF. Under KKL-JNF leadership, various water, agriculture and environment projects in both countries will begin. The first proposed project is the construction of a greenhouse in northern Manitoba aimed at producing fresh vegetables for First Nations inhabitants. It will be supervised by an Israeli engineer.

Agriculture

- KKL-JNF has been invited to join as a partner in an international forum – The Green Revolution - which will involve Israeli NGOs and government ministries in an international effort to find ways to improve the environment and agriculture around the world. The current goal of the forum is to assure that food production will be sustainable and accessible to all.

8.2.3 Bilateral Climate Cooperation

- In 2000, the Israeli MNI and the US Department of Energy signed an implementation agreement for cooperation in the field of renewable energy. The fields of cooperation include, *inter alia*:

  1. Solar tower technologies;
  2. High temperature thermal storage;
  3. Photovoltaic energy;
  4. Electric vehicle battery technologies;
  5. Biofuels production and use;
  6. Improved energy efficiency in water desalinization.

  The project's financing is shared equally between the parties via the United States – Israel Binational Science Foundation (BSF) and the Israel-U.S. Binational Industrial Research and Development Foundation (BIRD). In this framework, four calls for proposals regarding renewable energy were published during 2009.

- Israel's involvement in environmental protection has led to some 20 bilateral agreements between the MoEP and its counterparts in countries worldwide. These bilateral agreements provide a framework for the exchange of information and expertise in the fields of environmental protection and biodiversity conservation, and in case of some of the agreements, in desertification, agro-ecology and climate change. Implementation of the agreements takes different forms including exchange visits of professionals, workshops, research studies and joint projects on environmental problems of common interest. Specific bilateral agreements on cooperation on climate change related topics include:

  - Agreement between Israel and Spain on cooperation in the field of desertification (1993).
  - Memorandum of Understanding between the Israel MoEP and the Ministry of the Environment and Territory of the Republic of Italy on cooperation in the area of climate change and development and implementation of projects under the Clean Development Mechanism of the Kyoto Protocol (2005).
  - Memorandum of Understanding on cooperation regarding Clean Development Mechanism projects between the Israel MoEP and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety of the Federal Republic of Germany (2008).

  General bilateral agreements on cooperation on environmental protection topics include:

  - Memorandum of Understanding between the Ministry of Environment of Israel and the Environmental Protection Agency of the USA (1991)
  - Agreement between the State of Israel and the Republic of Kazakhstan (1995)
  - Agreement between the Government of the State of Israel and the Government of Ukraine (1996)
  - Agreement between the Government of the State of Israel and the Government of the Republic of India (2003)

8.2.4 International Cooperation on Climate Change and Renewable Energy Research

- Israel's MoEP is a member of CIRCLE – Climate Change Research Coordination for a Larger Europe. CIRCLE seeks to coordinate European research on climate change impact, assessment and adaptation by networking and aligning national research programs in the 19 partner countries, including Israel (See section 6.2.4).

- Israel has been an active member of the EU's Framework Programs on R&D since 1996. The current program (FP7) dedicates a significant portion of its funds to environmental and climate change research. In this framework, joint groups from the EU and Israel conduct research regarding energy, environment, agriculture and more. In the years 2007-2009, the FP7 included three calls for proposals under the environmental theme, with a budget of €613 million. 129 proposals from Israel were submitted, of which 18 were approved, with a total budget of €69.4 million. Three of the approved projects deal directly with climate change issues:
    - Solutions for environmental contrasts in the coastal areas;
    - Prevention and restoration actions to combat desertification. An integrated assessment;
    - Caribbean coral reefs in the face of climate change.
- Israel participates in three International Energy Agency (IEA) forums for technological and scientific cooperation:
    - Solar thermal energy (SolarPACES);
    - Photovoltaic Power Systems;
    - High-Temperature Superconductivity (HTS) on the Electric Power Sector;
    - Buildings and Community Systems (Energy Conservation in Buildings and Community Systems-ECBCS).
- Israel has signed and ratified (May 2010) the Statute of the International Renewable Energy Agency (IRENA), an intergovernmental organization for promoting the adoption and sustainable use of renewable energy worldwide.

9 Research and Observation

The challenge of confronting and coping with climate change is largely supported by the results of research and observation. In Israel, dozens of research projects in the field of climate change have been initiated, some within the framework of regional and international studies and others with the support of different government ministries. Such research is vital to help identify the impacts of climate change and to identify options for mitigation and adaptation. Major emphasis has focused on researching the local impacts of climate change and increasing knowledge on adaptation strategies in different sectors. For in-depth information on research in these areas, refer to Chapter 6.

The following sections present a general overview of the climate change research conducted in Israel within the framework of different organizations, both international and national.

9.1 Climate Change and Related Impacts

9.1.1 GLOWA Jordan River

Israel takes part in GLOWA Jordan River, which is a German-Israeli-Jordanian-Palestinian cooperation project (http://www.glowa-jordan-river.de). The Jordan River basin is located within the climate zone of the Mediterranean which is one of the most sensitive regions in relation to global climate change. According to the 2007 report of the IPCC, semiarid regions such as the Mediterranean, will likely suffer a decrease of water resources due to climate change.

GLOWA-JR addresses the vulnerability of regional water resources as a case study of Eastern Mediterranean ecosystems under climate change. A multi-disciplinary integrated research approach provides the scientific framework for sustainable management practices in the Jordan River watershed. The project consists of some 30 interdisciplinary scientific synergies. To date, it has yielded over 100 publications and more than 70 presentations. Within the project, models/methodologies are developed for understanding the interplay between climate/land use changes (and socio-economic processes) and water resources. In addition, the project includes the development and application of climate change related regional vulnerability assessments, adaptation methods and methods to enhance stakeholder involvement.

GLOWA-JR is structured into different subprojects dealing with global change processes, different water resources, ecosystems, agriculture, and integration and stakeholder participation. The project is currently in its third phase.

Climate Change in the Jordan River Region

During the first two phases of GLOWA JR, several regional climate experiments were conducted by the involved research groups, with the following results:

- Trend analysis of the lower atmosphere showed a statistically significant increase of temperature in the order of 1°C in the period 1948-2002.
- Until 2050, a further increase in mean annual temperature of around 1-2°C is expected.
- A decrease of mean annual precipitation is expected for larger parts of the region (up to 30%) until 2050, continuing with higher levels of significance till 2100.

Recent GLOWA work regarding climate change includes the following studies:

Regional climate scenarios:

- Regional Climate Model Simulation experiments with 25 and 13 km resolutions are currently performed for various periods at Tel Aviv University. The model runs will continue until approximately 2060. Key findings show that there will be a seasonal rise in air temperature of between 1.5 and 2.0°C over the eastern and southern Mediterranean region over a thirty year time scale, that there will be a drop in the annual precipitation over the same region of between 5 and 20% over the same period, and that there will be an increase in the number of days when there are extreme temperatures and those when there are extreme rainfall events.

Water resources:

- Global climate simulations with a Japanese super high-resolution model - water budget components over the whole Mediterranean were analyzed. The total moisture budget confirms that a drier scenario is to be expected at the end of this century for the water body area and most of the coastline countries.
- Modeling the effects of land-use and land cover change on water availability in the Jordan River region - this study presents an overview of the current and possible future land and water conditions of a major part of the Eastern Mediterranean region.
- Scenario Analysis of Strategies - in June 2009, a regional SAS workshop was held at Tel Aviv University for the development of sustainable water management scenarios. The workshop was attended by both scientists and stakeholders, and focused on the following guiding question: "Which strategies or combination of strategies can provide adequate water for the region?"
- Hydrology and water management of the upper Jordan River - as part of a growing effort to develop analytical tools to manage the water sources of the Jordan River and the Sea of Galilee (Lake Kinneret), three studies were conducted:
  - The effect of extreme rainfall events on the water resources of the Jordan River.
  - Latent and heat fluxes from Lake Kinneret.
  - System hydrology models for Mt. Hermon karstic springs and for the saline springs of Lake Kinneret.
- Interactions of climate and land-use (afforestation) on water yield and carbon sequestration - this nine-year study relates to the carbon balance of a semi-arid pine forest in Israel. The results show that on the one hand, a cooling effect is attained from shifts in photosynthesis activities during the year, and on the other hand, a warming effect is observed due to the albedo effect. Another study examined evapotranspiration fluxes and water budget at the same forest.
- Impact of environmental change on water resources in the lower Jordan River - the study includes collection of rainfall, runoff and spring data from the Golan region, including the computation of drought indexes in terms of rain, surface and subsurface flow.
- Rainwater harvesting - the study uses a GIS model for the evaluation of the potential runoff

harvesting at the hill slope scale, including the impacts of land-use or water harvesting structure.

- Soft coupling of WEAP (Water Evaluation and Planning Tool) and TRAIN-ZIN for water management in the Lower Jordan - a database for the Harod River (170km^2), including topography, soil cover, land use, rainfall and runoff from natural areas, agricultural fields and urban areas, was constructed and transferred to the TRAIN-ZIN model. While WEAP allows for scenarios of management decisions regarding water use, the TRAIN-ZIN hydrological models provide the components of the water balance. It was found that while the amount of water lost by evaporation remains relatively constant regardless of the amount of rainfall, when there are extreme events percolation and surface runoff are highly variable. Rainfall variability is amplified by the hydrological cycle.

Land use and biodiversity:

- Effects on natural and semi-natural ecosystems - this ongoing study examines the impacts of climate change on germination of seeds from soil seed banks.
- Medium term effects of climate change and land use change on the structure and function of natural ecosystems - this project deals with changes in the herbaceous vegetation spanning the 10 years of the GLOWA, monitoring of the changes in the vegetation due to inter-annual variation in climatic conditions and rain manipulations.
- Animal biodiversity - this project seeks to improve spatial models of projected change in animal species distributions in response to climate change and to study the effects of land use practices on patterns of biodiversity in human-dominated landscapes.
- Degradation risk of uncultivated rangelands subject to climate change - this study evaluates the sensitivity of basins to soil loss, as a function of their physio-geographic properties and degree of disturbance, under different climatic scenarios.
- Invasive species and climate change - this 2009 publication assessed whether natural plant communities along an aridity gradient in Israel were resistant to invasion by considering differences in abiotic conditions and community characteristics in these regions. The study used *Conyza Canadensis* as a model plant as it is a common invader in Israel.

Agriculture:

- Climate change impact on agricultural land - a model for the evaluation of farming profits and the corresponding nationwide land and water uses under four climatic scenarios for the years 2010, 2030 and 2050 was developed. The analysis points to a positive trend of evolvement along time of the farming profits under the four scenarios; however, there is a considerable sensitivity of the farming profits to the assumed scenarios.
- Assessing the socioeconomic benefits of ecological system services and their integration into models of optimal land-use under climate change in the Jordan River basin - the study focuses on the collection of values for ecosystem services and their adaptation to conditions in Israel.
- Integrated modeling of land-use change and environmental impacts - the study models farmer decisions on crops and technology to use as a function of climate conditions.
- Regional-based land evaluation for effluent reuse - the study includes the collection and analysis of water and wastewater availability in the Harod River watershed.
- Enhancing water productivity in agriculture - within the framework of this study, a thematic land-use map of the Upper Jordan Valley was prepared, with seven classes of land-use.

9.1.2 Israel Meteorological Service

Israel takes part in the research activities of the Intergovernmental Panel on Climate Change (IPCC), and the head of the IMS serves as Israel's focal point to the organization. Israel has one representative in the IPCC (AR5), who is a lead author of Chapter 7 of the IPCC Working Group I. The IMS is a member of the WMO (See Table 8.1) and participates in the Mediterranean Climate Data Rescue project (MEDARE) for rescuing data and metadata in the region. The IMS also contributes data to the World Climate Research program and to the European Climate Assessment & Dataset project. Local activities of the IMS include conducting homogeneity tests for data series and construction of metadata of historical meteorological observations and data rescue of historical meteorological paper documents.

9.1.3 Climate Impact Research Coordination for a Larger Europe (CIRCLE)

Israel participates in the research activities of CIRCLE, which aims at increasing the cooperation and coordination of adaptation research activities carried out at national or regional level by the EU and associated states. CIRCLE is funded by the ongoing European Commission's Framework Programs. Its main goals are:

- Exchanging knowledge and experiences;
- Aligning research plans and activities via cooperation;
- Establishing trans-national research programs and joint calls.

In this framework, an Israeli study was completed in 2007 on climate change and the incidence of West Nile Fever eruption. It was found that the appearance of the disease reflects the distribution of the mosquito population, while the risk tends to escalate around metropolitan areas characterized by an urban heat island. An important finding in the study is the potential impact of extreme heat in the early spring on the increase in vector population and on the disease's appearance weeks later. Awareness of such a potential may help authorities to reduce the disease risk. Another study involves the University of Haifa, as part of an international team, in the examination of the impact of climate change on Mediterranean intertidal communities and attempts to assign an economic value to intertidal zones.

9.1.4 Israel Oceanographic and Limnological Research (IOLR)

Israel Oceanographic and Limnological Research (IOLR) is a national research institution with a mission of generating knowledge for sustainable use and protection of Israel's marine, coastal and freshwater resources. IOLR conducts scientific research in the fields of oceanography, limnology, mariculture and marine biotechnology. Some recent IOLR research projects tackle climate change issues:

- Within the frameworks of the Italian-Israeli cooperation in the environmental R&D sector and the 7th Framework Program of the EU (see Chapter 8), the IOLR is involved in several projects that aim to analyze the biological changes of the marine environment in the Mediterranean Sea, identify impacts of climate change and develop, accordingly, sustainable ecosystem management options. So far, the program has generated a comparison of the status of invasive species along a temperature gradient in the eastern Mediterranean shallow water habitats and an electronic database of marine alien species in the Mediterranean.
- The IOLR operates the Kinneret Limnological Laboratory (KLL), which is located on the shore of Lake Kinneret (the Sea of Galilee). The KLL monitors major environmental factors that determine the state of Lake Kinneret and conducts limnological research aimed at understanding how present and future conditions might affect the ecosystem of the lake and the quality of its water. One of the KLL studies examines the environmental impacts of the phytoplankton population, including toxic cyanobacteria as an indicator of water quality in the lake. The population of cyanobacteria in the lake has increased during the last fifteen years and the link to climate change is being investigated.
- The KLL is involved in an international research network, GLEON, which collects limnological data from water bodies around the world, with an emphasis on the climatic and regional impacts on ecological water systems. The KLL is also engaged in a German project that exam-

ines the impacts of global changes on hydrological systems.

9.1.5 Ministry of Environmental Protection

The Chief Scientist of the MoEP supports studies in various environmental fields, including climate change. Most of the studies in the climate change category focus on climate change impacts and adaptation:

Regional climate research:

- Climate and environmental history reconstruction in the environs of Tell es-Safi/Gath during the last millennia - a forecasting tool for the possible effects of climate changes: The study results show that Mediterranean climate conditions with rain fluctuation of about 20% affected landscape evolution processes in the past. These conditions have even been recorded in a few landscape units. High-resolution investigation of various layers enabled the determination of processes that the landscape underwent as a result of climate fluctuations.

- Spotting the trends of climate change over Israel by analysis of a long-term series of aerosol data: This study integrates results of long-term observations and analyses of natural and anthropogenic atmospheric aerosols over Israel. The measurement site, at Sede Boker in the south, is relatively remote from local pollution sources; however, it lies at the crossroad between dust from the Sahara and the Arabian Peninsula, anthropogenic pollution from Europe, and maritime aerosols from the Mediterranean Sea. It was found that Sede Boker is primarily influenced by long-range transport of aerosols rather than locally-produced aerosols. Therefore, this site can be considered as a "background" site to local aerosols and hence reflects the long-term variations related to climate change.

Afforestation:

- CO_2 sequestration in semi-arid forests and its effect on the local carbon budget: A project based in the Yatir forest monitored CO_2, H_2O and energy fluxes between the forest canopy and the atmosphere during three ecological/hydrological years, focusing on the Aleppo pine ecosystem adaptation to regional hot and dry conditions. The results show that the carbon sequestration rate in the reviewed semi-arid forest was similar to the global average rate, measured in the international FluNet network. In addition, it was found that water use efficiency and carbon sequestration peak during the rainy season and water use efficiency increases by 25% until the trees reach the age of 30.

Climate change policy:

- Effects and projections of climate change in Israel - scenario and various domain analyses of the influence of climatic change in Israel: Ways to combat these changes: A review of local and international institutional studies adapted to the problems faced by decision makers in Israel.

- Frame & framing analysis for the study of preparedness for climate change in Israel - a study regarding the perception of stakeholders in the climate change field regarding the preparedness of Israel to climate change.

Biodiversity:

- Scenarios for the assessment of herbaceous vegetation response to change in rainfall and temperature: A model based study which suggests that the vegetation in the semi-arid area is adapted to stress conditions and therefore, only long dry spells in this habitat significantly affect the primary production of herbaceous vegetation.

- Predicting the impact of climate change on butterfly and woody vegetation species richness in Israel: A study which examined the influence of predicted climate changes on woody vegetation and butterfly species richness at 20 sites across Israel. The study shows that butterfly species richness is more sensitive than woody vegetation in response to annual precipitation decline.

- The effects of climate change on sexually dimorphic ungulates: A study regarding the ibex population in the Negev Highlands indicates that female ibex are more sensitive than males to drought conditions.

Land use and agriculture:

- Reduction of GHG emissions in the treatment of wastewater for agricultural reuse: 2% of GHG emissions (about 1.8 thousand tons of CO_2eq) are emitted during sewage treatment processes. The study suggests that emissions can be reduced by some 11%, by adapting treatment processes, which will then provide the maximum replacement of fertilizers used in agriculture and the generation of energy from biogas.
- Economic evaluation of climate change effects on agricultural land use in Israel: The study simulates agricultural land-use changes as a response to variations in climate variables such as temperatures and precipitations. A regional scale economic model has been developed to determine the socially optimal agricultural land allocation from a private and social point of view.
- Implications of current climatic changes on land erosion and loss in Israel: The study is mapping land erosion risks at the regional and national levels as a function of physiographic and climate conditions, topography and lithology.
- Sand dunes mobility under global warming: A study of dune mobility in Israel in general, and in the Nitzana area in particular, according to different scenarios of wind and precipitation change.

Public Health:

- Analysis of aerosol effects, as a result of global climate changes, on public health: The study evaluates dust distributions predicted by a modified DREAM model with a more detailed set of eight dust particle size classes, in order to better understand the model's capabilities for providing reliable dust forecasts and better deal with unusual long-distance dust routes.

9.1.6 Information and Knowledge Center for Adaptation to Climate Change

The MoEP is advancing the establishment of an Israeli information and knowledge center for adaptation to global climate change. Israel has accumulated broad knowledge and experience in various fields related to adaptation to climate change:

- Academic and research knowledge: Water use efficiency and water reclamation in the domestic, manufacturing and agriculture sectors, implications of using effluents for irrigation, dryness and salinity resistant crops, land conservation, combating desertification, etc.
- Management data: Water resource management (monitoring and pricing), granting incentives to adaptive agricultural branches, etc.
- Technological knowledge: Irrigation systems, urban water use, solar systems, etc.

The proposed Knowledge Center will deal with consulting for the development of strategies of adaptation to climatic change in Israel and worldwide. In addition, the center will initiate the collection of information on climate change in Israel and the Mediterranean region; develop climatic forecasts together with other countries in the region; compile and concentrate Israel's scientific activities on climate change; and assist in technology transfer regarding different aspects of climate change.

The MoEP conducted a feasibility study of the necessity and benefit of establishing an Information and Knowledge Center on the basis of the following: international decisions regarding climate change; preparedness in Mediterranean countries for climate change; existing Israeli institutions which deal with various aspects of climate change; Israeli firms which develop and produce technologies that mitigate the influences of climate change; and the countries and relevant organizations to which the services of the center could be relevant. The study confirmed the need for establishing the center in Israel. Consequently, the MoEP is examining operational alternatives for the center.

9.2 Energy Research

Research on renewable energy is carried out in Israel by both academic institutions and by industry, with the aid of funding from government ministries and investment funds. In the wake of a 2008 government decision on a five year program of investment in renewable energy research and development (See section 5.2.1), calls for proposals for academic research with commercial feasibility were published by the MNI. In addition, the Director General of the Ministry of Industry, Trade and Labor issued a directive on procedures for the establishment of a renewable energy technology center in the Negev or in the Arava which will provide industrial companies with renewable energy R & D services. The objectives of the technology center are to encourage technological entrepreneurship in the development of electricity-generation technologies based on renewable energy and to encourage cooperation between academic institutions, research institutes and industry in the development of such technologies.

Dozens of Israeli companies have pioneered innovative developments in renewable energy that are used worldwide. They include Ormat Industries, a world leader in geothermal energy, and Solel Solar Systems, recently renamed Siemens concentrated Solar Power, a leader in solar thermal technology.

During the first decade of this century, the MNI supported and funded many studies on renewable energy, in particular solar and wind energy. In 2008, it published a call for proposals, which included a call for novel photovoltaic and thermo solar energy and energy conservation technologies.

Supported solar energy R&D projects included the following photovoltaic and solar thermal technologies.

9.2.1 Photovoltaic Energy

A relatively large number of research teams are involved in photovoltaic R&D, most of them from academia, spread over most research areas. Some research is conducted by private firms with support from the MNI. Many of the research teams cooperate with leading teams worldwide (both in academia and in industry).

Highly innovative R&D projects, both in academic institutes and in the business sector, which are currently conducted and supported by the MNI, include:

- At the Weizmann Institute of Science, a project is underway to develop high-voltage semiconductor-sensitized nanoporous cells. Building three cells, sensitive to different parts of the solar spectrum, in a series has resulted in greater than 40% efficiency, but these cells are extremely expensive. The purpose of this project is to investigate ETA cells (which are intrinsically inexpensive) with the intention of finding one which is selectively sensitive to the high energy part of the solar spectrum and can provide the high voltage part of a PV cell. This will be done by identifying a materials combination that is capable of giving a high voltage and engineering the different interfaces in the system to minimize the energy losses in the conversion process.
- Ben-Gurion University's Blaustein Institutes for Desert Research (BGU-Blaustein) has initiated work on constructing solar radiation contour maps (both direct normal irradiance and global horizontal irradiance) of the Negev desert at a scale of 1:100,000. Currently, solar radiation data are available for nine specific sites at which monitoring equipment is located. However there is great demand for solar radiation data in other parts of the Negev (e.g., the Ashalim site, where the country's first solar power plants will be built). Furthermore, since land availability is severely restricted, it is important to site solar plants as optimally as possible. A set of contour maps, prepared using appropriate interpolation between the measurement sites, would be of great functional use.
- 3GSolar Company is developing novel modules of dye-sensitized solar cells (new class of low-cost solar cell). According to the company, a

corrosion-resistant current-collecting grid has been developed that allows a scale-up mechanism which increases stability and reduces waste of cell active area.

- MST Company has developed a highly-efficient technology to generate solar electricity. After two years of development, the company has unveiled its first commercial 50 KWp concentrating PV tracker in the city of Arad, in the south of Israel. The system tracks the sun accurately on two axes, generating 100,000 kWh per year. It is based on concentrating photovoltaic (CPV) technology employing high-efficiency solar cells designed and used in the space industry and adapted to terrestrial use. Present CPV cell efficiencies are very high (about 37%) and are expected to reach 45% industrially within three years. The sunlight is concentrated 500 times by lenses and projected on the cell through an optical medium. The electricity produced is collected by a specially designed system and fed to the grid. Overall power plant efficiency exceeds 25%, making it especially efficient.
- Solaris Synergy Company has developed a floating concentrated PV system. Featuring patented cooling technology, the system leverages the low temperature of the water on which it floats to keep the PV elements at a low, steady temperature, thereby significantly increasing efficiency. With a 1 kWp working prototype already up and running, Solaris Synergy is set to begin work on a 50 kWp pilot project in 2010.
- ZenithSolar Company is developing and producing a cogeneration solar power system, with a full vertically integrated strategy, that can be deployed as a distributed energy network. Its concentrated solar energy generation system is based on a new paradigm in optical design and high-efficiency solar cells. The company entered into an agreement with BGU-Blaustein (which developed the optics) and Germany's Fraunhofer ISE (which developed the PV cells) to commercialize an industrial-scale, dish-based, concentrator-photovoltaic (CPV) system. In its first generation, the basic 10 m^2 aperture Zenith Solar CPV unit generates approximately 2 kWp of electrical power and 5 kWp of thermal power (in the form of hot water). A multi-dish pilot system was inaugurated in early 2009 at Kibbutz Yavneh, east of the city of Ashdod.

9.2.2 Solar Thermal Energy

The Solar Research Facilities of the Weizmann Institute of Science (WIS) are among the most advanced laboratories in the world for concentrated solar energy research. A major feature of the Unit is a Solar Power Tower containing a field of 64 large, multi-faceted mirrors (heliostats), each measuring 7 X 8 meters. Each heliostat tracks the movement of the sun independently and reflects its light onto a selected target on a 54-meter high tower containing five separate experimental stations, each of which can house several experiments. Light can be reflected toward any or all of these stations, allowing a number of experiments to be carried out simultaneously. WIS invested over $15 million in the construction and maintenance of this laboratory. A new unique optical feature was added several years ago in the form of a 75 m^2 reflector attached to the tower at about 45 meters above ground level. The goal of research projects conducted at the Solar Research Facilities Unit is to explore solar-driven thermal and chemical processes, enabling power production, fuel alternatives, long-term storage and convenient transportation options. Research programs address the following topics:

- Electricity production - developing cost effective ways for environmentally clean, solar-driven electricity production.
- Hydrogen production - WIS scientists work on several methods to produce hydrogen, a clean and efficient fuel, using solar energy. These methods include: hydrocarbon reforming, methane decomposition, and solar thermal-electrochemical dissociation of water at high temperatures.
- Biomass gasification - developing means to use solar energy to convert biomass (such as organic waste) to fuel.
- Pollution-free, combustion-less heating of gas to very high temperatures.

- Reduction of metal oxides, for example, the production of zinc from zinc oxide - developing a clean process to provide zinc for fuel cells and other purposes.

Energy Towers

An energy tower, another innovative solar technology, was developed at the Technion – Israel Institute of Technology (See section 7.1). The MNI supported the effort to commercialize this technology and granted seed money to begin designing a scaled up prototype of this technology to produce electricity from dry desert air and brackish or sea water. A by-product of the technology could be low-cost desalinated water. In 1996, an expert review committee, nominated by the MNI, investigated the project. The committee found that an energy tower is an economically attractive method of electricity generation, compared with electricity generated from conventional fuel sources. An international review of the basic principles utilized by the energy tower has also indicated that the physical principles are feasible, as are the projected economic benefits.

The National Solar Energy center

The Ben-Gurion National Solar Energy Center, originally established by the MNI to advance and assess promising alternative energy technologies, particularly solar energy, is a major research center in Israel. It houses six laboratories, each of which is used for the study of one or more aspects of solar energy conversion. Of special importance is the Photon Energy Transformation & Astrophysics Laboratory (PETAL), based on a 400 m^2 parabolic dish multipurpose research facility. The other laboratories include: the Photovoltaic Advanced Materials Laboratory, the Parabolic Troughs Laboratory, Outdoor Photovoltaic Laboratory, the Meteorological Data Laboratory and the Solar Optics Laboratory.

9.2.3 Wind Energy

The IMS, supported by the MNI, conducted a comprehensive survey of wind potential mapping in the Negev and Arava region. The mapping process was based on wind measurement data, topography, and other characteristics of 24 IMS meteorological stations in this region. The wind potential estimation was performed using the WASP software, which analyzes wind climates, wind resources and power production from wind. The survey pointed out that the highest wind potential is found in the high mountains of the Negev, Southeast Judea Mountains, Elat Mountains and the Elat Gulf.

Another survey, conducted by the Neaman Institute for Advanced Studies in Science and Technology, examined the potential for establishing offshore wind farms in two sites across from the Israeli Mediterranean coastline. In addition, an estimate of the cost and revenues of these offshore wind farms was performed. The results showed that the wind potential in these sites is not high and that offshore wind turbines are not economically feasible in Israel at this time.

9.3 Transport Research

Israel is a small and highly populated country with an increasing motorization level. By 2020, the number of private vehicles is projected to reach 3 million versus 2.4 millions in 2008 (See section 3.9). In the long run, the demand for roads is projected to exceed the road supply. The MOT recently presented a vision for promoting Intelligent Transportation Systems (ITS) by 2020 in Israel. ITS combine computer-based, communication, remote sensing and database technologies in order to reach more effective and efficient transportation systems. The development of ITS has to take into consideration social and institutional barriers. According to its vision, the MOT would provide the institutional and legal base for ITS development by creating a suitable infrastructure and promoting R&D and important initiatives in that field.

In 2008, Israel announced its partnership with Better Place and Renault-Nissan and committed to install an all-electric car infrastructure across the country. Israel also adopted a policy of green taxes on vehicles (See section 5.2.2), which encourages the use of electric vehicles in Israel. Electric cars are projected to be commercially available by 2011. Meanwhile, in 2009, Israel Railways and Better Place signed an agreement to develop electric vehicle charging infrastructures in train station parking lots. The agreement calls for Better Place to install and operate 220 charge spots in parking lots that serve thousands of vehicles every day. Similar agreements were signed with the city of Jerusalem and with a leading Israeli shopping center group.

9.4 Agriculture Research

In 2009, the MARD approved a plan to invest NIS 7 million in six new studies on adaptation of Israeli agriculture to climate change. Additional funds will be allocated in the coming years for further research. The studies will be carried out by several collaborative research groups. Each group includes researchers from different disciplines and research institutions. One of the groups will examine the impacts of climate change on open areas in Israel, in particular, the impacts of extreme precipitation events, temperature increase and change in rain distribution on crops and pasture, used for cattle, sheep and goats. Another group will create tools for estimating evapotranspiration, which is an important factor in the processes of water loss and soil salination. Other studies will focus on a technology for improving irrigation water intake by crops and developing methods for GHGs emission abatement using bio-coal, a by-product of agricultural waste. Yet another group will develop a new approach for the installation of cooling systems in dairy farms (See section 5.2.5) with maximal water use efficiency.

In parallel, different methods are being investigated to improve commercial crops that may serve as the raw material for mass production of biofuels, and Israeli companies are developing unique algae-based solutions for producing biodiesel and bioethanol.

9.5 Land Use and Forestry Research

The KKL-JNF annually invests $1 million in applied research to develop optimal afforestation techniques in arid and semi-arid regions. As a part of its sustainable development policy (See section 5.2.6), it is planning to concentrate its research efforts on formulating recommendations for climate change adaptation and mitigation in cooperation with academia and research and developments units in the agriculture and land use sectors. Accordingly, the KKL-JNF and the MARD will soon publish a call for tenders regarding afforestation and climate change and will allocate up to NIS 2 million for that purpose. The acquired experience, knowledge and technology will be shared with developing countries with similar arid and semi-arid conditions.

9.6 GHG Calculation Methodology

F-gases include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6), which are industrial gases used in several applications – magnesuim casting, refrigeration, air conditioning systems, foam blowers, electrical switches, semi-conductors and many others.

Thus far, the CBS did not include F-gases in the GHGs inventory due to lack of suitable methodology for their calculation. In 2010 the CBS concluded the development of a methodology for calculating F-gases emissions in Israel. The methodology was developed with the assistance of an expert from the Medstat II Program, a regional statistical cooperation program between the European Union and 10 Mediterranean partner countries.

The methodology refers to emissions from the use of F-gases in manufacturing processes, consumption of products and use and removal of products/systems which contain the gases. F-gases are not locally produced in Israel and their usage stems only from importation. The calculation of emissions is based on the annual quantities of imported F-gases, their distribution among the various consumers, their extent of use for the different applications and the appropriate emission coefficients. The emission coefficients were adapted to local conditions as far as possible. Emissions are calculated from the following sources:

- Production and use in refrigeration;
- Production and use in air conditioning systems;
- Production and use in fire protection systems;

- Production of semi-conductors;
- Production and use of electrical switch gears and switchers;
- Production and casting of magnesium;
- Use of Metered Dose Inhalers (MDI) for asthma patients.

An F-gases survey is currently in process in the CBS and results are expected in the following months. Thus, the F-gases will be included in the next inventory for 2008.

10 Education, Training and Public Awareness

One of Israel's major achievements in the past decade was to raise public awareness of the environment and integrate it as a central subject in public and political discourse. Sustainable development and climate change capture growing attention in the media and in various forums. Education and awareness raising are perceived as central tools for achieving Israel's sustainable development targets. The idea is to use every means and every media to make the environment a central item in public opinion and decision-making. Therefore, environmental education has been defined as one of the five priorities of the MoEP in coming years.

10.1 Formal Education

In Israel, environmental education is part of the educational curriculum from kindergarten to high school. Education for sustainability ranks high on the priority list of both government and public organizations. Of special importance is the Green School accreditation program, under the auspices of the MoEP and the Ministry of Education. The idea is to encourage schools, with the cooperation of administration, students, parents and community, not just to teach environmental subjects but to act in a sustainable manner, to conserve resources, and to advance eco-efficiency.

Green Schools

In order to help schools along the road toward sustainability, the MoEP and its partner institutions drafted guidelines and indicators for Green Schools. The three-step process calls for commitment on the part of the school, mapping of the current state of environmental education, and formulation of environmental indicators for achievement. The action plan relates to three main areas:

1. **Formal studies** – 30 annual hours of formal study of environmental subjects must be integrated into the school curriculum, in two grades, in elementary school, within the framework of such subjects as geography, science, social studies, etc. Ten annual hours are required for half of the students in a high school.
2. **Rational use of resources** - schools are required to reduce resource use (water, electricity, paper) and/or to collect waste for recycling (bottles, paper, batteries, toners, etc.).
3. **Contribution to the community** - an additional grade beyond those engaged in formal

environmental studies is required to implement a community project aimed at increasing awareness of the environment and bringing about behavioral changes. Examples include adopt-a-site projects, recycling, etc.

As of 2009, 400 schools have been accredited.

Green Kindergartens

Kindergartens have a critical role to play in setting the educational basis for the understanding of basic concepts at the personal and social levels. The aim of the "Green Kindergarten" program is to lead kindergartens through an educational process in which children, kindergarten teachers, assistants and parents take part in incorporating environmental subjects into the kindergarten.

The action plan for accreditation as a green kindergarten includes preparation of the following:

- Annual work plan on environmental subjects;
- Community-oriented environmental projects;
- Behavioral expression of environmental literacy in the kindergarten's life: activities meant to conserve natural resources and reduce environmental pollution.

As of 2010, 600 kindergartens have been accredited.

Green Campuses

All of Israel's major universities and colleges offer graduate or undergraduate programs on environmental studies and environmental management. The range of academic programs is very rich and environmental courses are offered in a wide range of disciplines. Courses and programs on environmental subjects are added each year, assuring a pool of professionals and researchers capable of environmental problem-solving and taking part in policy and decision making at all levels.

Campuses also serve as centers of climate change education. For example, the solar education facility at the Sede Boker campus of Ben-Gurion University of the Negev has launched several educational and outreach projects aimed at increasing public awareness of the importance of solar energy. The visitors program offers demonstration tours as well as advice to individuals and groups on solar energy.

Alongside growing emphasis on environmental study, efforts are also focusing on introducing environmental behavior into university campuses. The "Green Campus" project, which was initiated by the MoEP and several academic institutions in Israel, is based on the following criteria for the accreditation of institutes of higher education:

- **Environmental studies** - each campus will allow each student to take one elective course on the environment.
- **Contribution to the community** - each campus will choose and implement a community environmental project, to be conducted by the administration, the students and the community. The project should lead to a change in behavioral and conceptual norms in the community in terms of environmental orientation.
- **Rational use of resources** - each campus will choose and implement one environmental aspect: a "reduction" program such as reduction of electricity use, water use, private car use, paper use or an "increasing" program, such as increase in the quantity of bottles, toners, batteries and water collected for recycling. The assimilation of green building as one of the components of the rational use of resources program is recommended.

Green Network

In 1998, the Heschel Center for Environmental Learning and Leadership teamed together with Project Involvement of the CRB Foundation to launch the Green Network, a network of schools committed to a new vision of environmental education. The Green Network, which includes some 180 schools and 60 kindergartens, links schools and community groups across the country in environmental learning and community action. The Network uses a core staff of educational facilitators to work with schools in developing new projects and helps to “green” the school culture and curriculum by teaching skills and providing information, encouraging community educational experiences, and introducing environmentally friendly practices into schools.

10.2 Informal Education

Formal education is augmented by informal education programs which play a pivotal role in fostering environmental awareness and participation. Both governmental and non-governmental organizations organize special events, lectures, field trips, seminars, periodicals, posters, television shows and films to increase environmental consciousness in the general public. In addition, courses are offered to youth group and community center counselors and to committed citizens on environmental activism and on means of translating ideas into action. Both young and old are trained to advance plans on the municipal and neighborhood level.

Community centers play an important role in encouraging environmental activism on the local level, and the Association of Community Centers has been an active partner in training courses for community level environmental activists. In 2005, the MoEP and the Israel Association of Community Centers initiated a pilot project on "Green Community Centers". Criteria for accreditation include:

1. Imparting knowledge on the environment;
2. involvement in a community environmental project;
3. Rational use of resources;
4. Establishment of an environmental committee to implement the annual work plan on the environment;
5. Establishment of a corner, billboard, or exhibition on environmental subjects, aimed at increasing the awareness and involvement of members of the community center and residents in the work plan and its implementation.

NGO Initiatives

Some 150 environmental NGOs operate on both the national and local levels in Israel. They have been especially active in promoting education toward sustainable development and increasing awareness of climate. Following are some representative examples:

- **"Paths to Sustainability"**: This coalition was created in 2002 by a group of more than 25 leading environmental organizations which sought to increase their effectiveness in influencing policy and public opinion, by pooling ideas and resources. The coalition uses a variety of strategies, including written policy papers and reports, participation in official committees, national and international forums and conferences, meetings with senior officials, and intensive media work to advocate a more cohesive approach to sustainability and climate change by government. The coalition member organizations are represented in the interministerial governmental committee on climate change and its sectoral work teams on mitigation and adaptation policy, voicing the views of civil society and environmental NGOs.
- **Heschel Center for Environmental Leadership and the Center for Local Sustainability:** These organizations, in conjunction with other NGOs and the MoEP, are especially active in capacity building for sustainability. Recent projects include:
  - **The 20/20 initiative** of major cities in Israel to reduce GHG emissions by 20% by the year 2020.
  - **The Zero Waste Initiative** focusing on capacity building for community waste actions.
  - **The New Horizons** project with a concentration on sustainable energy production and consumption.
  - **The Good Energy Initiative**, which aims to reduce GHG emissions through voluntary carbon offsetting, with revenues invested in non-profit social/environmental activities. Projects include providing residents in peripheral communities and poor urban neighborhoods with CFLs (compact fluorescent light bulbs) and installing a solar air conditioning system in the southern city of Elat, which will be integrated into an educational program focusing on climate change and clean energy solutions.
  - **Environmental Fellows Program,** established in 1999, which aims to develop a new

generation of environmental leaders for Israel.

- **Green Course**: This nationwide student environmental organization, set up in 1997, includes over 6,000 student volunteers in 23 chapters on campuses across Israel. The group raises student awareness and consciousness through lectures, media projects, surveys and festivals. Projects include work with schools and youth groups as well as work with students on issues such as greening the campus. The organization also organizes environmental leadership training programs.
- **The Convention of the Forum 15 for Reducing Air Pollution and for Climate Protection:** Israel's major cities signed a convention in 2008 on the reduction of air pollution and the protection of climate (See section 5.2.3). Following the preparation of a baseline emissions inventory and forecast, the municipalities are moving toward the development of action plans in four main areas: transportation and fuels, energy conservation and environmental friendly construction, waste and recycling, and green spaces.
- **Israel Union for Environmental Defense (IUED):** As a national environmental watchdog, IUED encourages and catalyzes government action on climate change as a high priority on the national agenda. The organization conducts research, publishes professional reports, and presents its recommendations to the general public, government agencies and Israel's Knesset. IUED is a member of the government's interdisciplinary committee of experts accompanying the preparation of a national climate change plan.
- **The Israel Energy Forum (IEF):** Established in 2007, IEF focuses on promoting sustainable energy for Israel. Its primary goals include reducing the environmental damage related to rising electricity consumption, including mitigating GHG emissions. The organization advocates for regulatory changes, helps shape public debate by publishing op-eds, interviews and press releases, builds coalitions and provides professional knowledge.

KKL-JNF: This organization concentrates on six action areas that include water, forestry and environment, education, community development, tourism and recreation, research and development. Through its Land Development Authority, it is the official afforestation administration for Israel (See section 5.2.6). Each year, tens of thousands of students and adults participate in tree planting ceremonies organized by the organization, most of them taking place in Tu Bishvat (Arbor Day). The KKL - JNF website features a Carbon Calculator which estimates the amount of greenhouse gases the surfer emits and offers to allow offsetting of the environmental damage by planting trees.

Transport Today & Tomorrow: This NGO partners with ministries and local authorities to promote sustainable transport in Israel. Projects relate to green commuting, sustainable transportation in local authorities, annual sustainable transportation contests for local authorities, sustainable transport courses and a Public Transportation Day.

Israeli Association for the Initiative of a Sustainable Built Environment: Founded in 2004, this non-profit organization aims to promote public awareness and development of professional skills and practices in the field of green building, while making it accessible and available to all. It conducts seminars and workshops, assists companies and contractors in implementing the green building standard, trains green building facilitators, and publishes papers.

Israel Green Building Council: Founded in 2007, this non-profit organization, aims to bring green building education to architects and builders in Israel, and to create a rating tool for real change in Israeli buildings. It expects to create a green design course for professionals to provide them with theoretical and practical training in designing green building. A rating tool committee is working on research that will set the benchmarks for green buildings in Israel.

10.3 Events, Conferences and Exhibitions

Special events, conferences and exhibitions are an important part of the effort to increase public awareness of the environment and of sustainable development. Competitions, photography and art contests, workshops and environmental exhibitions take place annually. In parallel, publications, guidelines and information on environmentally-responsible behavior on the individual and corporate levels are available on the websites of government ministries and environmental NGOs.

Following are some examples of environmental events and conferences which take place in Israel:

- Annual Children's Conference: A National Young Environmentalists Conference, initiated in 2000 by the Green Network, the Heschel Center for Environmental Leadership and the Society for the Protection of Nature in Israel in cooperation with the MoEP and the Ministry of Education, brings together young activists from around the country in order to present their activities on behalf of environmental betterment. The conference provides these youngsters with the necessary tools to encourage other students, teachers and families to engage in environmental action.
- Sede Boker Symposia on Solar Electricity Production: These symposia which take place at the Ben-Gurion National Solar Energy Center, provide a forum where scientists, industry and government planners can discuss different forms of solar power generation. The symposia combine solar-thermal and photovoltaic presentations in a single conference.
- CleanTech - the International Summit and Exhibition for Renewable Energy and Water Technologies, Recycling and Environmental Quality, Infrastructure and Green Building: With some 320 companies in Israel that can be defined as specializing in the CleanTech field and investments of over $300 million in the CleanTech industry in the last two years, this annual international event has emerged as a major international business platform where companies, researchers and professionals display their developments and technologies.
- WATEC Israel, the annual International Conference and International Water Technologies & Environmental Control Exhibition: Some 20,000 visitors from Israel and around the globe attended the most recent conference and exhibition, which focused on the water-energy nexus. Within the framework of the 2009 exhibition, the MoEP constructed a model greenhouse to demonstrate the environmental and economic benefits of sustainable building.
- Eilat-Eilot International Renewable Energy Conference and Exhibition: This conference and exhibition provides a business and policy platform for industrialists, scientists, regulators, bankers and investors. Participants share information and showcase their products.
- The State of Climate Change in Israel: This conference was organized by the MoEP in September 2009. Presentations are published on the website of the MoEP.
- Workshop on Energy Efficiency in Industry: This German-Israeli workshop was organized in June 2009 to demonstrate the energy efficiency potential in the different branches of industry and to illuminate the concrete advantages for companies that participate in the international carbon market. The presentations underlined the win-win implications of energy efficiency: financial savings to companies and reductions in GHG emissions.
- International Workshop on Establishing a Voluntary Mechanism for Greenhouse Gas Registry and Reporting System in Israel (See section 5.2.1): This workshop was convened n February 2008 by the MoEP in cooperation with the Manufacturers Association of Israel and the German Federal Ministry of Environment, Nature Conservation and Nuclear Safety. The workshop helped pave the way for an Israeli initiative on the establishment of a voluntary system for reporting GHG emissions.
- Earth Hour: Lights in homes, offices, factories and other structures were shut off for an hour in fourteen cities in Israel on Earth Day 2010 for the third year running. This symbolic and educational act aimed to increase awareness of the need to reduce energy consumption and its adverse impacts on global climate and to underline the public's capacity to bring about change.

- UN Climate Change Conference in Copenhagen, 2009: Dozens of representatives of government ministries, local authorities, the industrial sector, the electricity sector, academic and research institutions and environmental NGOs participated in the Copenhagen Conference. Israel held a side event at the conference titled: Adapting to Arid Climate Conditions – Updated Research & Development Practices from Israel.
- UN Climate Change Conference in Cancun, 2010: Israel will participate in the conference with a wide delegation representing various government ministries. Israel will also hold a side event at the conference, titled "Agriculture and Forestry under Hot and Arid Conditions."
- In November 2010, Israel will hold a forum on Green Environmental Systems and Technologies. The forum will aim at encouraging environmental technology development in Israel, and will include representatives of governmental authorities, academics, civil society, media and the private sector.

10.4 Freedom of Information

Israel's Freedom of Information Law was enacted in 1998 to assure open access to public information. The law enables individuals and public organizations to apply to a public authority for information. A 2005 amendment to the Freedom of Information Law specifically relates to the publication of environmental information with "relevance to public health, including data on substances that are emitted, spilled, discharged or released to the environment and the results of measurements of noise, odors and radiation, not on private property." The objective is to make environmental information which exists in government agencies more accessible, through its publication on websites and by other means.

The Minister of Environmental Protection promulgated Freedom of Information Regulations on the availability of environmental information for public access in February 2009. This will provide the public with vital information about the state of the environment in their vicinity.

11 Constraints and Gaps

Mitigation and adaptation to climate change present major challenges both globally and locally. Despite Israel's progress in the field of climate change during the last decade, many gaps remain with regard to research, technology, policy and public awareness.

Following is a short review of some of the major challenges as they apply to the different sections of this communication. Most of the gaps fall into four broad categories: fragmentation and duplication of authority for legislation and administration among different stakeholders, multiple and conflicting interests among stakeholders, financial constraints including inadequate incorporation of external costs and inadequate data, information and awareness.

11.1 GHG Inventory

- The calculation of the F-gases is in its final stage. Although the methodology has already been established, data limitations are still an obstacle due to the vast distribution of F-gases applications in Israel.
- Data limitation due to commercial confidentiality of information.
- The calculation of uncertainty of the GHG inventory is still under development.

11.2 Policy and Measures

- Fragmentation of authority among government ministries, planning agencies and other stakeholders impedes or delays cross-sectoral agreements and goal achievement. Progress in the implementation of both mitigation and adaptation measures requires the bridging of disagreements among ministries and stakeholders. Such a complex process requires major efforts and good will. It is also important to harmonize policy and enhance cooperation between government and the business sector in order to prevent duplication of efforts and contradictory actions.
- Although some of the mitigation and adaptation measures have already been set, the application process, the means and the timeframe are yet to be determined.

11.3 Adaptation

- The preparation of an Israeli adaptation plan is still under development. To complete the process, the following actions are required:
  - Mapping vulnerability to climate change and potential climate change action plans.
  - Assessing economic damages versus implementation costs.

- Identification of key players and their contribution.
- Identification of relevant financing mechanisms.

- Incorporation of climate change considerations and sustainable resource management (e.g., water and coastal ecosystems) across all sectors of the economy.
- Assimilation of required changes in the relevant sectors (e.g., changes in agricultural cultivation methods). Many of the measures require long-term investment, which do not benefit users in the short run. This challenge needs to be addressed by policy makers and stakeholders.
- Improvement of forecasts and models used in meteorology, agriculture, coastal management and more.
- Better sharing of the accumulated adaptation knowledge within the country and with other countries, which face similar challenges.

11.4 Forecasts and Mitigation Options

Numerous obstacles and challenges have been identified in the field of mitigation. Some apply to all mitigation measures and others are more specific to their fields.

Challenges which universally apply to all mitigation options include:

- Bridging conflicts of interests between different interest groups, responsible for application of mitigation measures, such as building planners with users.
- Harmonization of legislation and administration.
- Internalization of external costs.
- Recognition that investment in mitigation measures is often a long-term process with uncertain consequences with respect to technology and prices.
- Harmonization of mitigation targets across sectors.
- Increasing knowledge and data accessibility.
- Simplifying existing complex and bureaucratic planning and building procedures.

Obstacles in the field of energy efficiency, conservation and renewable sources include:

- Lack of hydroelectric energy potential.
- Lack of transparent data on different aspects of renewable energy sources, including wind measurements and present and future scope of roofs for installation of solar facilities and micro wind turbines.
- Lack of open space for renewable energy installations.
- Uncertainty with regard to investments in developing technologies.
- Uncertainty with regard to mitigation potential of developing technologies.
- Uncertainty with regard to tariffs.
- Inadequate analysis and enforcement of energy efficiency surveys in the industrial sector.
- Lack of indicators on energy efficiency.
- Inadequate public awareness of energy efficiency labels on appliances.
- Obstacles in connecting remote renewable energy installations to the electricity grid.

Obstacles in the field of green building include:

- Lack of uniform and clear building standards due to the great variety of building types.
- Lack of a single body to compile data on existing conditions and distribution of consumption within this sector.
- High cost of renovations which comply with green building standards.

Obstacles in the field of transportation include:

- Complexity of planning and implementation of public transportation projects, which require substantial land and financial resources.
- Uncertainty regarding the emission impact of public transportation due to the likelihood of increased use of this means.

- Dependence of the Israeli vehicle market on imports; hence, its impact on the global market is infinitesimal.

11.5 Research and Observation

- Establishment of online hydrological and climate monitoring systems, which broadcast high-resolution data.
- Establishment of an historical (from the 19th century and on) homogenous climatic database, available for the research community.
- Development and improvement of integrated atmospheric, hydrological and limnological models in order to examine long and short-term scenarios.
- Recruitment of financial and human resources for climatic research and operation of climate prediction and climate monitoring systems.
- Development of forest management practices and tree species better adjusted to hotter and drier conditions.
- Better understanding of the impact of climate change on pests and diseases in the region.
- Development of biological tools to identify the impacts of climate change on local ecosystems.

11.6 Education and Public Awareness

- Promotion of knowledge and awareness of climate change among policy makers and planners.
- Raising public awareness of climate change and its implications.

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