

Chapter 2

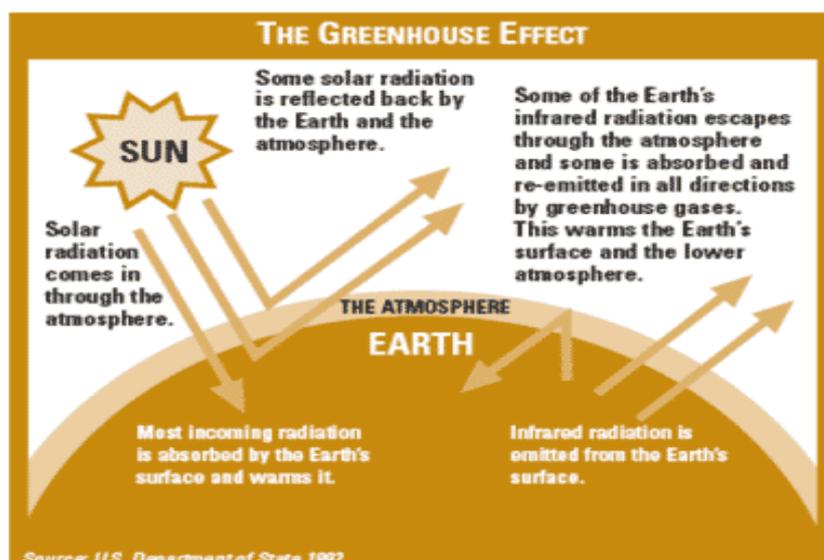
Climate Change: Scientific Basis

a. The Greenhouse Effect

Climate scientists have clearly established that:

- The Earth's atmosphere is like a greenhouse, reflecting some of the sun's harmful rays and trapping life-sustaining heat.
- The burning of fossil fuels – coal, oil and natural gas – releases gases that accumulate in the atmosphere and trap additional heat at the Earth's surface.
- **An increase in concentration of “greenhouse gases” is already changing the Earth's climate**, and the temperature may rise to dangerous levels unless we greatly reduce our emissions.

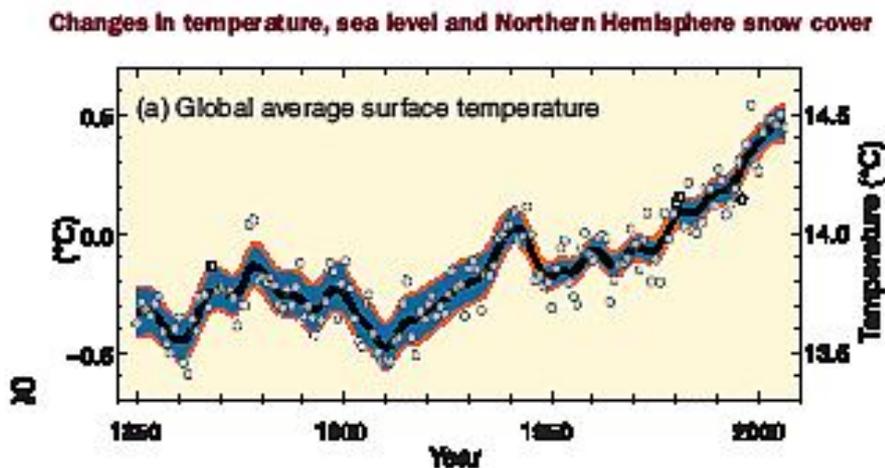
Like the glass of a greenhouse, a layer of water vapor, carbon dioxide (CO₂) and other gases surrounds the Earth, keeping surface air temperatures at a comfortable worldwide average of 57°F. Without this natural insulation, the global thermometer would drop to about zero degrees and many life forms could not survive. Greenhouse gas emissions include methane emissions from landfills, mining, and agriculture. They also include nitrous oxide (N₂O) emissions predominantly from fossil fuel combustion, fertilizer use in agriculture, and industrial production of nitric acid and adipic acid. Hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), release as byproducts of industrial processes and as fugitive emissions from the replacement of ozone-depleting substances. Sulfur hexafluoride (SF₆), mainly from semiconductor manufacturing, accounts for a relatively minor percentage of emissions.



Concentrations of these greenhouse gases remained relatively stable 10,000 years or so prior to the industrial revolution. However, the emissions from burning greater quantities of fossil fuels in recent centuries has thickened the “glass” of the greenhouse, which started warming the planet beyond its natural range.

Atmospheric concentrations of CO₂, the principal greenhouse gas, are higher than they have been at any other time in the last 650,000 years, and they continue to climb. The IPCC Special Report on Emissions Scenarios (SRES, 2000) projects an increase of global GHG emissions by 25% to 90% (CO₂-eq) between 2000 and 2030¹, with fossil fuels maintaining their dominant position in the global energy mix to 2030 and beyond. More recent scenarios without additional emissions mitigation are comparable in range.

Of the previous twelve years, eleven of them (1995-2006) rank among the warmest years in the instrumental record of global surface temperature since 1850.² The 100-year linear trend (1906-2005) of 0.74 [0.56 to 0.92]°C is larger than the corresponding trend of 0.6 [0.4 to 0.8]°C (1901-2000) given in the Third Assessment Report (TAR). The temperature increase is happening all over the globe, and tends to be higher further north in latitude. Land regions have warmed faster than the oceans.³



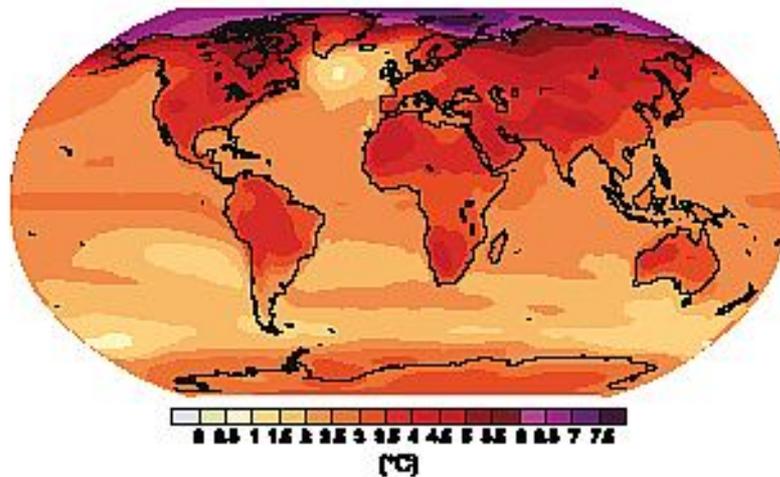
¹ Intergovernmental Panel on Climate Change. “Summary for Policymakers (SPM).” *Fourth Assessment Report, Synthesis Report*. 2007. p.4, http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf.

² National Climatic Data Center. “Climate of 2005-Annual Report.” *U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, and Data Information Service*. 2005. <http://www.ncdc.noaa.gov/oa/climate/research/2005/ann/global.html>

³ Goddard Institute for Space Studies. “Global Temperature Trends.” *Global Surface Temperature Analysis*. 2007. <http://www.giss.nasa.gov>

If we continue on this course, the climate impacts we are already seeing will become much worse by the end of this century:

- Average temperatures are expected to rise from 1.5 – 4 degrees.
- Worldwide sea level is expected to rise as much as 60cm or more, should massive ice surfaces melt.



Projected surface temperature changes for the late 21st century (2090-2099). This is an average projection for one of the IPCC scenarios (A1B SRES, which assumes rapid economic growth, a peak in population mid-century, and rapid deployment of a range of energy technologies). Temperatures are relative to 1980-1999.

*Source: IPCC Fourth Assessment Report, Synthesis Report, SPM, 2007, p. 9
<http://www.ipcc.ch/ipccreports/ar4-syr.htm>*

- More extreme weather events, intense drought, floods, and severe heat waves will occur.
- Increased likelihood of rodent and insect-borne diseases, spreading plagues to new parts of the world.
- Certain ecological systems will change dramatically, and lead to the extinction of 40-70% of all species studied worldwide.
- Damage to world economies, especially the developing countries.

The expected climate change in the Mediterranean basin is far more extreme than the global average. An average temperature rise from 2.2 – 5.1C°, and decrease in precipitation of up to 27% are expected by the end of the century. Moreover, extreme rain events, maximum summer temperature increases and a number of heat waves are predicted.⁴

⁴ Golan-Angleco I, and Brawer, Y. "Israel's Preparations for Global Climate Changes." *The Ministry of Environmental Protection, Chief Scientist Bureau*. Jerusalem, 2008.
http://www.sviva.gov.il/Environment/Static/Binaries/ModulKvatzim/p0475_1.pdf

Global Warming Potential

Each greenhouse gas contributes differently to global warming, depending on three factors: 1) its ability to retain heat, 2) its molecular weight, and 3) the amount of time it remains in the atmosphere. The idea behind the “Global Warming Potential” (GWP) thus is to compare the ability of different gases to "trap" heat in the atmosphere over a certain period of time, which then in turn causes global warming. The GWP for a specific greenhouse gas (GHG) is defined as “the ratio of heat trapped by one unit mass of the greenhouse gas to that of one unit mass of CO₂ over a specified time period.”⁵ Carbon dioxide is the baseline gas against which the GWP of other GHGs is measured. Therefore, the GWP of CO₂ = 1. The GWP of the different gases changes over time, and the IPCC has suggested using a 100-year time horizon.

CO₂ is responsible for approximately two-thirds of total greenhouse gases.⁶ There are high quantities of CO₂ in the atmosphere, and it stays there for a long period of time. However, it is not as strong (or potent) in terms of its heat-trapping potential as other gases.

On the other hand, methane (CH₄), often emitted from landfills and agriculture, is a significant contributor to the greenhouse effect, even though less methane is emitted than CO₂ to the atmosphere and it stays for a shorter period of time, because methane has a GWP of 25 (i.e., has a greater ability to trap GHGs than CO₂). In other words, 1 ton of methane has the equivalent heat-trapping potential to that of 25 tons of CO₂.⁷

Another important GHG is nitrous oxide (N₂O), which is emitted from agricultural (i.e., primarily fertilizers) and industrial processes. Its GWP is 298 and thus much higher than the aforementioned GHGs.⁸

Moreover, a group of “high GWP” GHGs exist, which are the HFCs, PFCs and SF₆, which have a GWP ranging from 437 to as high as 22,800. The length of time these gases remain in the atmosphere varies dramatically (e.g., from 1.4 years to 50,000 years). They can contribute to global warming in a far more dangerous way than equal amounts of other GHGs.⁹

⁵ Available at: <http://www.epa.gov/highgwp/scientific.html>

⁶ United States Environmental Protection Agency, *Global Greenhouse Gas Data*.
<http://www.epa.gov/climatechange/emissions/globalghg.html>.

⁷ Intergovernmental Panel on Climate Change. “Physical Science Basis Report.” *Fourth Assessment Report, Working Group I Report*. <http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter2.pdf>.

⁸ Ibid.

⁹ Ibid.

Global Warming Potential ¹⁰		
Gas	Atmospheric Lifetime	GWP (100 years)
Carbon Dioxide (CO ₂)	50-200	1
Methane (CH ₄)	12	25
Nitrous Oxide (N ₂ O)	114	298
Hydroflourcarbons (HFCs)	1.4 – 270	437 – 12,000
Perfluorcarbons (PFCs)	740 – 50,000	7390 – 17,700
Sulphur Hexafluoride (SF ₆)	3200	22,800

One way to moderate the most dangerous effects of climate change is to replace greenhouse gasses used in various industrial processes. This replacement should not damage manufacturing processes, and move towards minimal warming potential gas emission. Due to vast range of GWP between different gasses, such a change can greatly influence the greenhouse effect.

¹⁰ Ibid.

b. Sources of Greenhouse Gas Emissions

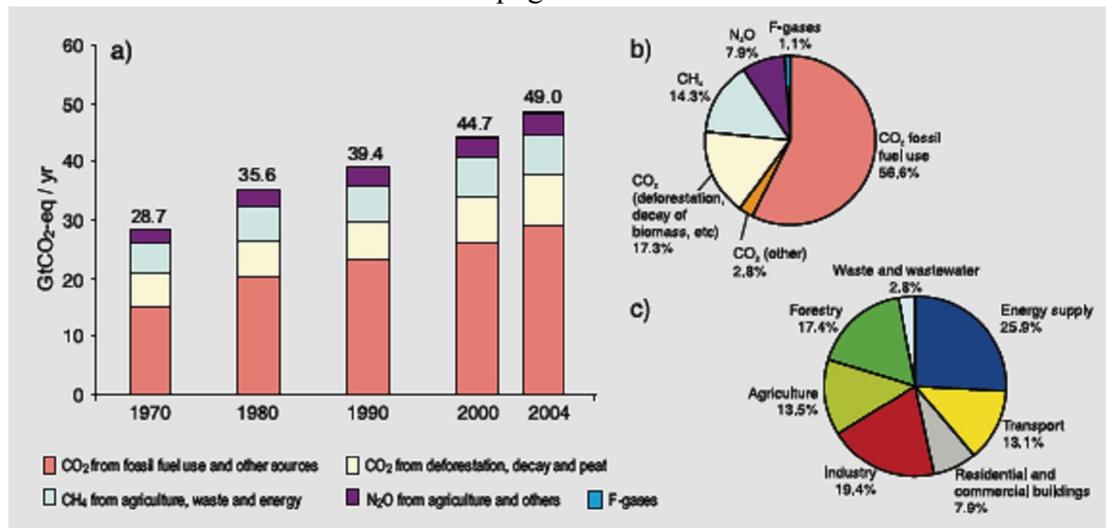
There are six major green house gases:

- Carbon Dioxide (CO₂)
- Methane (CH₄)
- Nitrous Oxide (N₂O)
- Sulfur hexafluoride (SF₆)
- Hafnium carbide (HFC)
- Perfluorocarbons (PFCs).

Carbon dioxide (CO₂) is the most important anthropogenic GHG. In 2004, its annual emissions represented 77% of total anthropogenic GHG emissions (See diagram). Fossil fuel burning is its primary emission source, mostly for electricity generation and transportation. Another important CO₂ source is a result of forest fires and Biomass decomposition.

GHGs differ in their warming influence (radiative forcing) on the global climate system due to their different radiative properties and lifetimes in the atmosphere. These warming influences may be expressed by a common metric based on the radiative forcing of CO₂. In comparison to other GHGs, the amount of CO₂ in the atmosphere is considerably higher. However, other GHGs can last longer in the atmosphere, and hence, have a larger ‘warming potential’ (See chapter 2A). Methane has a warming potential 25 times greater than that of CO₂.

Global Anthropogenic GHG Emissions



(a) Global annual emissions of anthropogenic GHG's from 1970 to 2004.

(b) Share of different anthropogenic GHG's in total emissions in 2004 in terms of CO₂ eq.

(c) Share of different sectors in total anthropogenic GHG emissions in 2004 in terms of CO₂ eq (forestry includes deforestation)

Energy generation is responsible for almost 26% of world GHG emissions. Other major sources of GHG emissions are:

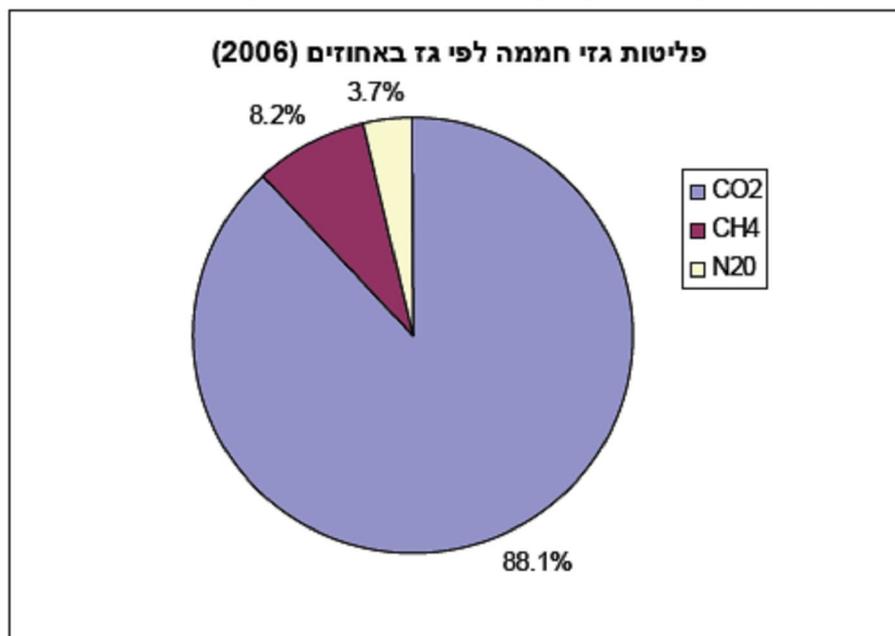
- Industry – 19.4%
- Deforestation – 17.4%
- Agriculture – 13.5%
- Transportation – 13.1%.

Sources of GHG Emissions in Israel

Sources of emissions in Israel vary because of diverse geographic and economic conditions. This is why deforestation is probably not a large factor on the emissions map.

As required by the UNFCCC (See chapter 4B) and the Kyoto Protocol (See chapter 4C), Israel has led a national inventory to tally human-related emissions and sequestrations. The first inventory was taken in 1996 and updated in 2000.¹¹ It included the three most common GHGs – Carbon Dioxide (CO₂), Methane (CH₄) and Nitrous Oxide (N₂O). Similar data from other countries showed that there was minimal contribution of other GHGs that had not been tested for in Israel. The central Bureau of Statistics published updates to this data according to IPCC instructions (See chapter 2C, 4A).¹²

Greenhouse gas emissions according to percentages (2006)

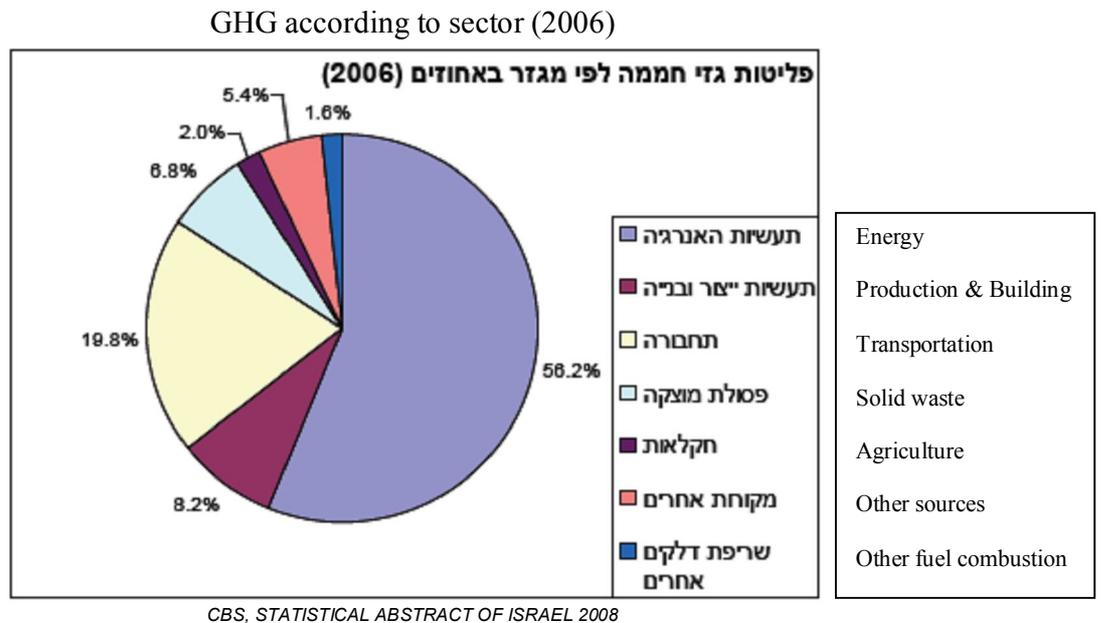


CBS, STATISTICAL ABSTRACT OF ISRAEL 2008

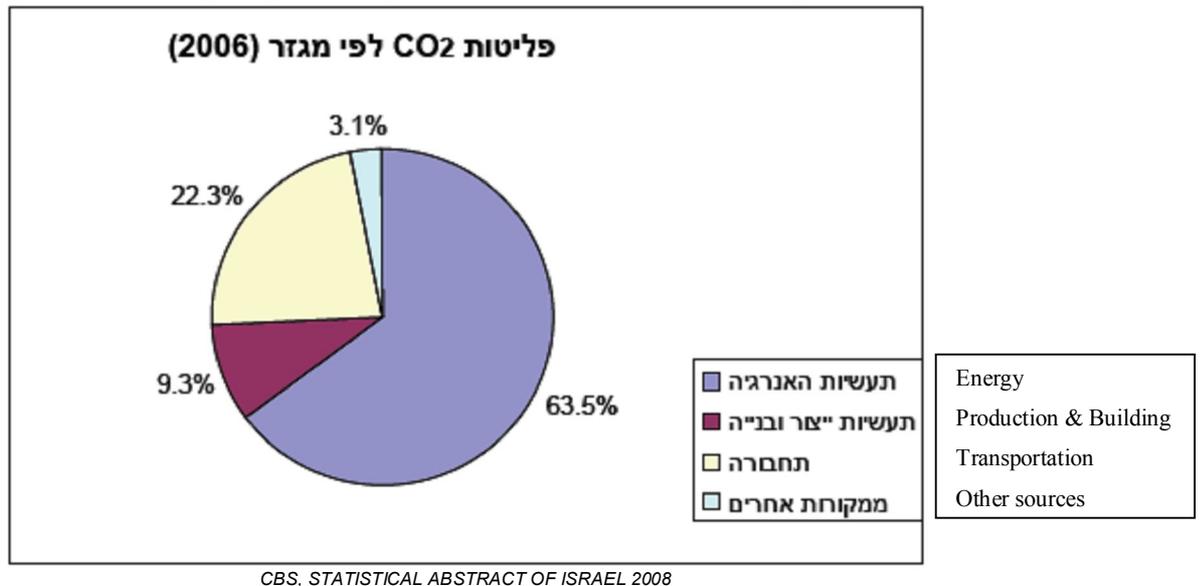
¹¹ Available at: http://www.environment.gov.il/Environment/Static/Binaries/index_pirsumim/p0108_1.pdf

¹² Available at: http://www.cbs.gov.il/shnaton59/st27_06.pdf

Based on the latest details published by the central bureau of statistics, 74 million tons of CO₂-equivalent GHGs were emitted in Israel in 2006. Data analysis shows the energy sector is responsible for 56.2% of the GHG emissions in Israel (mostly results of fuel use); transportation caused 19.8%, industry 8.2%, waste 6.8%, and other sources 2%.



The following diagram analyzes carbon dioxide emissions by sector



Based on data gathered by the ministry of Environmental Protection¹³, a “Business As Usual” (BAU) policy would increase emissions by 63% by the year 2025, compared to the year 2000 level. According to this scenario, a sectoral division is estimated as follows: Energy - 59.3%, industry – 20%, transportation – 19.8%, and other sources – 1.9%.¹⁴

The BAU approach includes a wider use of natural gas and less methane emissions from garbage dump sites. The BAU scenario also considers current and future population growth, water shortage, lack of effective and frequent public transportation, and other factors. The ministry of Environmental Protection also estimates a wider range of reduction tools, including renewable energy, conservation and more effective public transportation, which could prevent 30 million tons of CO₂-equivalent gasses by 2025, or, two thirds of expected growth.

Energy

Throughout the 1990s, the generation of CO₂ emissions per capita either decreased or remained steady in industrialized countries. In Israel, however, a considerable rise in CO₂ per capita occurred at that time until it grew close to the highest levels reached in Europe in 2000. The average electricity consumption growth rate increased from 3-4% in the first decade of the 21st century, and reached 7% by 2007.

In September 2008, a government resolution called for a 20% cut of expected electricity consumption by 2020, (based on electric demand in 2006), and a 10% increase in consumer efficiency by the end of 2012. Environmental organizations consider this plan of action as “too little, too late.” The Ministry of National Infrastructure predicts another 3% annual growth in electricity demand.

Another way to reduce emissions in the energy sector is by changing the means of generating electricity. Coal accounts for 70% of electricity generation in Israel and 20% from natural gas, diesel fuel and fuel oil (2007 data). A wider use of natural gas is planned in the next couple of years, with an expected 35-40% of the electricity economy by 2025.¹⁵

In addition, the National Infrastructure Minister promised to enhance the use of renewable energy in Israel by 15-20% until 2020. So far, Israel has not reached much lower targets (only 2% in 2007), and the current use of renewable energy is only 0.5% of all electricity generation.

¹³ Available at:

<http://www.sviva.gov.il/Enviroment/bin/en.jsp?enDisplay=view&enDispWho=News%5E14372&enDispWhat=object&enZone=News&enPage=BlankPage&&redirect=1>

¹⁴ Presentation by Yosi Inbar. “Climate Change: a Challenge to Europe and Israel.” *The Ministry of Environmental Protection*. 13 November 2008.

¹⁵ Correspondence with Hadar Almog, *The Power Company*, 2008.

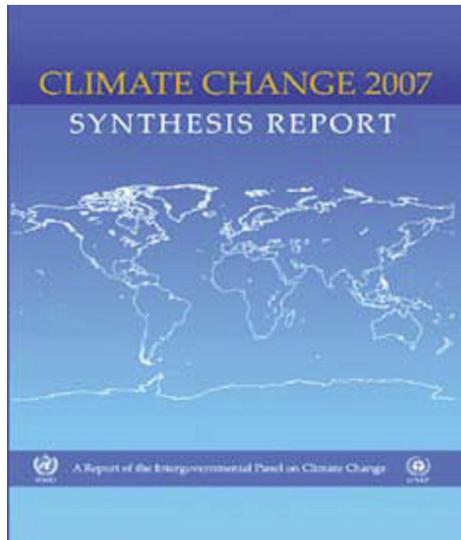
Transportation

Carbon dioxide emissions from the transportation sector are mainly from passenger cars. Between the years 2000-2007, there was a 25% rise in the number of vehicles. A growing trend of using private passenger cars instead of public transportation increased the amount of private cars to 30%, which now amount to 80% of all vehicles. The number of seats on buses hardly changed from the beginning of the 1980s, although the population grew. Diminishing use of public transportation causes fuel consumption increases, and a considerable increase of GHG emissions.

Waste

Whereas the amount of waste generated in Israel is similar to other developed countries, recycling rates are lower by far. Thus a considerable amount of solid waste is buried. Methane and carbon dioxide are formed in waste sites, resulting in disintegration of organic materials. Solid waste incinerators are also used, so expanding recycling and waste management may significantly reduce GHG emissions in this sector. Methane sequestration in garbage pits, and its conversion to energy will assist in reducing this source of GHG, and could be an additional energy source.

c. IPCC: Intergovernmental Panel on Climate Change¹⁶



Source: IPCC, www.ipcc.ch

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in order to assess the "risk of human-induced climate change." In 2007, the IPCC released its Fourth Assessment Report (AR4) on global climate change. The AR4 is organized into three Working Group Reports covering the scientific basis and impacts of climate change as well as possibilities for adaptation and mitigation (See chapter 4a).

Some findings from the panel:

- It is likely that the average Northern Hemisphere temperatures during the second half of the 20th century were higher than during any other 50-year period in the last 500 years, and were also probably the highest in at least the past 1300 years.
- It is very likely that over the past 50 years, cold days, cold nights and frosts have become less frequent over most land areas. Hot days and hot nights have become more frequent. It is also likely that heat waves have become more frequent over most land areas, and the frequency of heavy precipitation events has increased as well.
- From 1900 to 2005, precipitation increased significantly in eastern parts of North and South America, northern Europe and northern and central Asia but declined in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. Globally, the area affected by drought has likely increased since the 1970s.
- Rising sea levels are correlated with warming. Global average sea level has risen since 1961 at an average rate of 1.8 [1.3 to 2.3] mm/yr and since 1993 at 3.1 [2.4 to 3.8] mm/yr, with contributions from thermal expansion, melting glaciers, ice caps, and polar ice sheets.

¹⁶ Intergovernmental Panel on Climate Change (IPCC) <http://www.ipcc.ch/>

The report does not refer to Israel *per se*, so the most relevant forecast is that of southern Europe. It includes an increase in temperatures, heat waves and droughts, along with negative impacts to water availability, agriculture, tourism and public health.

According to the panel's recommendations, GHG emission concentrations in the atmosphere must be stabilized in order to mitigate the increases in global average temperature, which has risen 2-2.4 C° since the pre-industrial era. GHG emission concentrations should be stabilized at 445 – 490 ppm per CO₂-equivalent. To do so, we must reach the emission peak by 2015, and by 2050 cut emissions down by 50-85% of emissions in the year 2000.¹⁷

In order to stabilize GHG emissions in the atmosphere at the rate of 450 ppm, the Climate Convention Annex 1 countries (See chapter 4a) would be required to cut emissions by 25-40% below the 1990-2020 levels, and 85-90% by 2050.¹⁸

¹⁷ IPCC *Fourth Assessment Report Synthesis Report*. 2007, Table 5.1, p.67
http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

¹⁸ IPCC "Policies, Instruments and Cooperative Agreements" *IPCC Fourth Assessment Report, Working Group III Report* Ch.13
<http://www.ipcc.ch/ipccreports/ar4-wg3.htm>.