

FOIA MARKER

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OA/ID Number: 21608
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Folder Title:
[Global Climate Change & Israel] [loose] [1]

Stack:	Row:	Section:	Shelf:	Position:
S	21	5	1	1



Joseph E. Aldy

04/25/2000 03:17:27 PM

Record Type: Record

To: CraneWH@state.gov @ inet

cc:

Subject: follow-up

Bill,

Thanks again for hosting us in Jerusalem week before last. I thought the meetings went well and I enjoyed the opportunity to do some sightseeing.

I wanted to provide you with some follow-up information from our meetings. First, I have attached a powerpoint file with the presentation I made so you can reference if necessary. Second, here are the 3 websites that are in the powerpoint presentation:

Economic Report of the President
<http://w3.access.gpo.gov/eop/>

The Kyoto Protocol and the President's Policies to Address Climate Change:
Administration Economic Analysis
<http://www.whitehouse.gov/WH/New/html/kyoto.pdf>

OECD Climate Change Modeling Workshop
<http://www.oecd.org/dev/news/Environment/Modelling.htm>

Third, we discussed with several of the business folks the voluntary efforts by industries in the United States and other countries. Here are websites that describe several of the larger corporations' efforts on climate change. It would be great if you could share this with those interested in Israel.

BP-Amoco
http://www.bpamoco.com/climatechange/index_bpamoco.htm

DuPont
<http://www.dupont.com/corp/environment/climate/climate.html>

Monsanto
<http://www.monsanto.com/monsanto/mediacenter/background/ClimateChange.html>

Fourth, I received a request from Yoram Zvirin of Technion for more information about the U.S. experience in phasing down lead in gasoline (I mentioned this as an example of past trading programs). Apparently, Israel is in the process of trying to figure out how to phase down lead in gasoline, so I provided 6 academic papers describing the U.S. experience. If you would like these, please let me know and I can forward copies to you as well.

I hope you and your family have been able to enjoy your vacation. All my best,



Robert J. Tuccillo

05/04/2000 02:36:02 PM

Record Type: Record

To: Joseph E. Aldy/CEA/EOP@EOP

cc:

Subject: Budget Information

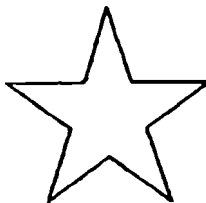
Joe --

Below is the budget information you requested. I used Federal outlays since that is the number we use to represent how much the gov't will spend in a fiscal year. Revenues are projected to be higher than outlays, thus we have a surplus in the unified budget which includes social security. I did not include the revenue numbers since that might be confusing.

FY 1999 are actuals. FY 2000 and 01 are estimates. FY 01 is based on the POTUS budget, which may not be the same as the actual budget once appropriations are finalized later this year.

I will fax you the detailed table on environment spending from chapter 4 of the budget in the event you want to send it along.

	<u>1999</u>	<u>2000</u>	<u>2001</u>
(dollars in billions)			
Total Federal Spending	1,703	1,790	1,835
Environmental Spending	37.7	38.4	42.5



EMBASSY OF THE UNITED STATES
71 HAYARKON STREET
TEL AVIV

ENVIRONMENT, SCIENCE, & TECHNOLOGY OFFICE
FAX: 03-510-1035 (DOMESTIC)
972-3-510-1035 (INTERNATIONAL)

TEL: 03-519-7434 (DOMESTIC)
972-3-519-7434 (INTERNATIONAL)
MOBILE: 050-353-491 (DOMESTIC)
972-50-353-491 (INTERNATIONAL)

E-MAIL: CRANEWH@state.gov

PAGES INCLUDING COVER SHEET: 1

DATE: 3 MAY 2000

TO: JOSEPH ALDY, SENIOR ECONOMIST
COUNCIL OF ECONOMIC ADVISORS

FAX: 1-202-395-6870

FROM: WILLIAM H CRANE

MESSAGE: BUDGET NUMBERS

Joe,

Dalia Itzik will preside over a joint ministerial meeting in several days, and her staff are rushing about preparing her presentation. They have asked for the following US numbers, which I hope you can authoritatively provide (or at least make up):

- the current total federal budget; and
- "total expenditure on environmental issues from the national budget, including ministries and/or national agencies and projects".

Appreciate the help. By the way, what is your correct email address. The one I have written down doesn't work, so I must have messed up somehow.

Regards,
Bill
DRS: _____

Carbon dioxide, methane and nitrous oxide emissions and removals (in Ktons) per IPCC sector 1996

IPPC sector	CO ₂ emissions (Ktons)	CH ₄ emissions CO ₂ eq. (Ktons) for 100 years	N ₂ O emissions CO ₂ eq. (Ktons) for 100 years
Fuel combustion total	49,600		230
Energy production and transformation	26,500		170
Industry combustion	11,000		7
Transport	10,300		35
Commercial and Residential	1,800		15
Forestry	-400		
Agriculture	2,500	900	1,200
Industrial processes total			540
Cement	1,700		
Solid waste		7,800	
Wastewater treatment		200	
Total	53,400	8,900	1,957

Summary of policy recommendations

Measure	Expected reduction of emissions (Percent of total)			Additional advantages
	Pessimist. scenario	Reason. scenario	Optimist. scenario	
1. Waste and sewage sludge treatment	8	10	12	Solution of waste problem Israel
2. Switch to natural gas in power stations	3	8	11	Reduction of air pollution
3. Energy production in combined cycle	2	5	7	Use of fuels with higher efficiency. Postponing of building power generation plants
4. Co-generation	2	3	4	Use of fuels with higher efficiency. Postponing of building power generation plants
5. Energy conscious building	3	5	7	Energy savings and postponing of building power generation plants
6. Transportation Improvements	2	4	6	Reduction of air pollution. Improvement of environment in cities
7. Industry improvements (without co-generation)	4	7	10	Improvement of air quality. Postponing of building power generation plants
8. Agriculture	0.5	1	2	Reduction of underground water and air pollution
Total	24.5	43	59	

A. Reduction of emissions in the energy generation sector

Alternative	CO ₂ reduction per year ton/year	Technology	Cost \$/kW	Percent of sector's emissions	Percent of total emissions	Remarks
1. Switch to natural gas						Requires gas distribution system. Problem of EMERGENCY RESERVES
1A. Switching only plants operating on fuel	Reduction of emissions by 30%. 2 million tons	Existing	10	7.5	3.2	
1B. Switching of 50% of plants operating on coal	Reduction of emissions by 41.4%. 4.1 million tons	Existing. Simple in plants operating on coal/ heavy fuel	420	15.1	6.6	
2. Co-generation	Increase of efficiency from 40% to 60%	Proven and available				Limited market for steam. Effective for water desalination in energy production plants
3. Combined cycle	Increase of efficiency from 40 to more than 60%. 1.3 million tons in scenario 1A. Additional 3.3 million tons in scenario 1B.	Existing. Pending on switching to gas/		In scenario 1A: 5%. In scenario 1B: 12.4%. Total: 17.4%	In scenario 1A: 5%. In scenario 1B: 5.3%. Total: 7.3%	
4. Increase of efficiency in power generation plants.	Increase of 1% per annum	Technology will be developed abroad	*			Reduction of emissions by 2/3 by 2020.

* In conjunction with system replacement and enlargement

A1. Alternatives under development

Alternative	CO ₂ reduction per year	Technology	Cost	Percent of sector's emissions	Percent of total emissions	remarks
Nuclear energy						
Wind energy (1)	Substitution of 6% of current production technology	Existing	Investment of 2000 - 3000 \$	6%	2.6%	
Waste incineration (1)	Substitution of 5% of current production technology	Existing		5%	1%	See chapter 7
Energy towers (1)	Production of all of Israel's electricity needs	Under development	~4000 \$ per kW	100%	43%	
Parabolic mirrors (1)	Production of 25% of Israel's electricity needs	Under development		25%	11%	Requires energy saving system
Solar tower (1)	Production of 25% of Israel's electricity needs	Under development		25%	11%	Requires energy saving system

(1) Data from Zaslavsky's report (1998)

(2) All calculations are based on equivalent for 1996.

B. Reduction of emissions in the industry sector

Alternative	CO ₂ reduction per year ton/ year	Technology	Cost	% of sector's emissions	% of total emissions	remarks
1. Switch to natural gas	maximum potential 3 million tons	Existing		16%	4.8%	Requires distribution system
2. Co-generation	Savings of 1.5 million tons	Existing	Savings in most cases	6.4%	1.9%	Requires agreement with IEC
3. Energy conscious building	Savings up to 30% of consumption for climate control. 1.2 million tons	Requires adaptation and development		6.4%	1.9%	
4. Switch to "dry" process in cement production	Savings of 53% in energy consumption. 2.3 million tons	Existing		12%	3.7%	Switching to "dry" process has begun

F. Reduction of emissions from waste and sewage sludge

Alternative	Efficiency of Methane reduction	Reduction of CO ₂ eq. ton/year	Investment for reducing CO ₂ eq. \$/ton	Percent reduced of sector's emissions	Percent reduced of total emissions	Remarks
Landfilling with gas collection land fill gas flare	50% of methane will be burnt	4 million tons	10	48%	6.5%	Difficult to control
Landfilling with gas collection and energy recovery	50% efficiency	4 million tons	24	48%	6.5%	credit for energy production
Aerobic Composting	Oxidation efficiency 90%	7.2 million tons	9	86%	11.1%	Need for waste classification
Incineration	Oxidation efficiency 100%	8 million tons	195	100%	12.9%	

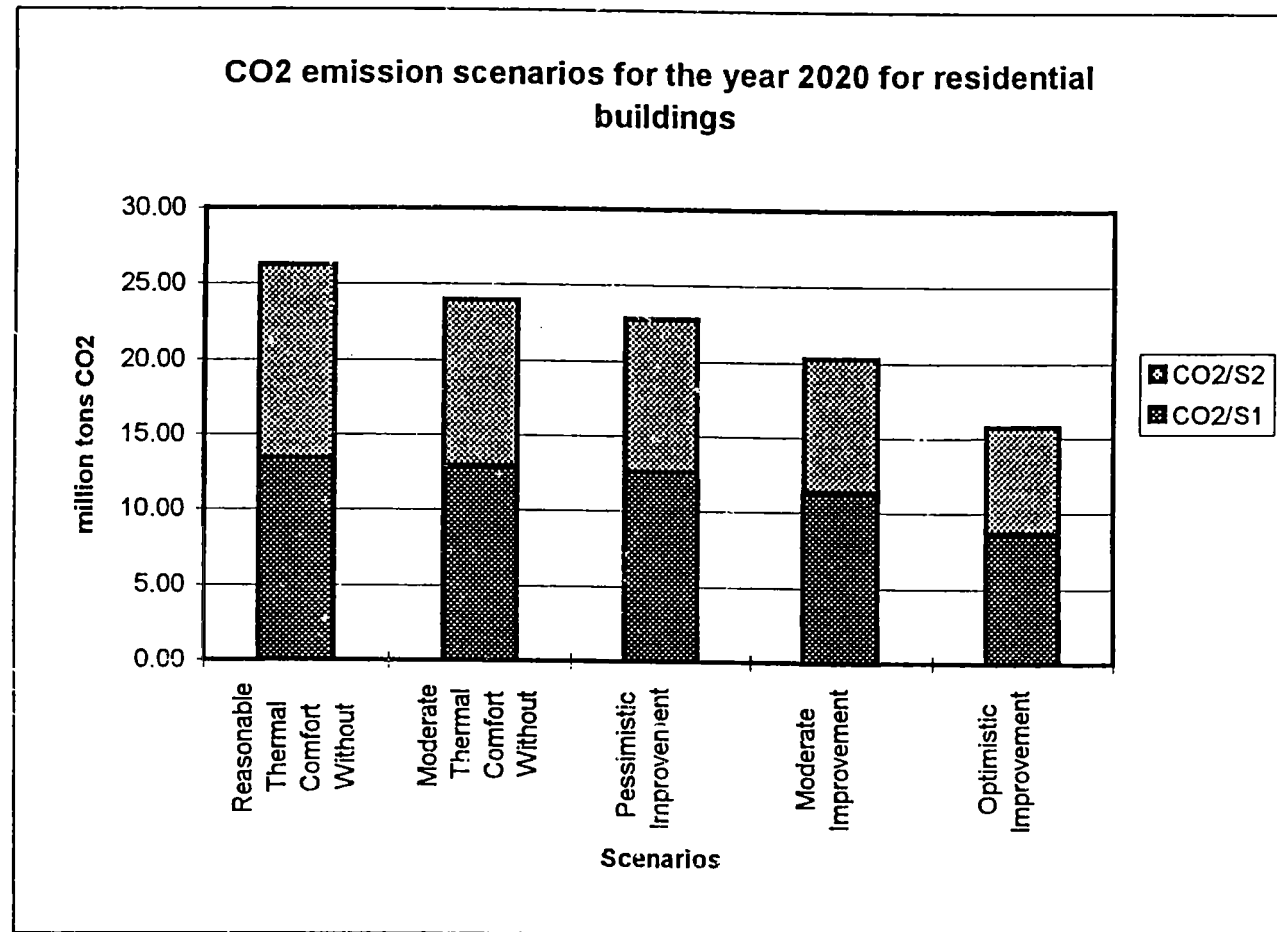
E. Reduction of emissions in the agriculture sector

Alternative	CO ₂ reduction per year ton/year	Technol.	Cost	Percent of sector's emissions	Percent of total emissions	remarks
10% increase in crop coverage	million tons	Existing	Depends on agriculture policy		0.8%	Serves other national aims - preserving open space.
10% decrease in crop coverage	Increase emissions by 0.5 million tons					
Minimal tillage, 25% of land	2 million tons during 10 years	Existing	Usually saves expenses for farmers		0.3%	
Improved feeding cattle	8000 tons methane, 0.2 million tons CO ₂	Existing		0.3%		
Improved manure handling	2500 tons methane, 0.1 million tons CO ₂	Existing		0.16%		
Improved fertilizer application	1200 tons N ₂ O, 0.4 million tons CO ₂	Existing, requires improvements		0.6%		

C. Reduction of emissions from energy for buildings

Alternative	CO ₂ reduction per year ton/ year	Technology	Cost	% of sector's emissions	% of total emissions	remarks
1. Improvements in electricity appliances	No increase in electricity consumption despite increase in use	based on development abroad	no investment			
2. Energy conscious building. (set of measures)	Reduction of emissions of 20 - 40%, 1 - 2 million tons. (Up to 10 million tons in the year 2020)	Existing. Requires adaptation and development.	Investment of 0.5 - 3 NIS per savings of one kWh/year.	6 - 12% (up to 10% in 2020)	1.6 - 3.2% (up to 40% in 2020)	Energy consumption for climate control is expected to grow significantly
3. Co-generation in public and business complexes	Reduction of energy consumption for heating and cooling of more than 50%.	Existing	Financial savings			

Figure 4.3: Potential CO₂ emissions savings in the residential sector. *S1* and *S2* refer to existing buildings and new buildings respectively in table 5.6.



Range and average effect of energy savings potential of planning parameters in buildings. *The list is arranged according to the expected energy savings in residences (Kwh per sqm floor per year)*

		Residential			Public
		Mountain		Coastal plain	Coastal plain
+ shading: windows in summer (external)	10-12	11	18-29	24	24
0 non-shading: windows in winter	9-26	18	3-25	14	
+ insulation: roof	18	18	13	13	7
+ passive solar energy (southern window & shutter)	5-35	20	3-12	8	
+ sealing against air infiltration	15-25	20	3-15	9	
+ insulation: hanging floor	15	15	11	11	
0 building orientation	5-16	11	3-14	9	
0 thermal mass	8-15	12	5-10	8	4
+ insulation: walls	5-15	10	3-15	9	
+ night ventilation: natural and artificial	5-15	10	5-10	8	
- surface area to volume ratio	5-16	10	5-8	7	
+ comfort ventilation: natural and artificial	5-10	8	5-10	8	
- size of windows facing east and west (with shutter)	3-7	5	3-17	10	
0 color: roof	5-7	6	7-10	9	
0 solar building orientation	2-15	9	2-6	4	
0 solar building proportions	1-15	8	1-3	2	
- size of windows facing north (with shutter)	1-3	2	4-8	6	
+ shading: roof			3-5	4	10
0 non shading: roof	3-5	4			
+ type of glazing: double versus single	3-5	4	2-4	3	
0 color: walls	1-5	3	1-5	3	
+ non shading: walls	1-5	3	1-2	2	
0 proportions	1-3	2	1-3	2	

Legend

- + higher cost
- 0 identical cost
- lower cost

Table 4.6: CO2 emission scenarios for residential buildings in the year 2020 (in million tons)

Scenario	Reasonable Thermal Comfort Without measures	Moderate Thermal Comfort Without Measures	Pessimistic Improvement	Moderate Improvement	Optimistic Improvement
CO ₂ from existing buildings	13.45	12.95	12.62	11.29	8.63
CO ₂ from new buildings	12.78	10.99	10.16	8.96	7.10
Total emission	26.23	23.94	22.78	20.25	15.73



United States Department of State

Bureau of Oceans and International
Environmental and Scientific Affairs

Washington, D.C. 20520

FAX MESSAGE

TO: Joe Aldy, CEA
Joe Kruger, EPA
Abe Harpel, DOE Date: 4-6-00

Fax Number: 395-6958
565-6673 No. of Pages: 3
586-8177

Message:

*please deliver to
addressee.*

Revised Schedule.

FROM:

Susan C. Gordon
Senior Advisor for Environment
Telephone: 202-647-3253
Fax: 202-647-0191
EMAIL: gordonsc@state.gov

STATE OF ISRAEL
MINISTRY OF THE ENVIRONMENT

INTERNATIONAL RELATIONS & SPECIAL PROJECTS

P.O.B. 34033, Jerusalem 95464 Tel: 972 2 6553745/6 Fax: 972 2 6553752

Climate Change Workshop

9-12 April 2000

to be held at the Jerusalem Institute for Israel Studies

Teddy Kollek Hall, 20 Radak Street, Rehavia

Jerusalem

Sunday, 9 April 2000

10:00	Pick up delegation from Hilton Hotel, Jerusalem. Proceed to Tel Aviv
11:30-13:30	Meeting at the Manufacturers Association of Israel with Yossi Arie, Director, Chemistry, Pharmaceuticals & Environment and reps from Nesher, Israel Chemicals, Machteshim, and Oil Refineries
15:00-16:30	Preparatory Meeting at the Ministry of Environment
TBD	Return to Hilton Hotel, Jerusalem
1930	Informal dinner with Ministry of Environment staff & of Ministry of National Infrastructure DG Yaakov Efrati, ??? Restaurant, Jerusalem
RON	Hilton Hotel, Jerusalem

Monday, 10 April

09:00	Pick up delegation at Hilton Hotel Jerusalem. Proceed to Embassy.
10:30	Meeting with/pre-briefing for DCM Richard Roth
12:30-13:30	Meeting at Israel Union for Environmental Defense, with Danny Fisch, Director, 7 Carlebach, Tel Aviv
16:00-18:00	Tour of Jerusalem (Old City)
RON	Hilton Hotel, Jerusalem

Tuesday, 11 April 2000

8:30-9:00	Registration and coffee
9:00-9:20	Opening remarks - Mr Yitzhak Goren, Director General, Ministry of the Environment (MoE)
9:20-9:50	Presentation of Neeman Institute document (Technion and Haifa University) - mitigation options
10:20-10:45	Presentation of Jerusalem Institute for Israel Studies and Arava Institute document - policy recommendations
10:45-11:45	Economics and the Kyoto Protocol: Implications of the Flexibility Mechanisms
11:45-12:45	US Domestic Actions
12:45-13:00	Coffee break
13:00-14:00	Discussion lead by Director General, MoE
14:00	Light lunch
PM	Meeting with officials from Ministries of Finance and National Infrastructures
RON	Hilton Hotel, Jerusalem

Wednesday, April 12

8:30-9:00	Registration and coffee
9:00-9:20	Opening - Dr Miki Haran, Deputy Director General, Hazardous Substances, MoE - Climate Change Convention and Kyoto Protocol
9:20-9:50	Presentation of Neeman Institute document - mitigation options
9:50-10:20	Presentation of Jerusalem Institute for Israel Studies and Arava Institute document - policy recommendations
10:20-10:45	Coffee break
10:45-11:45	Economics and the Kyoto Protocol: Implications of the Flexibility Mechanisms
11:45-12:45	US Domestic Actions
12:45-13:00	Coffee break
13:00-14:00	Discussion, inter-ministerial committee on Climate Change
14:00	Light lunch
TBD	Tower of David Museum, Chihuly Exhibit
RON	Hilton Hotel, Jerusalem



United States Department of State

Bureau of Oceans and International
Environmental and Scientific Affairs

Washington, D.C. 20520

FAX MESSAGE

TO: Joe Aldy, CEA
Joe Kruger, EPA
Alfred Kessel, DOE Date: 4-4-00
395-6958
Fax Number: 565-2141 No. of Pages: 3 4
586-8177

Message:

*please deliver
to addresses above*

FROM:

Susan C. Gordon
Senior Advisor for Environment
Telephone: 202-647-3253
Fax: 202-647-0191
EMAIL: gordonsc@state.gov

April 4, 2000

NOTE TO: **Joe Aldy, CEA (395-6870)**
 Abe Haspel, DOE (586-8177)
 Joe Kruger, EPA (565-2141)

Please find attached a preliminary draft of the agenda for the Climate Change Workshop to be held in Jerusalem, 11-12 April. Our EST Officer, Bill Crane, advises that the Israelis have requested that we concentrate on:

- Economic Issues associated with the Protocol. This would be the Joe Aldy presentation. We have suggested that the item be re-titled: Economics of the KP and Implications of the Flexibility Mechanisms.
- What the U.S. is doing domestically. This would present the opportunity to talk about domestic trading (SO₂, and considerations about "early action"), the CCTI and our voluntary programs, and recent Presidential Initiatives (such as tax credits, R & D, etc.). We would look to Joe, Joe, and Abe (or other DOE rep.) to cover this second hour. (Let's meet either Saturday afternoon or Sunday in Jerusalem to sketch out our approach, and decide who will cover what.)

As Mark advised us earlier, the first day of the workshop will address government policy makers. The second day will include NGOs, and possibly the press (we are checking on that).

The Israelis and Bill Crane will now begin to flesh out other aspects of our schedule.

Tentatively, we will have some sort of field event on Sunday. There is the possibility of visiting a near-by Kibbutz that has an environmental education focus. We will have a small dinner meeting on Sunday with key Environment Ministry staff.

On Monday, we will meet with a group of industry representatives. I have also asked for a meeting with a well known Israeli (and American) environmentalist, Phillip Warburg. We will brief the CDM or Ambassador in Tel Aviv.

The Israelis would like to arrange a session after lunch on Tuesday (4/11) with senior officials from other ministries. (We will also have a Wednesday afternoon session with the working level inter-ministerial committee on Climate Change.)

Wednesday's program would be followed by a debrief of the DCM/Ambassador in Tel Aviv.

While nothing is scheduled for the remainder of the week, for those of us staying on, we have will have the opportunity to accept follow-on meetings as appropriate.

Page 2
USDEL to Israel

I will touch base with each of you today or tomorrow morning to provide you with logistical information for the trip. The Embassy has made our hotel reservations at the Jerusalem Hilton Hotel. The country clearance cable is going out today. (If anyone needs a copy, please call Denise Goode at 647-4069.)

Once everyone's schedule is set, I will suggest a time and place for a delegation planning meeting in Jerusalem (probably Sunday).

Re: handouts. Joe K.—I am bringing along some EPA climate change outreach materials (from Julie S. shop). You may also want to grab some of the Energy-wise material. Ditto for DOE. Do we have any CCTI information?

Susan C. Gordon
Senior Advisor for Environment

cc: Ambassador Hambley

STATE OF ISRAEL
MINISTRY OF THE ENVIRONMENT

INTERNATIONAL RELATIONS & SPECIAL PROJECTS

P.O.B. 34033, Jerusalem 95464 Tel: 972 2 6553745/6 Fax: 972 2 6553752

Climate Change Workshop

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- 10:20-10:45 Presentation of Jerusalem Institute for Israel Studies and Arava Institute document - policy recommendations
- 10:45-11:45 Flexibility mechanisms and economical implications of the Kyoto Protocol
- 11:45-12:45 US policy
- 12:45-13:00 Coffee break
- 13:00-14:00 Discussion lead by Director General, MoE
- 14:00 Light lunch

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- 12:45-13:00 Coffee break
- 13:00-14:00 Discussion, inter-ministerial committee on Climate Change
- 14:00 Light lunch

late afternoon: Debut - Embassy, Tel Aviv



United States Department of State

Bureau of Oceans and International
Environmental and Scientific Affairs

Washington, D.C. 20520

FAX MESSAGE

TO: Joe Aldy, OEA 565-6673
Joe Krieger, EPA 5
Mike Naspel, DOE Date: 4-1-00
395-6958
Fax Number: 586-8177 No. of Pages: 3 5

Message:

*please deliver
to addresses above*

*Revised Israel
Itinerary*

FROM:

Susan C. Gordon
Senior Advisor for Environment
Telephone: 202-647-3253
Fax: 202-647-0191
EMAIL: gordonsc@state.gov

Gordon, Susan C (OES)

From: Crane, William H
Sent: Wednesday, April 05, 2000 9:56 AM
To: Gordon, Susan C (OES); DeRosa, Barbara M (OES)
Cc: Schwartz, Deborah R; Butchart, Jenny P; Wylie, Cecilia W; Regelman, Sharon E; DaSilva, Denise A
Subject: Climate Change Workshop

Susan,

I spoke again with Ronnie Cohen, and here's what the schedule looks like:

SUNDAY 9 APRIL

1130 Meeting with Manufacturers' Association of Israel
Tel Aviv (Embassy car & driver will pick up at hotel)

1600 Guided tour of Jerusalem Old City

TBD Informal dinner with Ministry of Environment staff, Jerusalem

MONDAY 10 APRIL

0900 Pick up from hotel

1030 ~~TENTATIVE~~ Meeting with/pre-briefing of DCM Richard Roth,
Embassy Tel Aviv.

PM Meeting with Phillip Warburg, Society for the Protection of
Nature in Israel

TUESDAY 11 APRIL

0830 Workshop

PM TBD Meeting with reps from Ministries of Finance and National Infrastructures (NB: If this can't be arranged,
alternative time would be Monday PM in Jerusalem after Warburg meeting)

WEDNESDAY 12 APRIL

0830 Workshop

Ronnie will re-title the two workshop sections as we discussed. I will forward via separate email the list of each day's participants provided by Ronnie.

Your country clearance cable was received and our response should be transmitted today.

Regards,

Bill

List of invitees, 11 April 2000 - Climate Change Workshop

Ministry of Infrastructure	Yaakov Efrati	Director General
Ministry of Infrastructure	Eli Ronen	Deputy Director General
Ministry of Infrastructure	David Sugarman	Head, Environment Section
Ministry of Infrastructure	Shlomo Brovender	Director, Electric Authority
Ministry of Finance	Avi Ben Bassat	Director General
Ministry of Finance	Ronen Wolfman	Deputy to Budget Coordinator
Ministry of Finance	Shaul Tzemach	Energy Coordinator
Ministry of Finance	Avi Geffen	Deputy to Budget Coordinator
Ministry of Finance	Tzipi Gal-Yam	Director Division of Economics
Ministry of Finance	Danny Katarcvas	Director, Division of Int'l Relations
Ministry of Industry	Reuven Horesh	Director General
Ministry of Industry	Zohar Perry	Director, Foreign Trade
Ministry of Industry	Ohad Orenstein	Director, Chemistry
Ministry of FA	Eitan Bentzur	Director General
Ministry of For. Affairs	Yitzhak Lior	Deputy Director General, Int'l Org
Ministry of Transport	Benzion Salman	Director General
Ministry of Transport	Zvi Yoznat	Deputy Director General, Traffic
Ministry of Transport	Alex Langer	Deputy Director General, Land
Prime Minister's Office	Yair Cohen	Senior Advisor, Economics
Ministry of Environment	Yitzhak Goren	Director General
Ministry of Environment	Miki Hara	Deputy Director General
Ministry of Environment	Shuli Nezer	Director, Air Quality Division
Ministry of Environment	Yaron Arnon	Director, Division of Economics
Ministry of Environment	Rana Samuels	Assistant, Deputy Director General
Ministry of Environment	Ronnie Cohen	Foreign Relations Coordinator

Invitees - 12 April 2000- Climate Change Workshop

Position	Name	Place of Work
Head, Agriculture & Environment	Miriam Waldman	Ministry of Science
	Zvika Avni	Jewish National Fund
Director, Meteorology Authority	Zvi Alferson	Ministry of Transport
	Jan Koch	Sorek Nuclear Research Center
Director	Uriel Safriel	Desert Research Center, Ben Gurion University
Deputy Director General	Zeev Golan	Center for Strategic Studies
Director, Water and Soils Institute	Shabtai Cohen	Agricultural Research Authority
Chairman	Alon Tal	"Life and Environment"
Deputy Director General, Infrastructure	Yossi Inbar	Ministry of the Environment
Legal Adviser	Ruth Rotenberg	Ministry of the Environment
Lawyer	Ayelet Ben Ami	Ministry of the Environment
Director, Division of Planning	Valerie Brachya	Ministry of the Environment
Coordinator, Sustainable Development	Yossi Gamlieli	Ministry of the Environment
Director, Division of International Relations	Ori Gonen	Ministry of the Environment
	Aharon Sahar	Israel Electric Company
Science Division	Geula Sharf	Israel Union for Environmental Defense
Legal Division	Keren Shahr Ben Ami	Ministry of Foreign Affairs
Dept of Geography	Uri Dayan	Hebrew University
Director	Eilon Shwartz	Heschel Center
Director	Eyal Yadv	Transportation Today and Tomorrow
	Office of the Director General	Society for the Protection of Nature
Transportation Consultant	Yaakov Garb	
Director, Environment Division	Yossi Arie	Manufacturer's Association
	Limor Lestingzon	Manufacturer's Association
Head of Environmental	Mordechai Schechter	Haifa University

Rescarch Center		
Environment	Alona Vardi	"Shatil"
Representative in Israel	Claude Weinber	Heinrich Boll Foundation
	Eran	Megama Yeruka (Student Movement)
Director, Israel	Gidon Brumberg	Friends of the Earth Middle East
Director, Israel	Ofer Ben Dov	Greenpeace

~~5426~~

5804

Israel

mandat 1: from env ministry

conclusions from natl comm

env ministry strongly support target (esp #2)

Secy Richardson did not raise GCC in formal talks

(but perhaps informally)

Team - Hambley - lead, incl others

mandat 2: proposed plan

want to use '96 as baseline, not '90 (bc of pop growth)

get email address of technical contact

nbecher@econ.haifa.ac.il - Nir Becher

workshop - 4/11 - 4/12

4/11 - brig in #23 from Transport, Finance, Infrastructure, Ag,

Bank of Israel, other ministries

→ focus on economic benefits from our side, + how to set tgt

→ Israel will present their action plan

→ how tgt could affect OECD accession

→ explain trading mechanisms (EPA) - eg SO₂

meet w/ Finance ministry in advance

concerned that turn-out may be low

Renewables, + waste ^{solid} → methane

↳ 50% of waste is organic, considering waste incineration

Options - (A), wind (but bad contracts), waste incineration, energy towers,
parabolic mirrors (solar)

Israel

get coal from US, Aus, SAfr

- 2 power ^(coal) plants, expect to build 1 new plant in next 10 yrs (may be coal or nat gas)

Day 2

audience much broader - press, public, NGOs
some science, background

be prepared to commit ^{their} strategy

lv Sat, or Sun - stay this week

Israel 4/3 mtg

Richardson visit w/ Barak - positive mtg

Env Ministry enthusiastic

Purpose of trip is to explain benefits of taking on a fight
Don't focus on CDM

Will be meeting w/ Secy Generals (#2,3 in depts)

OECD issue

Benefits from trading for Israel

Coal from US, Australia, S. Africa

Nat gas supplies (Gaza, Egypt)

CH₄ emis (landfills)

AQ co-benefits - clean air, clean H₂O key issues in Israel, not GCC

Renewables - wind, solar (in res uses, but just for H₂O)

Argentina + Israel have been in contact

Env minister Dalia Itzik

Workshop - day 1 - focus on econ issues

Israel presentation

an response, targets, US experience w/ trading

energy efficiency + renewable energy

day 2 - open to media, larger audience

? envl technology industry

Side meetings

- Min of Finance (+ maybe Bank of Israel)

- business community

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Printed By: Mark G Hambley 03/20/2000 11:35:52 AM

TEL AVIV 1483

From: AMEMBASSY TEL AVIV
Subject: AMBASSADOR HAMBLEY DISCUSSES CLIMATE CHANGE IN ISRAEL
MRN: 1483
ICNbr: TED4930

Date/Time: 171243Z MAR 00
Precedence: ROUTINE

Cable Text:

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ACTION NEA-01

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	UTED-00	VC-01	FRB-00	H-01	TEDE-00	INR-00	IO-00
	ITC-01	JUSE-00	L-00	VCE-00	NASA-01	AC-01	NSAE-00
	NSF-01	OES-01	OIC-02	OMB-01	OPIC-01	PA-00	PM-00
	PRS-00	ACE-00	P-00	SCT-00	SP-00	SSO-00	SS-00
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DEPT OF ENERGY WASHDC
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FOR NEA/IAI AND NEA/PPR

FOR OES-AMBASSADOR MARK HAMBLEY/SUSAN GORDON AND OES/EGC

WHITE HOUSE FOR CEA-JOSEPH ALDY

FOR USDOE-DR ABRAHAM HASPEL
AMMAN FOR REGIONAL ENVIRONMENT HUB-GEORGE SIBLEY

E.O. 12958: N/A
TAGS: SENV, ECON, ECIN, ETRD, PREL, TSPL, IS
SUBJECT: AMBASSADOR HAMBLEY DISCUSSES CLIMATE CHANGE IN ISRAEL

REF: TEL AVIV 001419

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1. AMBASSADOR MARK HAMBLEY, SPECIAL REPRESENTATIVE TO THE UN COMMISSION ON SUSTAINABLE DEVELOPMENT, VISITED ISRAEL ON 15-17 MARCH AT THE INVITATION OF THE MINISTRY OF ENVIRONMENT FOR DISCUSSIONS ON GLOBAL CLIMATE CHANGE. ISRAEL HAS BEEN A PARTY TO THE UN FRAMEWORK CONVENTION ON CLIMATE CHANGE SINCE MAY 1996, AND A SIGNATORY TO THE KYOTO PROTOCOL SINCE DECEMBER 1998. THE ENVIRONMENT MINISTRY HAS ESTABLISHED AN INTER-MINISTERIAL COMMITTEE ON CLIMATE CHANGE TO EXAMINE WAYS IN WHICH ISRAEL CAN "FULFILL ITS OBLIGATIONS FOR REDUCING GREENHOUSE GAS EMISSION IN(TO) THE ATMOSPHERE".

2. THE ENVIRONMENT MINISTRY WILL HOST A WORKSHOP ON 11-12 APRIL TO CONSIDER HOW ISRAEL (A DEVELOPING COUNTRY UNDER THE FRAMEWORK CONVENTION) CAN CUT OR LIMIT EMISSIONS OF GREENHOUSE GASES (GHG) OVER THE NEXT 10-15 YEARS, INCLUDING THE POSSIBILITY OF TAKING ON A BINDING TARGET UNDER KYOTO IN A VOLUNTARY MANNER. AMBASSADOR HAMBLEY WAS INVITED TO ISRAEL TO SHARE US EXPERIENCE AND VIEWS AS A PARTY TO THE FRAMEWORK CONVENTION ON CLIMATE CHANGE, AND TO RELATE THE STATUS OF INTERNATIONAL DISCUSSIONS IN THE RUN-UP TO THE SIXTH CONFERENCE OF THE PARTIES (COP-6) IN NOVEMBER. THE ENVIRONMENT MINISTRY HAS ALSO INVITED AMBASSADOR HAMBLEY AND A SMALL U.S. DELEGATION TO PARTICIPATE IN THE APRIL WORKSHOP.

3. AMBASSADOR HAMBLEY MET WITH ENVIRONMENT MINISTRY OFFICIALS, NGO REPRESENTATIVES, ACADEMICS, OFFICIALS FROM THE MINISTRIES OF NATIONAL INFRASTRUCTURES, TRANSPORTATION, AND FOREIGN AFFAIRS, AND WITH REPRESENTATIVES OF THE MANUFACTURERS' ASSOCIATION OF ISRAEL AND OF THE ISRAEL ELECTRIC COMPANY (THE STATE-OWNED, MONOPOLY ELECTRICITY SUPPLIER). HE EXPLAINED HOW THE STATE DEPARTMENT CO-ORDINATED THE EFFORTS OF AN INTER-DEPARTMENTAL/AGENCY TEAM RESPONSIBLE FOR OUR INTERNATIONAL EFFORTS ON THE ISSUE OF CLIMATE CHANGE AND DISCUSSED SOME OF THE BENEFITS WHICH MIGHT ACCRUE TO A COUNTRY ADOPTING A BINDING COMMITMENT.

4. THE ENVIRONMENT MINISTRY PRESENTED TWO COMPREHENSIVE STUDIES (STILL IN DRAFT) IT HAS FUNDED TO LOOK AT GHG MITIGATION OPTIONS (BY THE NE'EMAN INSTITUTE AT THE TECHNION), AND A CONCOMITANT SET OF POLICY RECOMMENDATIONS (BY THE JERUSALEM INSTITUTE OF ISRAEL STUDIES). THE STUDIES ARE RIGOROUS AND PROFESSIONAL, AND PROPOSE A RELATIVELY AMBITIOUS TARGET TO REDUCE GHG EMISSIONS BY THE PERIOD 2010-2015. THE APRIL WORKSHOP WILL USE THESE TWO STUDIES TO GUIDE A DISCUSSION OF:

--HOW ISRAEL MIGHT VOLUNTARILY TAKE ON A BINDING TARGET FOR GHG MITIGATION;

-- WHAT SUCH A TARGET MIGHT BE;

-- THE COSTS AND BENEFITS TO ISRAEL OF ADOPTING A TARGET; AND

-- HOW THIS MIGHT AFFECT ISRAEL'S PARTICIPATION IN THE

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VARIOUS MECHANISMS TO BE DISCUSSED AT COP-6 (JOINT IMPLEMENTATION, EMISSIONS TRADING, AND THE CLEAN DEVELOPMENT MECHANISM).

5. AMBASSADOR HAMBLEY'S BRIEF VISIT CONVINCED THE ISRAELIS THAT THEY CAN LEARN FROM THE US EXPERIENCE OF AND APPROACH TO CLIMATE CHANGE ISSUES. THEY LOOK FORWARD TO THE US TEAM'S PARTICIPATION IN THE APRIL CLIMATE CHANGE WORKSHOP, AND TO WORKING WITH THE UNITED STATES IN THE INTERNATIONAL CLIMATE CHANGE EFFORT.

6. AMBASSADOR HAMBLEY CLEARED THIS CABLE PRIOR TO HIS DEPARTURE FROM ISRAEL

INDYK
NNNN

End Cable Text

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STATE OF ISRAEL
MINISTRY OF THE ENVIRONMENT
Division of International Relations

P.O.Box 34033
JERUSALEM 95464
email: ronyg@environment.gov.il

TEL: 972-2-6553745
FAX: 972-2-6553752

FACSIMILE TRANSMISSION

ATT: Joseph E Aldy

FAX NO.: Executive Office of the President: 202 3956870

FROM: Ronnie Cohen-Ginat

DATE: 9 February 2000

NO. OF PAGES (INCLUDING THIS PAGE):
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RE: Climate Change Workshop

Dear Mr Aldy,

I was very pleased to receive your email and I would like to thank you for your willingness to assist us. We have decided to arrange our workshop from 11-13 April 2000 for Israeli professionals and decision makers. Hopefully, this will be a convenient time for you.

Sharon Regelman from the American Embassy in Tel Aviv phoned me recently and I hoped she would be able to assist me in getting together the various American contacts I had approached. I have written to Ambassador Hambley, Dr Abraham Haspel, Mr Michael Rucker, and Mr Elmer Holt regarding the workshop and have received replies from them.

Would you tell me who you had in mind when you mentioned a US technical team visiting Israel. We would like to learn from your experience regarding domestic policy for the reduction of greenhouse gas emissions, the means you take for meeting your obligations within the framework of the Kyoto Protocol, the economic implications of the flexibility mechanisms, the economic advantages for developed countries. Israel is considered a developing country in the framework of the Climate Change Convention and we are considering taking on voluntary commitment and would like to investigate the implications..

Thanking you again for your consideration.

Sincerely yours,


Ronnie Cohen



Joseph E. Aldy
02/03/2000 10:52:05 AM

Record Type: Record

To: ronyg@environment.gov.il @ inet

cc:

Subject: climate change workshop

Dear Ms. Cohen,

I very much appreciate the invitation to participate in your workshop on the economic implications of climate change issues in Israel. Based on a conversation I had earlier this week with a colleague from the Department of State, I understand that the workshop you have envisioned may be postponed until April or May. If this is the case, may I suggest that it would still be productive for a U.S. technical team to visit Israel in the near term to share with you our experience in assessing the important analytic and technical issues that can inform decisions regarding climate change policy. Such a meeting may facilitate your efforts to focus on key issues to Israel for your workshop. While I would still need to coordinate with several colleagues here in the U.S. who would likely participate in such a meeting, I believe some time in mid to late March would work for us. I should also note that we will gladly participate in the workshop you have in mind as well.

I look forward to the opportunity for us to work together and I believe that such cooperation will benefit both our countries.

Joe Aldy
Senior Economist for the Environment and Natural Resources
Council of Economic Advisers
Old Executive Office Building, Room 319
Washington, DC 20502
202-395-1455 (voice)
202-395-6870 (fax)
joseph_e._aldy@cea.eop.gov

**STATE OF ISRAEL
MINISTRY OF THE ENVIRONMENT**

Division of International Relations

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**TEL: 972-2-6553745
FAX: 972-2-6553752**

FACSIMILE TRANSMISSION

ATT: Joseph E Aldy

FAX NO.: Executive Office of the President, 202 3956870

FROM: (Ms) Ronnie Cohen-Ginat

DATE: 11 January 2000

NO. OF PAGES (INCLUDING THIS PAGE):

Please notify us if transmission is incomplete

RE: Climate Change Convention

Dear Mr Aldy,

I received your card from Ms Shuli Nezer, Director, Division of Air Quality, who was at the COP5 meeting in Bonn recently.

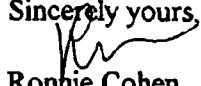
The State of Israel is considered a developing country within the framework of the Climate Change Convention and we are investigating the possibility of taking on voluntary commitment. I have been in contact with Dr Abraham Haspel and Mr Elmer Holt from the Department of Energy to request information that could be useful for us as we weigh the advantages and disadvantages of such a commitment.

We hope to arrange a two-day workshop for relevant Israeli professionals during the month of March on the subject of the economic implications of the Kyoto Protocol for Israel. The professional experience and input of American experts would be very beneficial for meeting the objectives of the meeting by providing a wider view of the pertinent issues to be discussed.

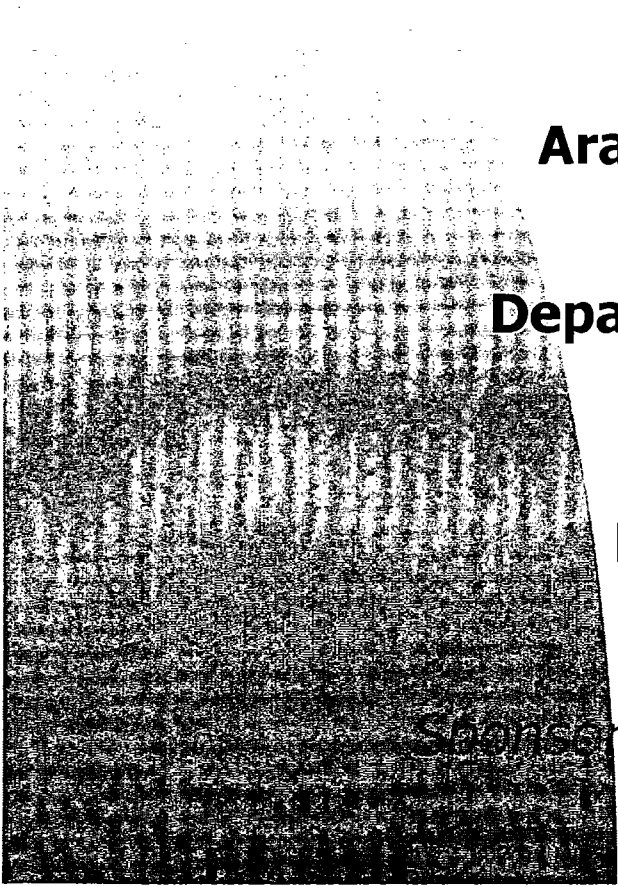
It would be appreciated if you could suggest sources of information that could assist us during the decision making process. Would you consider visiting Israel in order to participate in a workshop and give a presentation? If so, please let me know what dates would be convenient for you during the month of March.

I would like to thank you in advance for your consideration and I look forward to hearing from you.

Sincerely yours,


**Ronnie Cohen
International Relations**

**c: Shuli Nezer, Director, Air Quality Division
Yaron Arnon, Director, Division of Economics and Standards**



Climate Change / Israel

Proposing a National Climate Change Action Plan for Israel

Noam Gressel

Arava Institute for Environmental Studies

Nir Becker

**Department of Natural Resources & Environmental
Management, University of Haifa**

Doron Lavee

Lavee Economic Consulting & Investment

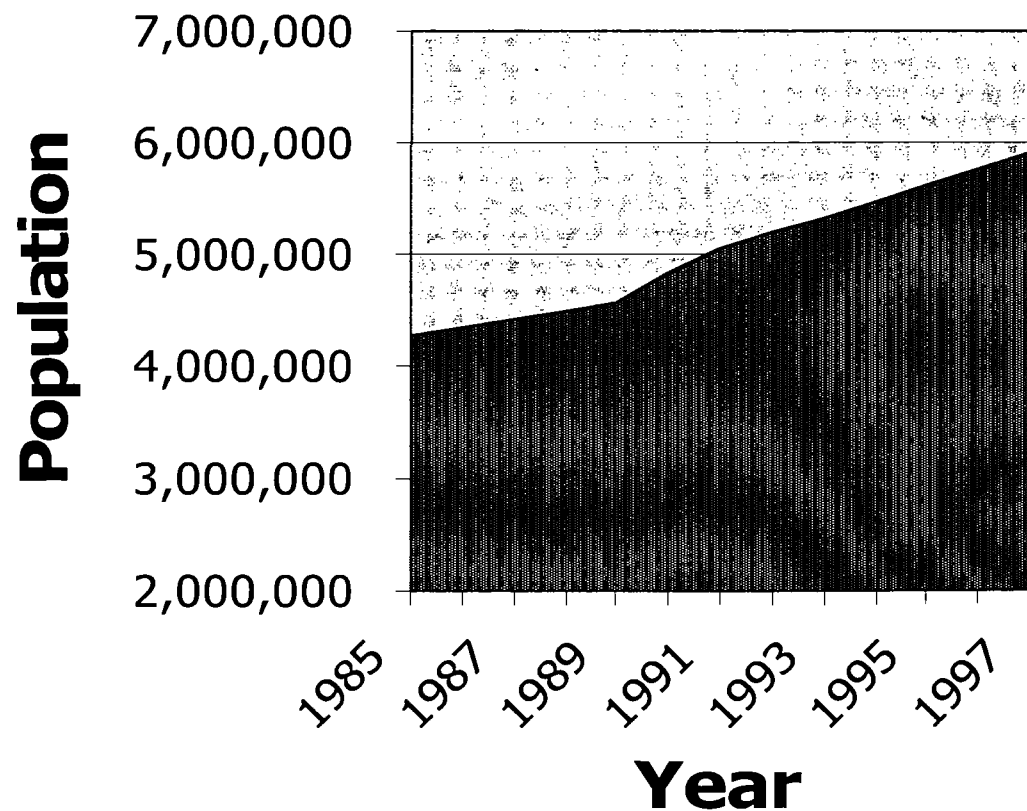
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Ministry of Environment, Israel*

Climate Change / Israel

Population Growth: 1985-1997

***Immigration as %
of total growth:***

1983-89 5.9%
1990-96 54.2%



Climate Change / Israel

GHG Emissions Inventory, 1996

Sector	CO₂ Emissions	CH₄ Emissions	N₂O Emissions	Total
(Ktons CO ₂ eq. For 100 years)				
Energy				
Production	1,500		170	1,670
Industrial Use	18,700		7	18,707
Transportation	10,300		35	10,335
Domestic Use	16,500		15	16,515
				-
Industry			540	540
Cement	1,700			1,700
				-
Forestry	-400			-400
Agriculture	2,500	900	1,200	4,600
Solid Waste		7,800		7,800
Wastewater Treatment		200		200
Total	50,800	8,900	1,967	61,667

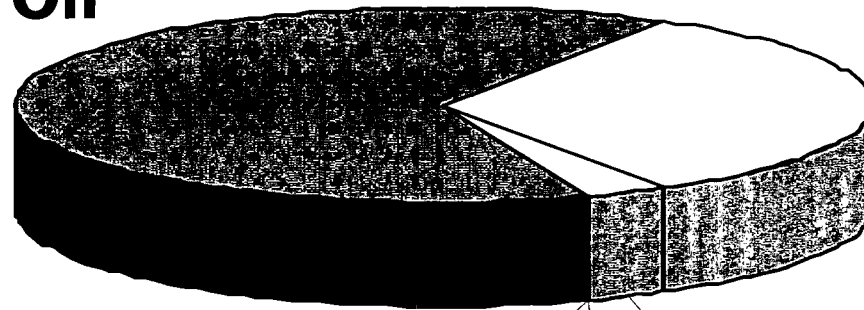
CO₂ Emissions for 1990: 36,160 Kt

Climate Change / Israel

Energy Sources in Israel, 1996

Crude Oil

יל זונקס
64%



Coal

סחפ
33%

Solar

שמש
3.1%

Nat. Gas

טבט ג
0.1%

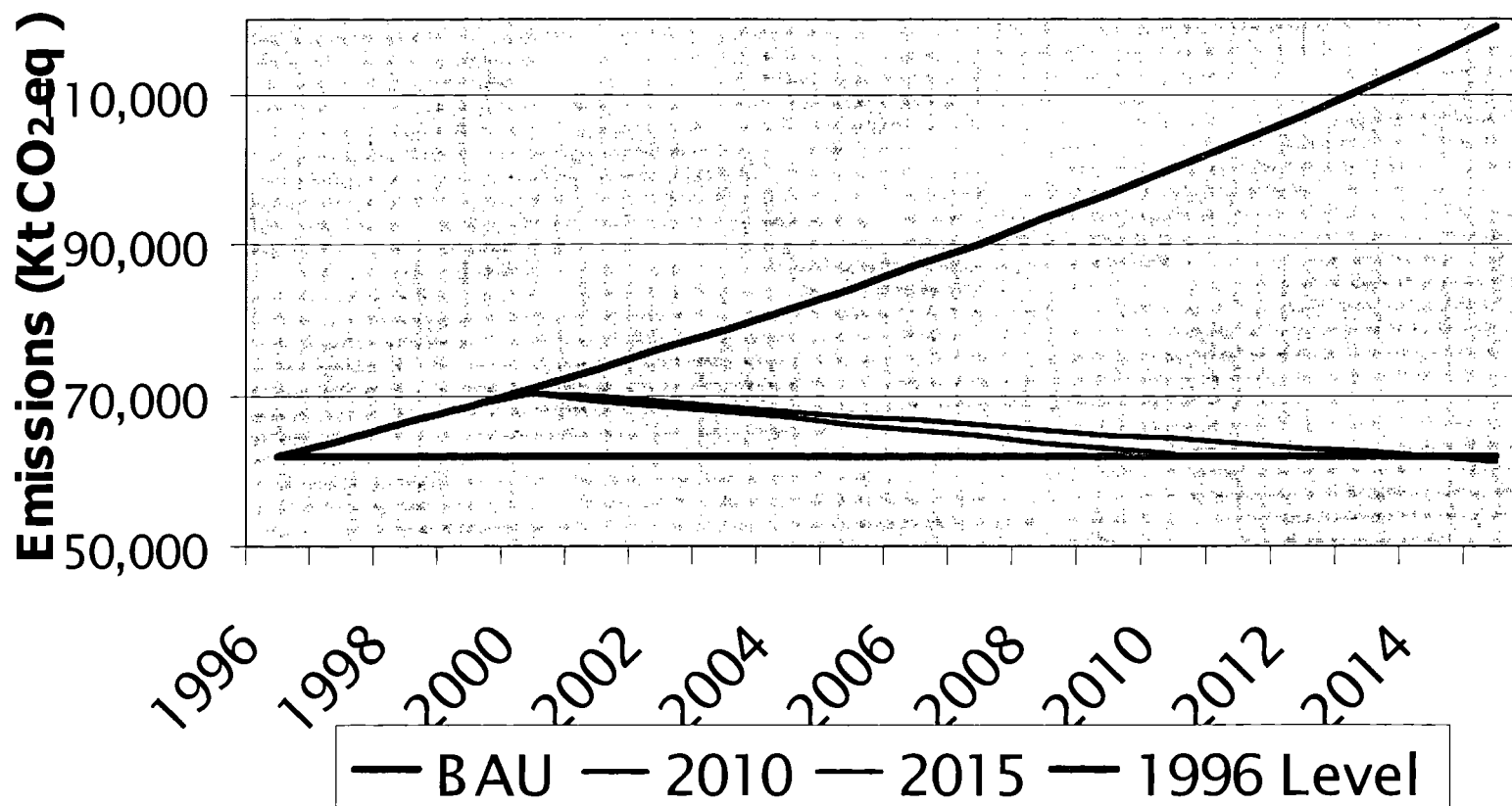
העמוב, חר
ס יחאו

0%

Alternatives

Climate Change / Israel

**Baseline Scenarios for Carbon emissions:
Business as Usual and target years 2010 & 2015**



Climate Change / Israel

Assumptions for GHG Reduction Analysis

Population Growth Rate: 2.5%

GHG Emissions Growth Rate: 3.5%

**Existing Policy: Conversion to Natural Gas
Methane treatment in disposal sites**

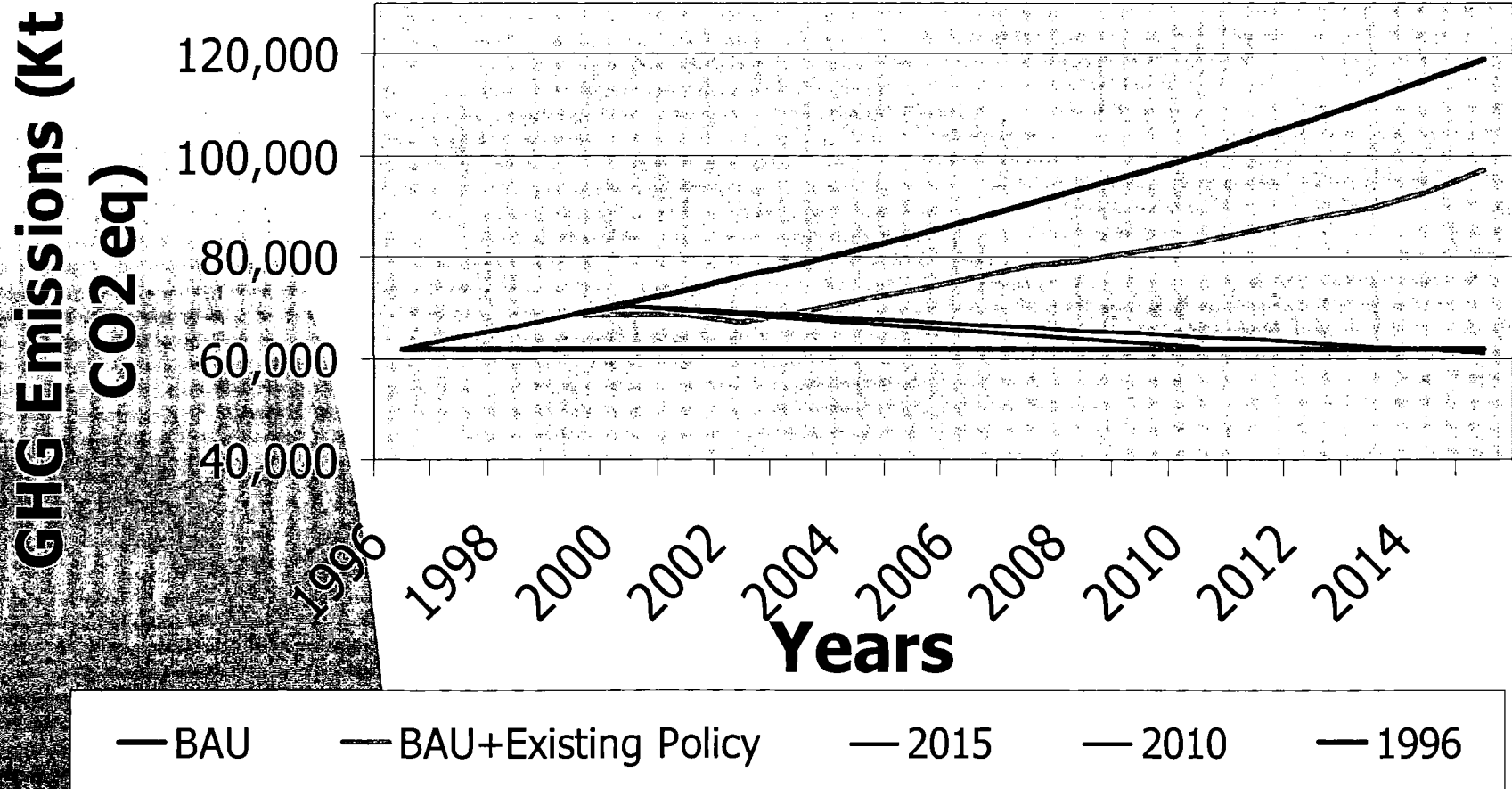
**Double Dividend from conversion to a 'carbon tax':
29%**

Pollutant Reduction Benefits:

SO₂ - \$ 3,858 NO_x - \$ 3,546 PM10 - \$10,837

Climate Change / Israel

Existing Policy Scenario



Climate Change / Israel

After implementing existing policy
there will be a need to reduce

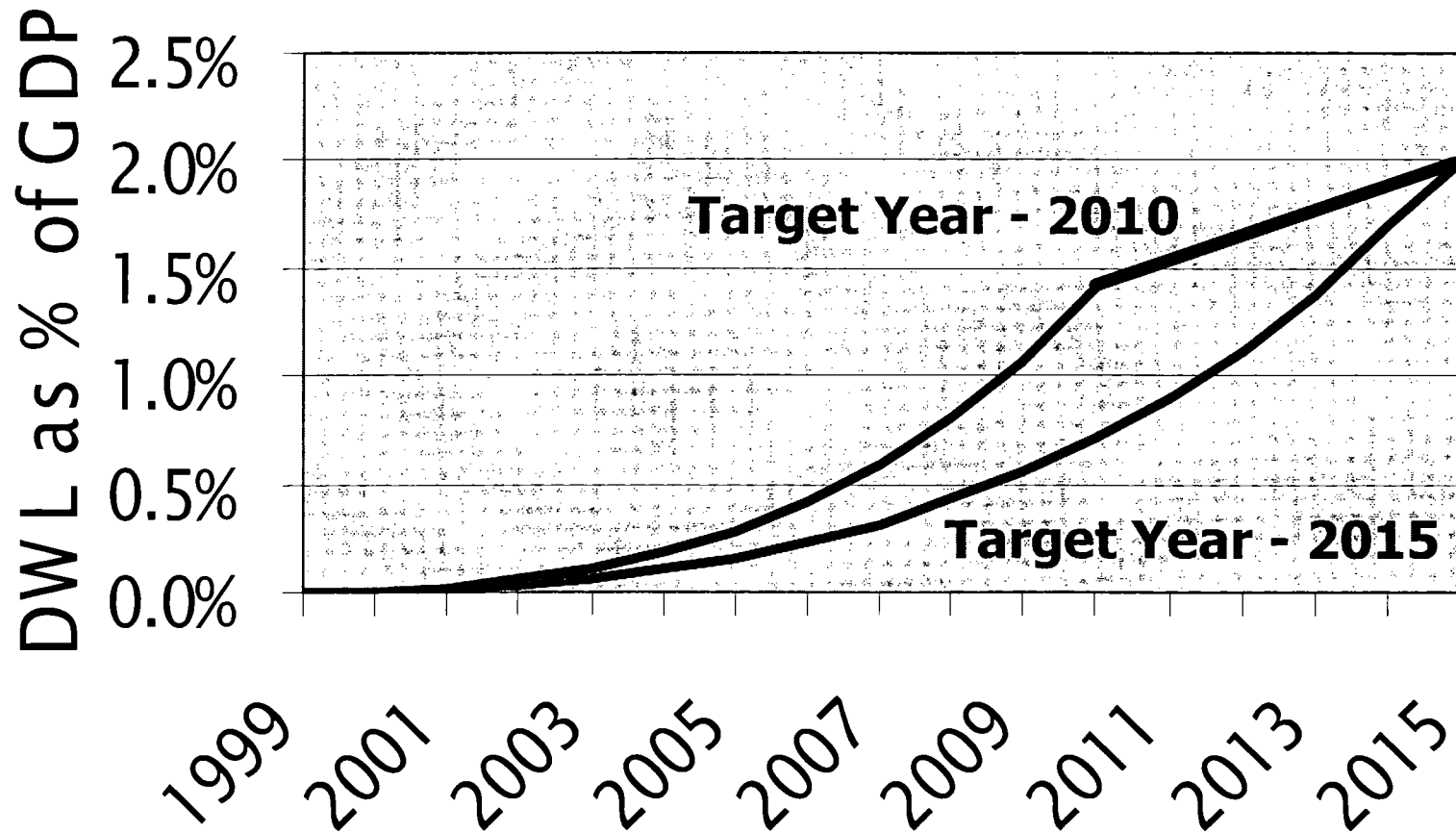
20,600 Kt CO₂ equiv. for target year 2010

or

? 35,900 Kt CO₂ equiv. for target year 2015

Climate Change / Israel

Dead Weight Loss (as % of GDP)



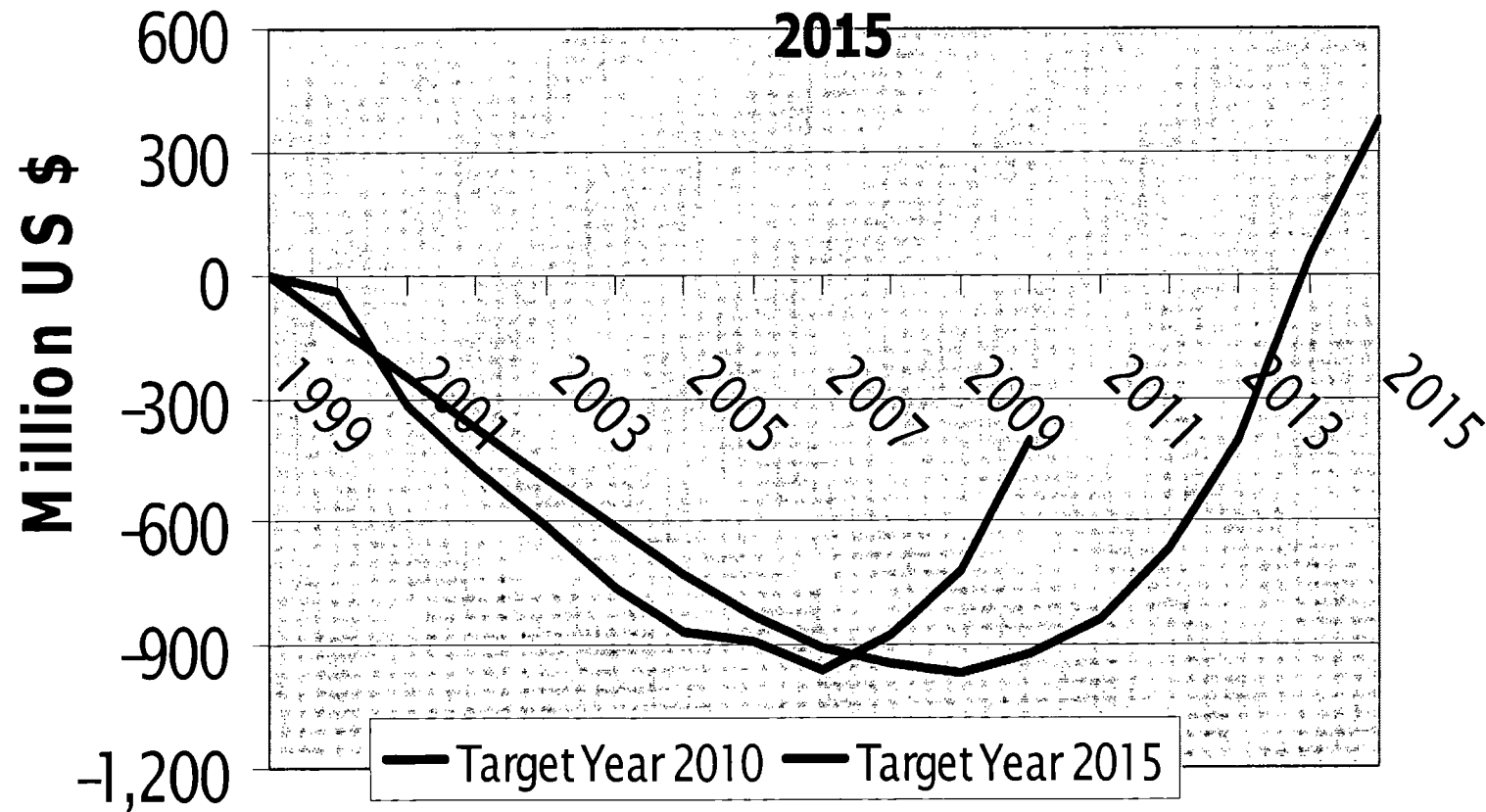
Climate Change / Israel

Summary of Economic Analysis

	Income from Tax	Max. Loss to DWL	Double Dividend	Benefit from Pollution Reduction	Max Addition to DWL after Existing Policy Implementation
	<i>(Millions of US \$)</i>				
Target Year 2010	6,641	2,251	1,925.90	732.5	258.48
Target Year 2015	8,256	3,791	2,394	1,020	530.61

Climate Change / Israel

**Net Economic Costs to Israel's Market for
Emissions Reductions by target years 2010 or
2015**



Climate Change / Israel

Energy Production Sector

- Transition to Natural Gas
- Efficiency of Power Plants
- Increasing Competitiveness
- Promoting Co-generation and Alternative Energy Production

Industry

- Energy Conservation in Industry
- 'Dry' Cement Production

Domestic Energy Consumption

- Green Building Codes
- Green Lighting & Appliances
- Demonstration & Training Centers

Transportation

- Technical Measures
- Tax Reform: Carbon Tax & Cancellation of Tax Breaks for Private Vehicles
- Promoting Changes in Urban Planning
- Congestion Relief Measures
- Incentives for HOV & Mass Transit

Waste Disposal

- Treatment of Methane from Landfills
- Composting
- Incineration

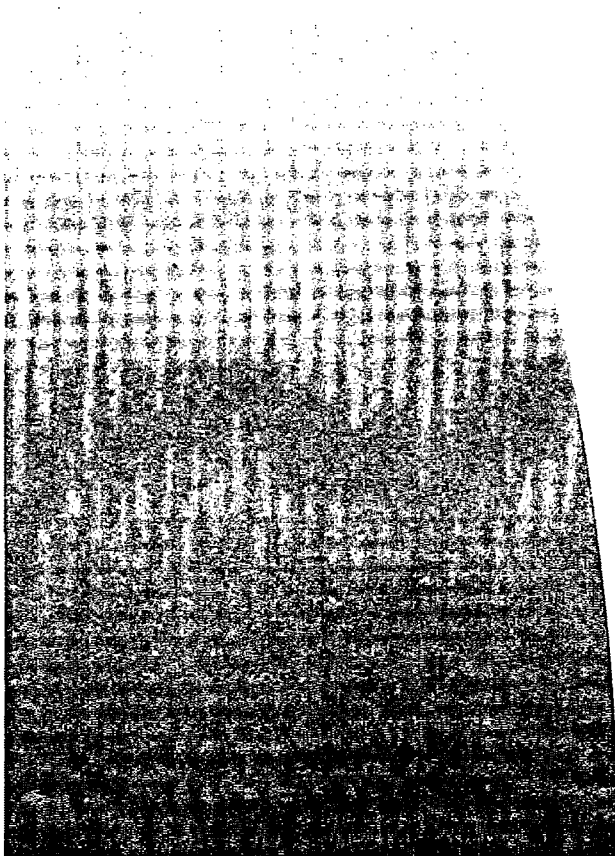
Agriculture

- Optimizing Animal Husbandry
- Minimizing Losses from Fertilizer Application

Climate Change / Israel

Recommendations

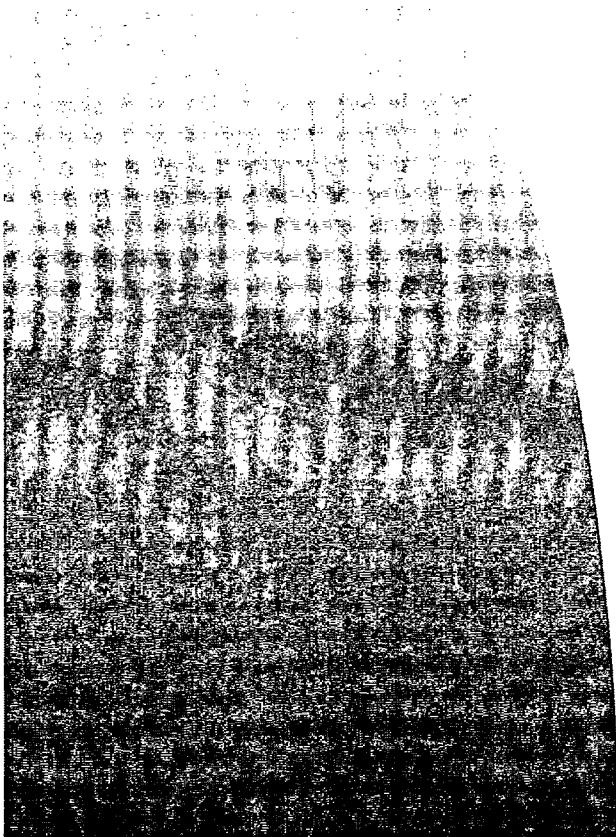
- 1. Removal of market failures associated with over-regulation.
 - () Competitive conditions in the energy production market.
 - () Reducing energy use in buildings and industry.
 - () Energy requirements of appliances and equipment.
 - () Cost-effective technological improvements in Israel's market-sectors.



Climate Change / Israel

Recommendations

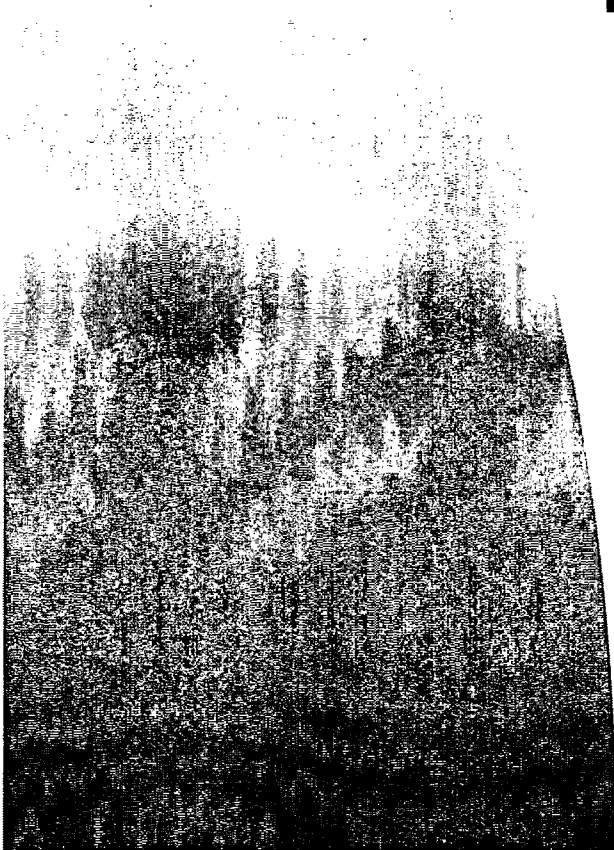
- 2. Government intervention through administration, R&D and education.
 - () Sector-based training & consulting centers.
 - () Research & development of “clean” energy production, carbon fixing and resource conservation.
 - () Solutions for transportation congestion.
 - () Metropolitan planning.



Climate Change / Israel

Recommendations

- 3. Changes to the tax system.
Imposing a Carbon tax that will replace other existing taxes.



Climate Change / Israel

Recommendations

- 4. A government mechanism to lead, facilitate and monitor the necessary change.
 - () A senior steering team
 - () Director Generals of government ministries
 - () From cabinet approval to initiation & implementation of changes

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page 4

The S. Neaman Institute
For Advanced Studies in science & Technology

Submitted to the Ministry of Environment, Israel

List of participants

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C A Dynamic Model of the Economy		D Essentials of policies to reduce GHG emissions in other countries	
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D3 The Japanes strategy to reduce GHG emissions			
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BSb.: BSb BSb			
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- 3) Im Feld Darstellung entfernen sie aus symbol 254 \f "Wingdings" \s 12 Verborgenen das symbol 252 \f "Wingdings" \s 12 ü
- 4) Bestätigen Sie den OK-Button

D3 The Japanes strategy to reduce GHG emissions
EXECUTIVE SUMMARY

Israel's policy for reduction of greenhouse gas emissions

This policy paper is a first attempt to determine a national policy for the State of Israel to reduce greenhouse gas (GHG) emissions. The paper is based on a thorough breakdown of the sources of GHG emissions and describes the different technical means that may reduce GHG emissions under the special conditions characteristic of Israel.

Conditions in Israel differ considerably from most developed countries.

1. Israel is still a state that is in a process of evolving and developing. As a result we have not yet reached stability and are not yet on a clear course of development in social, demographic, political and economic fields. Clearly different from other countries, Israel's population is projected to grow considerably (together with uncertainty in the different scenarios of population growth). Furthermore, the customary base year for emissions in other countries' policies, were years in which Israel enjoyed immense population growth and economic activity.

2. The demographic instability (together with uncertainties regarding other cardinal issues) makes it difficult to use future scenarios. The difference between scenarios is immense and difficult to bridge. Uncertainties in future projections and the absence of clear and agreed upon figures regarding future development in all sectors, is one of the main reasons that the different sections of this paper relate to different base and target years.

3. There is uncertainty regarding economic development and the directions industry will take. The heavy and chemical industries that compose a significant element of emissions in other countries, are not a significant segment in Israel. Projections do not point to growth in these industries in Israel, rather in the light and technological industries, which do not emit GHG in large quantities in their production processes.

4. A factor that is expected to carry considerable weight in energy consumption and therefore GHG emissions, water desalination, is still in early stages, and there is currently no formal policy or agreed upon technology for this process. In other developed countries that have prepared similar policy papers there is no precedent for this sector.

5. The climate in Israel demands heating in winter (relatively short) and considerable cooling in the summer. Yet, the climate in Israel is moderate and permits the utilization of climate components (radiation, breeze etc.) to reduce energy consumption.

6. Another element that differs Israel from other countries, is the fact that treatment of waste, including sludge from sewage facilities, there is currently no modern treatment system.

In light of all these reasons, this paper suggests some original and new technological approaches.

The recommendations and priorities in Israel's national policy for the reduction of GHG emissions were prepared subject to the following criteria:

1. The relative contribution of the sector to total emissions
2. The technical probability of a given action to reduce GHG emissions
3. The public and political acceptability of a recommended action

. 4. The relative cost

. 5. Time needed for implementation of a recommended action. The recommendation seeks actions that require a short time but actions requiring a long time and that are significant will be pointed out.

Tables A - F present a summary of the recommendations to reduce GHG emissions. In light of uncertainties in future projections, the tables were prepared based on figures for 1996, a year of which our data are detailed and reliable. We assume that the increase in GHG emissions of each of the sectors will be similar to trends subject of growth in population and GDP, and that the relative contribution of the sectors will be similar to today. It seems to us that this assumption is acceptable to most of the sectors, except the residential and commercial sector, which is projected to consume more energy in the future for comfortable thermal conditions, and will therefore contribute more than it does today to total emissions.

Recommended priorities

1. Waste and sewage sludge

This sector is responsible for over 12% of GHG in Israel (for a time horizon of 100 years. For a time horizon of 20 years methane emissions from waste equals to 24% of total GHG emissions). There are simple measures to reduce emissions caused by activity in this sector.

In an analysis of existing measures we found that the most cost effective measure is to treat the degradable components of waste by composting (investment of 10 US\$ in facilities to reduce emission of one ton CO₂ equivalent per year). Incineration of waste is also a very effective means to reduce GHG, but the cost is much higher than composting. The cessation of burying waste in landfills that produce methane and a shift to more modern measures carry additional advantages; It will save land allocated today for landfills, increase of recycling of materials, production of fertilizers and more. The policy change will be accepted by the public and its implementation depends on government policy.

2. Fuel switch in energy and industrial production processes.

By switching from fossil fuels to natural gas, it is possible to reduce GHG emissions at a rate of 30 - 44%. Switching from oil to gas will reduce Israel CO₂ emissions by 3.2% in a relative low investment. Switching half of the coal operating stations to gas will enable a reduction of an additional 6.6% of the country GHG emissions. Switching from oil to gas in industry will reduce emissions by a few percents (up to 5%).

Considerations other than reduction of GHG emissions exist; source of supply, cost of supply, credibility of supply and existence of emergency reserves, considerations that are beyond the scope of this paper. The magnitude of increase in use of natural gas in the future depends, among other things, on the political development in the region and the relations that will be created with neighboring countries.

3. Development of technologies for generation of energy from renewable resources.

In the detailed paper it was suggested several technologies for production of energy from

renewable resources, from the use of nuclear power to energy towers, wind power and solar energy. The use of nuclear energy is subject to political considerations, solution to nuclear waste and the availability of safe reactors. The utilization of wind power is well known in the world, but a thorough investigation is required to adapt technologies to Israel. The technologies suggested to produce solar energy (including power towers), are still undergoing development and it is too early to determine their feasibility.

These technologies require further research and demonstration. Though there is uncertainty regarding the success of any one of them, they carry enormous potential. The ability to be less dependent on foreign sources and on the non-replenished resource of fossil fuels, more than justify significant investments in R&D and constant actions to explore these novel methods.

Of all suggested means, the use of wind power can be implemented immediately. In the future, direct and indirect solar energy can be used.

4. Energy production in combined cycles

With gas turbines that operate on liquid fuels or gas it is possible to utilize combined systems in which efficiency is higher by a factor of 1.5 and more than existing systems. Potential reduction of GHG emissions by this method is between 2 and 7.3% of total emissions.

Co-generation of electricity

Systems that use the residual heat resulting from electricity production are limited in Israel because of the small market for heat and steam (as opposed to countries where the climate is cold and in which home heating in the near town provides a stable market). Yet there is a potential to build private energy generation plants in which residual heat and steam may be used for heating and air conditioning. Such plants may be built by the industries (while reducing some 2% of projected emissions) and large public and business buildings (university campuses, hospitals, hotels, office centers etc.) while reducing emissions by a similar portion to that of the industry sector).

(A thorough and quantitative description is provided in the appendix).

For implementation of this step, appropriate agreements with the Israel Electricity Co. for purchase of electricity is needed.

5. Encouragement of energy conscious buildings

The climate in Israel, in which winter is not very cold and summer is not always warm, it is possible to utilize solar heat and wind to save energy consumption of comfortable thermal conditions. Energy conscious buildings may save 20 - 40% of energy consumption for thermal conditions, which is a significant growing component in energy consumption in buildings. Cost analysis shows that an investment of 0.5 - 3 NIS may provide a savings of one kWh per year.

The investment required for energy savings in buildings is effective because the rate of return on the investment is from one to a few years, more so if electricity prices will include external costs.

There is a need to encourage a process of energy conscious buildings by law, fiscal measures of taxation and credit, and development of awareness among planners, builders

and the general public.

6. Transport measures

The transport sector is responsible for some 17% of total greenhouse gas emissions in Israel. This paper provides a set of measures that enable reduction of vehicle kilometer travel and reduction of emissions. These measures must be a component of a policy that develops alternatives of mass transportation and urban planning together with fiscal and administrative measures that limit travel.

It is difficult to project and even assess the efficacy of these measures, but it seems that it is inevitable to deal with this issue, especially due to the projected increase in this sector (doubling emissions by 2020) if the issue is not dealt with.

Decisions about measures in the transport sector should be subject to a variety of national and environmental considerations - to reduce congestion in cities and important transport routes, to reduce air pollution in cities, save land allocated for roads and others.

Summary of policy recommendations

Measure Expected reduction of emissions (Percent of total)

Measure	Expected reduction of emissions (Percent of total)	Pessimistic scenario	Reasonable scenario	Optimistic scenario
1. Waste and sewage sludge treatment	8	10	12	Solution of waste problem Israel
2. Switch to natural gas in power stations	3	8	11	Reduction of air pollution
3. Energy production in combined cycle	2	5	7	Use of fuels with higher efficiency. Postponing of building power generation plants
4. Co-generation	2	3	4	Use of fuels with higher efficiency. Postponing of building power generation plants
5. Energy conscious building	3	5	7	Energy savings and postponing of building power generation plants
6. Improvements in transport	2	4	6	Reduction of air pollution. Improvement of environment in cities
7. Improvements in industry (without co-generation)	4	7	10	Improvement of air quality. Postponing of building power generation plants
8. Agriculture	0.5	1	2	Reduction of underground water and air pollution
Total	24.5	43	59	

Several issues in the policy summary table need to be pointed out.

The detailed measures mentioned in this table are presented in the accompanied paper.

They have been assessed subject to three scenarios - the optimistic assumed implementation extracts full potential, while the pessimistic scenario assumed partial implementation.

Most of the measures presented in the summary table are those that do not demand significant changes in current processes and common practice. Some of the measures will contribute direct economic benefits (energy production in co-generation, green buildings and some of the measures in the agriculture sector) and some will produce indirect economic advantages like postponing in building new power generation plants. Almost all of the measures discussed produce double dividend as they bring upon additional advantages, some of them very significant environmental improvements such as reduction

of air pollution, reduction of transport congestion and improvement of the environment within cities by improving vehicles and transportation systems. Significant components of the measures suggested are actually steps of improving economic and service systems rather than their reduction.

Analysis of required investments within the different sectors is presented in figure A. It is important to point out that investments are one component of the economic factor. For example, investment in measures that reduce GHG emissions in buildings is quite high. Yet the suggested measures carry large energy savings, an element that changes the national economic balance. It is also important to note that many recommended actions produce more than one advantage, environmental and economic, which are not expressed in figure A.

Another consideration for recommending specific measures to reduce GHG is the required time for implementation. It is possible to change the method by which waste is treated within a few years. Other measures require gradual and constant changes such as energy conscious building, improvements in transport and in industry and the introduction of co-generation and combined cycle.

Considerations regarding base and target years

Israel will be committed by current and future decisions concerning the need to reduce global GHG emissions. Past experience regarding the cessation of the use of gases that harm the ozone level has shown to what extent Israel is obliged to fulfill international agreements concerning the environment, as a condition to participate in international trade.

Yet, we must see to it that implementation of international agreements do not burden us with unreasonable costs. In the economic analysis (chapter 8) it is possible to see that implementation based on 1990 as the base year will confront Israel with an unreasonable expense of 6.3% of GNP.

It is essential to point out that during the years between 1990 and 1996 Israel has experienced an unprecedented population growth, absorbing some one million immigrants from the former USSR, and consequently an immense economic growth as well.

The economic analysis demonstrates that if we relate to emissions per capita rather than national emissions, the cost of complying with requirements to reduce emissions will cost only 0.2% of GDP.

We point out that this method of calculation is not unique to Israel. Even Germany, which is richer than Israel, has referred to emissions per capita for a similar reason of population growth.

It is therefore our contention that the base year, as presented in this paper, for Israel's policy to reduce GHG emissions should be 1996.

We recommend implementation in two stages to reduce GHG emissions in Israel.

Duration of the first stage of the policy will be the coming 20 years, until the year 2020.

During those years it will be possible, as will be shown in the summary table, to reduce 24

to 59 percent of GHG emissions based on the situation in 1996, or to develop the economy at a similar magnitude without increasing GHG emissions. During this period resources must be allocated and pilot plants built to thoroughly examine new systems to produce energy (based on the suggested list and other technologies); new systems to save energy and development of new approaches that will reduce dependence on exterior sources of energy, if by reducing kilometers travel or by more efficient urban planning that will reduce energy consumption. Further on, the innovative technologies should be implemented.

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Energy conscious building (without electricity savings) Aerobic compostation of waste
Coal switch to natural gas Fossil fuels
switch

to natural gas Agriculture Industry co-
generation Investments

\$/ ton CO2 5-30\$ 0.32\$ 0.3\$ 0.07\$ 0 3-7% 8-12% 7% 3% 0.5-2% 4-10% 2-4%

Figure A: Investment Cost of Reduction of CO2 emissions (% of
total emissions in 1996)

A. Reduction of emissions in the energy generation sector

Alternative CO 2 reduction Technology Cost Percent of sector s emissions Percent of
total emissions remarks ton/year \$/kW 1. Switch to natural gas Requires gas distribution
system. Problem of EMERGENCY RESERVES 1A. Switching only plants operating on
liquid fuel Reduction of emissions by 30%. 2 million tons Existing 10 7.5 3.2 1B.
Switching of 50% of plants operating on coal Reduction of emissions by 41.4%. 4.1
million tons Existing. Simple in plants operating on coal/ heavy fuel 420 15.1 6.6 2.
Co-generation Increase of efficiency from 40% to 60% Proven and available irrelevant
irrelevant irrelevant Limited market for steam. Effective for water desalination in energy
production plants 3. Combined cycle Increase of efficiency from 40 to more than 60%. 1.3
million tons in scenario 1A. Additional 3.3 million tons in scenario 1B. Existing.
Easy to implement in gas plants In scenario 1A: 5%.

In scenario 1B: 12.4%.

Total: 17.4% In scenario 1A: 5%.

In scenario 1B: 5.3%.

Total: 7.3% 4. Increase of efficiency in power generation plants. Increased efficiency of
1% per annum Technology will be developed abroad * < 30 Reduction of emissions by 1/3
by 2020. 5. Switching old fuel plants, incl. combined cycle 1.36 million tons Existing.

* 5 2 Reduction of conventional pollutants

* In conjunction with system replacement and enlargement

A1. Alternatives under development

DDE_LINK1 Alternative CO 2 reduction Technology Cost Percent of sector s emissions
Percent of total emissions remarks DDE_LINK1 ton/year \$/kW Nuclear energy Wind
energy (1) Substitution of 6% of current production technology Existing Investment of
850 - 3000 \$ 6 2.6 Waste incineration (1) Substitution of 5% of current production

technology Existing 3000\$ 5 1 See chapter 7 Energy towers (1) Production of all of Israel's electricity needs Under development 3000\$ 100 43 Parabolic mirrors (1) Production of 25% of Israel's electricity needs Under development 15000\$ 25 11 Requires energy saving system Solar tower (1) Production of 25% of Israel's electricity needs Under development 13600\$ 25 11 Requires energy saving system
 (1) Data from Zaslavsky's report (1998)
 (2) All calculations are based on equivalent for 1996.

B. Reduction of emissions in the industry sector

Alternative CO₂ reduction Technology Cost Percent of sector's emissions Percent of total emissions remarks ton/year \$/kW 1. Switch to natural gas maximum potential 3 million tons Existing 10-42 16 4.8 Requires distribution system 2. Co-generation Savings of 1.5 million tons Existing Savings in most cases 6.4 1.9 Requires agreement with IEC 3. Energy conscious building Savings up to 30% of consumption for climate control. 1.2 million tons Requires adaptation and development 0.5-3 6.4 1.9 requires legislation 4. Switch to dry process in cement production Savings of 53% in energy consumption. 2.3 million tons Existing within the anticipated improvements 12 3.7 Switching to dry process has begun;
 reduction of conventional pollutants

C. Reduction of emissions from energy for buildings

Alternative CO₂ reduction Technology Cost Percent of sector's emissions Percent of total emissions remarks ton/year \$/kW 1. Improvements in electricity appliances No increase in electricity consumption despite increase in use based on development abroad no investment 2. Energy conscious building. (set of measures) Reduction of emissions of 20 - 40%, 1 - 2 million tons.
 (Up to 10 million tons in the year 2020) Existing. Requires adaptation and development. Investment of 0.5 - 3 NIS per savings of one kWh/year. 6 - 12

(up to 10% in 2020) 1.6 - 3.2

(up to 40% in 2020) Energy consumption for climate control is expected to grow significantly 3. Co-generation in public and business complexes Reduction of energy consumption for heating and cooling of more than 50%. Existing Financial savings

D. Reduction of emissions in the transport sector

Alternative Expected efficiency Technology Cost Remarks Improvements in vehicles 20 25% reduction per km. Developed abroad Increase of vehicle cost
 Switch to electric vehicle There will be no reduction of emissions in power plants.
 Reduction of up to 40% by switching to gas in power stations Existing Expensive today

Reduction of air pollution in cities Switch to gas operating vehicle Reduction of emissions of CO₂ by 10 - 30% Existing High cost of service and distribution system

Reduction of air pollution in cities New catalytic converters Prevention of N₂O emissions equals to reduction of 10% of total GHG. Under development Additional 2% to vehicle price Transport control measures (TCM) Regulatory TCMs (1) Reduction of travel by up to 20%. A more reasonable figure is 5% Requires regulation and enforcement Reduction of travel of non single occupancy vehicle (2) Reduction of travel in metropolitan areas by up to 8%. Requires regulation and enforcement Travel Demand Management (TDM) (3) Reduction of GHG emissions by 3% Market Based Mechanism (4) Reduction of GHG emissions by up to 7% Requires a central pricing policy traffic management (5) Reduction of up to 10%. Danger of induced traffic

(1) Measures include parking Restrictions, mandatory employer trip reduction programs, closed areas for transport

(2) Measures include high-occupancy vehicle priority lanes and facilities, transit service improvement and expansions, bicycle and pedestrian facilities and programs.

(3) Public education, employer-based transportation management programs, replacing travels with electronic communications, ridesharing

(4) Congestion taxes, emission taxes, fuel taxes, parking pricing

(5) Intelligent transportation systems, congestion management planning and systems, signal enhancement and automated traffic management systems.

E. Reduction of emissions in the agriculture sector

Alternative CO₂ reduction Technology Cost Percent of sector's emissions Percent of total emissions remarks ton/year \$/kW 10% increase in crop coverage million tons Existing Depends on agriculture policy 0.8 Serves other national aims - preserving open space. 10% decrease in crop coverage Increase emissions by 0.5 million tons Minimal tillage, 25% of land 2 million tons during 10 years Existing Usually saves expenses for farmers 0.3 Improved feeding to cattle 8000 tons methane, 0.2 million tons CO₂ Existing 0.3 Improved manure handling 2500 tons methane, 0.1 million tons CO₂ Existing 0.16 Improved fertilizer application 1200 tons N₂O, 0.4 million tons CO₂ Existing, requires improvements 0.6

F. Reduction of emissions from waste and sewage sludge

Alternative Efficiency of Methane reduction CO₂ reduction Investment for reducing CO₂ eq. Percent reduced of sector's emissions Percent reduced of total emissions Remarks ton/year \$/ton Landfilling with gas collection- landfill gas flare 50% of methane will be burnt 4 million tons 10 48 6.5 Difficult to control Landfilling with gas collection and energy recovery 50% efficiency 4 million tons 24 48 6.5 credit for energy production Aerobic Composting Oxidation efficiency 90% 7.2 million tons 8 86 11.1 Need for waste separation Anaerobic digestion Oxidation efficiency 100% 8 million tons 39 100 12.9 credit for energy production Incineration Oxidation efficiency 100% 8 million tons 195 100 12.9 Need to control conventional and toxic air pollutants. credit for energy production

Chapter 1

National inventory of greenhouse gas emissions and removals

This chapter presents a summary of Israel's emission inventory of the greenhouse gases CO₂ and CH₄ and N₂O for the year 1996. Emissions from international and national aviation and sea transport are not included in the national totals.

The methodology used for estimating emission is based on the IPCC Guidelines for National Greenhouse Gas Emissions Inventories (IPCC, 1995b).

Some of the data presented is a modification of the results presented in Koch and Dayan (1997) and Koch (1998) based on several government sources. The data was modified to facilitate determination of relative contribution to total emissions by the different sectors. In one case (diesel oil used by the industry sector) there is some uncertainty regarding the precision of the data.

Table 1.1 summarizes all emissions by sector in 1996 in Israel. The figures represent emissions resulting from fuel combustion and electricity consumption for each of the sectors, wherever it is applicable. An outstanding case is the energy sector; It burns most of the fuel to produce energy (the respective figure is presented in parenthesis) but consumes only a small amount of electricity (respective figure appears without parenthesis).

Table 1.1: Carbon dioxide, methane and nitrous oxide emissions and removals (in Ktons) per IPCC sector 1996

IPPC sector CO₂ emissions (Ktons) CH₄ emissions CO₂ eq. (Ktons) for 100 years N₂O emissions CO₂ eq. (Ktons) for 100 years Fuel combustion total 49,600 230 Energy production and transformation 26,500 170 Industry combustion 11,000 7 Transport 10,300 35 Commercial and Residential 1,800 15 Forestry -400 Agriculture 2,500 900 1,200 Industrial processes total 540 Cement 1,700 Solid waste 7,800 Wastewater treatment 200 Total 53,400 8,900 1,957 64,257 1.1 Greenhouse gas emissions (CO₂-eq).

To indicate the extent to which the emissions of various greenhouse gases contribute to total radiative forcing, the emissions were calculated in CO₂ gases from anthropogenic sources using the Global Warming Potential (GWP) values for a time horizon of 20 years from IPCC assessment (IPCC, 1996a).

CO₂ is by far the greatest contributor of greenhouse gases, some 51,000 Ktons constituting 82% of the total. CH₄ contributes to the total emission of greenhouse gases, some 8,900 Ktons CO₂ equivalents for a time horizon of 100 years, constituting 30% of the total. N₂O emissions are only some 2000 ktons, which are only 3% of total emissions.

Figure 1.1- Relative CO₂- eq. emissions

Excel.Chart.5

The current share of CO₂ equivalent emissions for each of the sectors is presented in three manners:

- . 1.CO₂ emissions resulting in fuel combustion and processes (table 1.2).
- . 2.Division of CO₂ emissions resulting from power generation among the sectors, based on electricity consumption by each sector (table 1.3).
- . 3.Combination of the results attained to present CO₂ emissions by sector (table 1.4).

Greenhouse gas emissions by sector is presented in CO₂ equivalent in two manners:

- . 1.Emissions resulting from fuel combustion, processes and other activities .
- . 2.Emissions resulting from electricity consumption (emissions originating from energy generation is burdened on electricity consumers), processes and other activities.

Emission from fuel combustion point to the energy generation sector as the leading sector with some 27,000 Ktons CO₂ constituting 53% of total emissions. Transportation and industry account for some 13,000 Ktons CO₂ (21% of total) and 11,000 Ktons (22%) respectively.

Figure 1.2 - CO₂ emissions resulting fuel combustion and processes.

The relative contribution of greenhouse gas emissions by sector resulting from fuel combustion and processes, is changed significantly when electricity consumption by sector is considered. It changes industry's share from 22% to 30% of total emissions, and the residential and commercial sector's share from an insignificant 4% to 26%, thus pointing out the potential to decrease CO₂ by focusing on electricity savings within these two sectors. Transportation retains its large share of emissions - 21% of total.

Solid waste in Israel emits some 8,000 ktons of CO₂ eq. Ktons for a time horizon of 100 years, constituting 13% of total emissions.

The electricity consumption factor has no effect on the share of solid waste, which still contributes 12% as can be seen in figure 1.3.

Figure 1.3- Total contribution to GHG emissions in Israel, 1996

1.2 Carbon dioxide CO₂

By far the largest anthropogenic source of CO₂ emissions is the oxidation of carbon when fossil fuels are burned to produce energy. Combustion of fossil fuels for the production of energy is the leading cause of CO₂ emission - some 53,000 ktons (96%). These emissions are accounted for by the energy generation sector which emits 26,000 ktons (53%), transportation emitting some 13,000 ktons (26%) and industry with some 8,500 ktons CO₂ (17%). Cement production is the most important non-energy industrial process emitting some 1700 Ktons CO₂ (4% of total CO₂ emissions).

Coal contributes about 40% of the CO₂ emissions in the energy sector, whereas the contribution of residual fuel oil is 27%. Gas, oil and gasoline contribute each 13%.

Table 1.2 presents the amounts of the various fuels consumed by the sectors, the respective CO₂ emission of each of the fuels and the total CO₂ emissions for each of the sectors.

Table 1.2: Fuel consumption and CO₂ emissions by sectors

Sector Electricity production
Transportation
Residential and commercial Industry
Fuel consum-
ption (1000 tons)
CO 2 emission (1000 tons)
Fuel consum-
ption (1000 tons)
CO 2 emission (1000 tons)
Fuel consum-
ption (1000 tons)
CO 2 emission (1000 tons)
Fuel consum-
ption (1000 tons)
CO 2 emission (1000 tons) LPG(*) 404 1,194 124 366 Gasoline 2,159 6,657 Diesel oil
137 435 1,013 2,876
199 632 900** 2,859 Naphtha 769 Residual fuel oil 2,031 6,252 2,277 7,099 Petroleum
Coke 168 675 Tar 267 821 Coal 8,190 19,882 Total CO 2 emission (1000 tons)
26,569
10354

1,826
10,999 Percent of total emissions

54
21
4

21 * Liquefied Petroleum Gas (LPG).

**uncertainty about precision of this figure

When CO₂ emissions resulting from power production are passed on to the consumers of electricity, namely we break down the energy sector's share of CO₂ emissions (53% of total emissions) by its consumers, the resulting picture becomes quite different. The power generation sector is responsible for only 3% of all CO₂ emissions resulting from electricity consumption, the residential and commercial sector consumes about 55% of the electricity produced in Israel and is therefore accountable for some 29% of all CO₂ emissions originating from electricity production. The industrial sector consumes 29% of all electricity produced and is, therefore, responsible for some 15% of total CO₂ emitted from power production. The agriculture sector is a small consumer of electricity and is therefore responsible for only 5% of CO₂ emitted due to power generation. Table 1.3 presents the relative electricity consumption for each of the sectors, and the subsequent share of total CO₂ emissions.

Table 1.3: Electricity consumption by sector

Agriculture	Industry	Residential and commercial	Electricity production
2,902*	8,725	16,706	1,722*
Electricity consumption (million kWh)			
9.6	29	55.6	5.7
Percent of total electricity consumption			

* The sectorial electricity consumption includes electricity required for water for each of the sectors

Table 1.4 shows all CO₂ emissions by sector due to fuel and electricity consumption (compilation of tables number 1.2 and 1.3). It shows that the industry sector accounts for a third of all CO₂ emissions in Israel, of which about half originates in direct fuel combustion and half in electricity consumption. The residential and commercial sector is responsible for another third of all CO₂ emissions, of which some 88% are a result of electricity consumption. The transport sector accounts for 27% of CO₂ emissions all originating from fuel burning. The agriculture sector accounts for some 5% of the CO₂ emissions originating in fuel combustion and electricity consumption. The power production sector is responsible for 3% of CO₂ emissions as a consumer of electricity. This figure should be treated carefully: the power generation sector may be a small consumer of electricity, but this fact should not conceal the enormous potential within the power production and transmission sector to decrease the amount of CO₂ emitted at the production and the transmission stages.

Table 1.4: Relative contribution of CO₂ emissions by sector due to fuel combustion and electricity consumption

Relative contribution of CO₂ (in %) as a result of fuel and electricity consumption

Total CO₂ emissions (1000 tons) CO₂ emission resulting from electricity consumption
 (1000 tons)* Percent of electricity consumption
 (percent of total CO₂ emissions) Percent of CO₂ emission
 resulting from fuel combustion CO₂ emission resulting from fuel combustion
 (1000 tons) Sector 3 1,515 1,515 5.7
 (3) 54 26,569 Energy production 37.5 18,704 7,705 29
 (15.5) 21 10,999 Industry 5.5 2,577 2,577 9.7
 (5.5)
 ? Agriculture 33
 16,544
 14,772
 55.6
 (30)
 4 1,826 Residential and commercial 21 10,354 - 21 10,354 Transport 100 49,694 26,569
 100 100 49,694 Total

* This column presents greenhouse gas emissions by sector based on each of the sectors
 relative electricity consumption

1.3 Methane (CH₄)

The largest source of methane emissions in Israel is the decomposition of solid waste,
 370 thousand tons or 20,700 thousand tons CO₂ eq. for a time horizon of 20 years (27%
 of all greenhouse gas emissions). It is second in importance to the contribution of CO₂
 emissions from energy production.

Methane emissions originating from agricultural activities produce 42,000 tons, some 3%
 and 1.5% of the total CO₂ equivalent of methane and CO₂ emissions for the time
 horizon of 20 years and 100 years respectively. Within the agriculture sector, dairy cattle
 account for some 50% of all methane emissions.

Methane is emitted from domestic livestock through two processes: enteric fermentation
 and waste management. Methane is also emitted during the decomposition of landfilled
 municipal solid waste and the treatment of domestic and industrial wastewater.

Enteric fermentation contributes about 75% of the methane emissions from domestic
 livestock, mostly from cattle. Manure management contributes only 25% of the
 emissions, mainly due to cattle and poultry Manure.

The sources of methane from agricultural activities are presented in table 1.5.

Table 1.5: CH₄ emissions from agricultural activities

Activity	CH ₄ emissions (t/year)	CH ₄ emissions (1000t)	Percent of total Domestic livestock enteric fermentation and manure management	Enteric fermentation (t/Year)	Manure management (t/Year)	Total
Dairy cattle	17,760	3,000	20.8	49	Non dairy cattle	11,340
Sheep	2,640	92	2.7	6.4	Goats	450
Camels	92	5	0.1	0.2	Horses	18
Mules and asses	10	1	0.0	0.0	Swine	113
Poultry	3,565	3.6	8.5	Total	32,423	9,996
						42.4

1.4 Nitrous oxide (N₂O)

The inventory of nitrous oxide (N₂O) emission in Israel points to three sources:

- . 1. Agriculture: direct emissions from agriculture soils, emissions related to animal production and emissions indirectly induced by agricultural activities
- . 2. Industrial processes: nitric acid production
- . 3. Fuel combustion

Agriculture accounts for 3,800 tons of N₂O, some 63% of all N₂O emissions as can be seen in table 1.6.

N₂O contributes to the total amount of CO₂ equivalents of greenhouse gases 2% for a time horizon of 20 years, and 3% for a time horizon of 100 years.

Table 1.6: N₂O emissions by IPCC sector

Sector N₂O (10³ tons) CO₂ equivalent (10³ tons)

20 years	100 years	Energy	0.55	1524	171	Industrial processes	1.73	484	536	Agriculture	3.81	1,067	1,181	Total	6.09	1,705	1,888
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Chapter 2

The Energy Generation Sector

2.1 Introduction

The 1990 CO₂ emissions from power stations in 1990 were estimated at 16.66 million tons. In 1996 this sector emitted some 26 million tons of CO₂ and some 0.2 million tons of CO₂ eq. via N₂O, contributing 43% of Israel's greenhouse gases emissions. By the year 2020 emissions from this sector are expected to grow to some 59 million tons of CO₂, an increase of 125% (business as usual scenario)

Figure 2.1: Contribution of different fuels to electricity production

Excel.Chart.5

The increase in demand for electricity in the past decade was an unprecedented 6% per year. In the last five years Israel has experienced an annual increase in electricity demand of 7.7%, but the increase in demand is expected to be less in the coming decade.

The total amount of electricity generated by the Israel Electrical Co. (IEC) in 1990 was 20,898 million kWh. The official IEC predictions of future production, including electricity of other producers are 55,760 million kWh in 2010 and 74,794 in 2020. We

shall use these numbers as the base for the future predictions of emissions. If we assume the same mix of types of generating stations and fuels we can extrapolate linearly from the current production capacity:

Table 2.1: Current and future electricity production and CO₂ emissions

Year	Production millions kWh	CO ₂ emissions million tons
1990	20,898	16.660
2010	55,760	44.213
2020	74,790	59.626

2.2 Mitigation options

It should be noted that this section presents two distinct paths to solve the problem of greenhouse gas emissions from energy production; the first advocates incremental changes (switching fuels) so as to attain a reasonable amount of decrease in emissions. The second points to the great potential that lies in a revolutionary approach to energy production, focusing on the benefits of energy production from renewable sources. It points out the large hurdles that obstruct the development of this approach in the form of external costs and subsidies for only some technologies, placing clean technologies at a disadvantage.

Eight options of mitigation of CO₂ have been considered:

1. Increased efficiency of energy production

It was estimated that the efficiency of electricity generators will increase in Europe from the current 40-42% to 60% in the coming 30 years. (Technologies, policies and measures for mitigating climate change, IPCC Technical Paper I, UNEP, 1997, p.5). In Israel the efficiency of electricity generation is lower than 40%, and can be improved in the future when installing new electricity generators.

2. Co-generation.

Utilizing the exhaust gases from gas turbines or steam generators to generate low pressure steam can increase the overall fuel efficiency to about 70%. However, these systems require large scale clients for the low pressure steam close to the generating stations. The common clients are:

- 6800 The chemical industry, which is relatively small in Israel and its demand for low pressure steam is limited.
- 6800 Steam for home heating in cities in cold climates. This market in Israeli climate is very limited.

3. Combined cycle.

Utilizing the exhaust gases from steam generators to operate low pressure gas turbines can increase the overall fuel efficiency to about 60%. However, the cost of low pressure gas turbines per kW generation capacity is much higher than for high pressure turbines.

4. Decarbonization of flue gas

It has been suggested to recover the carbon and oxygen from CO₂. This proposal assumes that unlimited energy is available from an unknown source. This idea can be relegated to the believers in perpetu mobile.

5. CO₂ storage.

It has been suggested to absorb CO₂ from flue gas and store it underground. This option depends on available non leaking depleted natural gas fields into which CO₂ may be pumped. However, extensive tests of many possible locations in Israel (for the purpose of storage of natural gas, at that time) have proven that all such proposed locations are too leaky for the use as storage of gases.

6. Nuclear reactors

This option is probably the best one for decreasing greenhouse gases. However, it can be realized only if its technology and safeguards can guarantee safe operation and waste deployment and the public resistance to nuclear reactors is overcome.

7. Higher energy fuels

Conversion of fuels for power generating stations from coal and oil to natural gas for economic and environmental reasons will also decrease the CO₂ emissions. Conversion from fuel oil to natural gas will decrease CO₂ emissions by 30%.

Conversion from coal to natural gas will decrease CO₂ emissions by 44%. The Electrical Co plans to import natural gas for the next generating station being planned and to convert gradually the coal using power plants to the use of natural gas.

Reduction of CO₂ emission as a result of partial conversion to gas is presented in table 2.2. The two scenarios for 2010 and 2020 are a good approximation to the Electric Co. data. Table 2.3 shows the costs of conversion of power plants to gas.

Table 2.2: Projected reduction of CO₂ in 2010 and 2020 resulting from conversion to gas.

Electricity production (M kWh)

CO₂ emissions (million tons)

Year	Gas	Current mix	Gas	Current mix	Total Reduction	Percent of reduction resulting from use of gas
2010*	13,940	41,820	6,273	33,874	40,147	6,134
2020*	37,395	16,828	30,290	47,118	14,358	24

* In 2010 25% of electricity production will be from gas and 75% by current mix

** In 2020 50% of electricity production will be on gas and 50% by current mix

Table 2.3: Cost of fuel conversion in power generation stations

Original fuel Original generating capacity

MW operation hours/

year fuel use kg/kWh kg CO₂ to kg fuel investment cost of conversion to gas \$/kW cost of new station \$/kW Cost

\$/kg fuel	Heavy FO	2160	8320	237	3.07	10*	1450*	0.12	Light FO	1876	1750*	355	3.06	
10*	1000*	0.19	Coal	3700	8250	360	2.47	42	1500	0.04	Nat. Gas	2160**	8320**	200*
2.75	---	420	0.15	* a rough estimate.										

** if all heavy fuel turns to gas

Leakage of methane from the transportation lines and the generating plant should be minimized, since the Greenhouse factor for methane is 21 times that of CO₂, which

means that a leakage of 7% of the methane used will more than double the CO₂ equivalent emissions.

8. Renewable resources (Solar, wind, hydro, bio mass, waste disposal and geothermal)

A team of experts has recently submitted a report to the Ministry of the Environment by Prof. Dan Zaslavsky. The team analyzed possible alternatives for energy production from renewable resources. This section presents some experts from the document. The report has not yet been approved by all parties concerned and by the Ministry of Environment.

External costs are an essential factor when discussing energy production from renewable sources. There is a wide disagreement on various evaluations of external costs.

Representative values are about 2 cents per kWh for energy produced from coal or oil.

These values are conservative. A comparison of the costs and benefits of different means of electricity production can be translated into economic values when two conditions exist:

a. The external costs are included in the cost because of environmental damage. b.

The present value of benefit or damage is calculated at a discount rate that approaches zero.

The allowable investments to prevent external costs resulting from fuel combustion for the generation of electricity reach \$8000 to \$9500 for an average kW generated from oil or coal, and \$2700 for an average kW generated from natural gas.

These values are based on an interest rate of 5%.

At an interest rate of 0% over 30 years, the allowable investment is double, i.e. \$16,000 - \$19,000 in order to prevent the use of coal or oil, and \$5400 in order to prevent environmental damage resulting from the combustion of natural gas.

Electricity subsidies, by a conservative estimate, are 3 cents per kWh. This value is controversial and sensitive, but there is wide agreement that subsidies are a significant component in of energy production costs.

Alternative and renewable energy sources, which do not require fuel import, are at a disadvantage in a competitive market, and cannot penetrate such a market, as long as energy prices are subsidized.

The resulting values of real costs, based on the aforementioned assumptions have been summarized as permissible investment for an average kW in a non-polluting power station

Table 2.4: Permissible investment for an average kW in a non-polluting power station

Replaced Source Coal Oil Gas Based on an interest rate of 5% 14800-16160

14800-16160 8752 Based on an interest rate of 0% 28900-31540 2890-31540 17080

These values only refer to the savings in the combustion of fuel in existing power stations, and are conservative.

Advantages to alternative and renewable energy sources include additional economic benefits such as averting the threat of future fuel-price increases, reliability in supply, steady expenditures, improving the balance of payments, and the advantages to Israel in the development of its technologies.

Five technologies are proposed to provide the generation of all Israel's electrical power from renewable resources. The investments in at least three of these are estimated not to exceed an average kW cost of \$3,000 to \$4000, much lower than the estimated permissible investments in order to prevent the external costs from finite resources.

Two technologies were proposed for immediate application to replace a million and half

tons of oil a year. With a complete internalization of the external costs, this potential can be doubled.

The first of these is wind power. Wind power potential is over 1.75 billion kWh/year according to a conservative estimate. In comparison, Israel's electricity consumption in 1997 was 30 billion kWh/year. Investment in wind power would make it possible to expand the yield from wind power generation to about one third of all electricity consumption in Israel by the year 2020. Wind energy: Usage of wind energy may be increased, if the investment in the generators and the transport of energy to the national grid can be decreased. Commercial wind generators are available. For instance: BWC EXCEL is rated at 10 kW and costs \$23,000 - \$27,000 including the tower (About 2500 \$/kW). Whisper wind generator offers a 3 kW generator (not including tower) for \$5390.

The second is biomass combustion. There is some inconsistency in the various data on biomass and waste combustion, and the use of their stored energies in different ways. From an overall view, and based on alternatives for waste treatment, this direction has a high economic potential. Calculations made in a pilot project during the eighties have indicated that the cost is competitive, although it was difficult to meet the subsidized and unrealistic cost of electricity. For example, if the cost for alternative electricity sources increases by 3 cents per kWh, the value of one ton of waste increases by \$15 - 20. The potential for waste utilization, including biomass, may reach 5 billion kWh/year. However, it is doubtful that biomass should be grown in Israel for energy purposes.

There are three technologies under development in Israel that could be applied within a relatively short time span. The Energy Towers technology could lower the price without the internalization of external costs and could provide for very cheap energy storage on a daily and weekly basis. The Energy Towers have a potential for supplying Israel's entire energy consumption. The cost of the expected electricity generation is competitive with the cost of coal combustion and even with that of gas, without internalization of external costs and even without the abolishment of subsidies. The investment for an average kilowatt is estimated to be less than \$4000. Energy Towers have a built-in storage system of close to 100% efficiency, on a weekly basis, and at a low investment. With the increased use of solar energy, there is a special interest in developing energy-storage systems. Energy Towers, as conceived today, may supply this important technology as well, even for other energy sources. Therefore, it should be combined with other solar technologies.

The technology of concentrating parabolic mirrors now under development in Israel could be applied if the external costs are partially internalized. It can supply between one quarter to one third of Israel's electricity demand, as well as steam to various plants. The Solar Tower technology, under development in Israel, will be ready within a few years. It too can supply between one quarter to one third of Israel's electricity demand without oil backup, and it too depends on the internalization of external costs. The two technologies last mentioned, will be worthwhile if the external costs are internalized, or if a technology for energy storage is developed which would enable the use of the technology 24 hours a day. This could supply any amount of energy required, provided a system for storing the energy is found. Without storage, they would be unable to supply more than one-fourth of the consumption, whatever the actual amount. These two technologies can also be used as an interim solution for enhancing fuel combustion with

solar energy. This solution may not be worthwhile to Israel, but it can be exported.

Some technologies may be used as interim solutions by supplementing combustible fuel with solar energy. The development of storage systems that will make solar energy available 24 hours a day is an important and promising development.

Solar energy is utilized in Israel more than in most other countries for home hot water and for large evaporation ponds.

Photovoltaic cells: Examining the current commercial status of solar energy technologies shows that large scale usage for energy production depends on the development of more efficient, cheap photovoltaic converters of solar energy to electricity. Sanyo has announced in May 1998 that it has developed the world's most efficient silicon solar cell that has an efficiency of 17.3%.

Commercial solar cells are small and expensive, for example:

Table 2.5: Examples of several commercial solar cells.

Company	Module Capacity	Module cost watts \$	\$/kw
BP Solar	90 595 5945	Soleq SQ	80 449 5612
Siemens	SP 75 490 6533	Solarex VLX	53 325 6132
Unisolar	US 64 395 6171		

These examples are still much better than the 10% efficiencies and \$10,000/kw reported in 1973.

The world's largest rooftop photovoltaic plant has been installed on the roof of the New Munich Trade Fair Center. Its peak output is 1 MW.

The most valuable use of solar energy could be for air-conditioning, since solar energy will be available at the warmest time of the day. However, only a few, heavily subsidized, solar air-conditioning units have been built so far.

Parabolic mirror solar energy concentrators for the production of high temperatures, like the Weitzman Institute Solar Tower, often get headlines but no commercial use. The commercial PSI parabolic concentrator uses 82 mirror facets with a total projection area of 87 sq. m. and delivers 70 kW at best.

There are two possible untapped sources of hydroelectric power :

1. From the sources of the Jordan. Only a small hydroelectric generator is presently using this resource. However, this option has been discussed for 40 years and has not been implemented due to water allocation disputes with neighboring countries.

2. Utilizing the height difference of the Mediterranean Sea and the Dead Sea. This option has been investigated in depth many times and is not viable economically currently.

Geothermal sources of energy are limited to a few small thermal springs that are used as tourist attractions and cannot be converted for other uses.

The Electrical Corp. is supporting research on technologies to exploit wave power for electricity production. The likelihood of an economic project of this type is low.

2.3 Recommendations

CO₂ reduction ability

Our objective is to reduce CO₂ and CO₂ equivalent emissions to the 1990 level by 2010. It is assumed here that an attempt will be made to reach the targets for 2010 and for 2020.

The 1990 emissions for electricity production were 16.660 million tons CO₂. The 2010 emissions, if no changes are made to decrease the GHG emissions, are expected to be 44.213 million tons CO₂. The 2020 CO₂ emissions if no changes are made to decrease the greenhouse effect will be 59.626 million tons CO₂.

The required reduction in emissions will, therefore, be 27,553 million tons of CO₂ for 2010 and 42,966 million tons for 2020.

Following the discussion of the available options above we recommend two approaches for the reduction in CO₂ emissions. One class do not require excessive investments or changes, the other, pursuing a more revolutionary change and requiring substantial changes in the energy sector pricing mechanisms, technical tradition and decision making criteria.

Class I recommendations

1. Switching the main fuel for power stations from coal and fuel oil to natural gas. The savings in CO₂ emissions for the current mix of fuels are 41.4%. The IEC does not plan to switch the fuel to the coal using power stations in the near future. If only the liquid fuel using power stations are switched to natural gas by 2010, and all future generating stations use natural gas, and the coal using generating stations are switched to natural gas by 2020, the reduction in emissions due to changing the fuel will be 6,464 million tons by 2010 and 24,685 million tons by 2020.

Current projections in IEC for the best case scenario are that natural gas will, at best, account for 50% of the electricity produced.

2. Increased efficiency of new power stations. We assume that the newer power stations will have an efficiency greater by 2% than current power stations and each 1% of efficiency is equivalent to 2.5% in CO₂ emissions (Technologies, policies and measures for mitigating climate change, IPCC Technical Paper I, UNEP, 1997, p.5). for the increase in capacity by 2010 and by 2020 the reductions in emissions will be 1,337 million tons by 2010 and 2,148 by 2020.

3. Reduction of 0.2 million tons a year of CO₂, or more, by 2010 and of 0.4 million tons a year by 2020, will come from increased use of solar heating, and more efficient refrigerators and air conditioning systems.

The total savings in CO₂ emissions from power stations by 2010 and by 2020 are presented in table 2.6

Table 2.6: CO₂ reductions for 2010 and 2020

Measure CO₂ reduction ability for 2010.

(Mtons CO₂) CO₂ reduction ability for 2020.

(Mtons CO₂) Changing of fuels 6.1 14.4 Efficient new power stations 1.3 2.1 Other 0.2 0.4 Total reduction 7.6 16.9 Desired reduction 27.5 43.0

If coal- generating stations are also switched to natural gas by 2010 the total reductions in CO₂ emissions will be 19.8 million tons CO₂. If no natural gas is used, the total reductions will be only 1.5 million tons CO₂.

If no natural gas is used by 2020 the total reductions for 2020 will be only 2.5 million tons CO₂.

2.4 Economic considerations

1. Changing of fuels: It is expected that the switch from coal and fuel oil to natural gas will not increase the cost of fuel per generated unit energy. However, considerable capital expenditures will be required. If Sinai natural gas is used, a gas pipeline will be required from the wells to the generating stations. If European suppliers are used liquefaction equipment will be required at the source and evaporation equipment at a local port, with pipelines from the port to the generating stations. Ships capable of carrying liquified natural gas will have to be purchased. In addition, some distillation equipment at the refineries will be idled and an additional fuel oil cracking unit will have to be built in order to correct the imbalance in products due to the loss of market for most of the produced fuel oil. However, advantages other than CO₂ reduction are anticipated, mostly reduction of other air pollutants (SO₂) and saving the cost of scrubbers.

2. More efficient power stations: If any combined cycle units, that produce process steam, are built, steam pipeline to their process clients will be required.

2.5 Discussion

The greatest reduction in CO₂ emissions will be achieved by switching all fuels used in generating stations to natural gas. New generating stations using low energy fuels with low efficiencies, such as a generating station using shale will only serve to increase the CO₂ emissions, and should be discouraged.

The best technological solution is to switch to non fossil fuel generating stations. There are two such possibilities:

1. Nuclear reactors. These are economical and can be safe if designed and operated properly.

2. Solar, wind and hydrothermal generating stations.

Wind and hydrothermal potential in Israel is less than 2% of the energy demand.

Solar energy is the ultimate desirable source of electrical power. It is clean, and renewable. However, its utilization has major hurdles. Solar energy is available only during part of the day, and its use will require massive energy storage devices. The cost is high, and will

continue to be expensive, except, perhaps, for solar energy air conditioners, till the reserves of fossil fuels decrease to a point, where the cost of energy from fossil fuels will be similar to solar energy.

Other long term options:

1. The use of combined cycle electrical generators in order to increase the efficiency of the usage of fossil fuels is attractive but limited. The initial cost of these systems are high, but may be justified in the future.
2. The demand for desalinated water is expected to be considerable by 2010. For desalination the use of flue gas in a low pressure evaporation plant can be economical, and should be encouraged.

Since practically most mitigation options are problematical, the best method to minimize CO₂ emissions is to decrease the demand for electricity. This may be achieved by encouraging, through lower taxes, homes designed for energy efficiency, and by setting electricity prices that increase with increased use. Current data of the Ministry of Infrastructure shows that 1995 fuel savings were 19,000 TOE/year. The savings in 2010 may reach 267,000 TOE/year. In electricity savings terms these translate to 24 and 68 million kWh respectively.

Class II recommendations

Table 2.7 below showing alternative energy is not a statistical forecasts, rather a declaration of the essential targets of the Israeli economy, and serve to illustrate what is possible to achieve.

Up to 35,000 GWh per year may be added with savings of more than \$30-70 billion from today until the year 2020. There is no doubt that the penetration of alternative sources depends on application processes that take time. This time depends on completing the development of new means at the rate of change of the economic climate and at the rate at which old power stations reach the end of their life cycle. One must also add two appreciable considerations: a. If the calculations shown here are verified, it will be worthwhile using alternative sources even at the price of preferring existing power stations in order to save on fuel combustion. b. There are number of steps which would facilitate meeting the targets. Among them are: an economic climate free of distortions, incentives and financial tools, the enactment of regulations, guidance, illustrations and the promotion of research and development at all levels.

We have not included in the tables a list of proposals for the interim period. Basically there are three main proposals. a. Replacing heavy oil and coal with natural gas. b. Combining gas turbines with steam-generating power stations (re-powering). c. Supplementing gas combustion with solar energy at a ratio of 25% and higher.

Table 2.7: Alternative Sources for Electricity Generation

Technology	Status	Expected Date of Application	Investment needed until
Application	Estimated Invest.	for average net Kw	Expected cost of Electricity Saved
Fuel,			
Assuming Coal			
Combustion Saved Fuel,			

Assuming Gas
 Combustion Additional Allowable Investment
 Based on the Coal Scenario
 0%
 Savings in
 \$ Billion Additional
 Allow-able Investment
 Based on Gas Scenario
 0%
 Potential
 In
 Israel

By the Year 2020

Years \$10 6 \$/Kw C/Kwh C/KWh C/KWh \$10 3 Kw \$10 3 Kw MW
 (GWh per year) MW
 (GWh per year) Windmills Fully commercial Immediately 10 3250 (2) 4-8 2 1.5 19,250
 (4.8) 8,064 (2) 1000<
 (3504) 750
 (2600) Biomass and waste Fully commercial Immediately 5 (4) 2860 (5) 5.7 (6) 2
 1.5 19,640
 13.7 8,454
 5.9 1000<
 (6000)< 700
 (4500) Parabolic concentrating collectors, solar part only Fully commercial, with improve.
 capabilities One year 5 15000 (7) 15< 2 1.5 7499
 0.25 3686(-)
 (-0.06) not limited, except for backup system 50
 (540) Solar tower of the Weizman Institute, solar part only Under develop. 6-7 years to
 complete a demo plant 20 13600 (9) 15< 2 1.5 8899
 0.3 2288 (-)
 (-0.08) not limited, except for backup system 100
 (1080) Energy Towers , no power limitation R&D has been completed, a pilot plant about
 to be constructed 3 years for start of construct. 7-8 y. to complete commercial plant 49
 3000 2.5-5 (8) 2 1.5
 19450
 (56) 8314
 (23.9) 9000<
 (80000<) 2900<
 (24000) Total (75) (31.7) not limited 4500

(32720)

Notes:

- . 1. Actions for the introduction of wind-power turbines: The completion of a country-wide survey, Enactment of laws and regulations which would require payment for electricity without limitations on the supplier, Setting prices that the Israeli Electric Company will have to abide by.
- . 2. Requiring the preparation of regional plans, Setting main power lines with a governmental investment which would later be charged to the companies, Bids for constructions.
- . 3. Investment per net kW: Based on \$1300 per kW, installed, based on a 40% performance coefficient: External cost for coal are only 5 cents per kWh, not including the national economic costs amounting to the addition of 2 cents per kWh of fuel, External cost for gas are only 2 cents per kWh, not including the national economic costs amounting to the addition of 1.5 cents per kWh.
- . 4. Preparation for the utilization of agricultural waste: Preparation of regional plans and the estimate of quantities, Allocation of industrial areas, Investigation, planning, collection, transportation, and storage, Bids.
- . 5. Expected investment based on \$2000 per installed Kw, and based on a capacity coefficient of 70%.
- . 6. Fuel cost per kWh, based on \$40 per ton, based on 0.15 ton oil equivalence, 5% interest rate for 20 years, 1 cent for operation and maintenance.
- . 7. Installation near industrial zones which require steam may double the energy savings and reduce the actual investment.
- . 8. Costs are dependent mostly on the interest rate which varies between 5.3% and 12%. At the average cost of electricity generation, the following benefits were not taken into account: desalination, the use of Energy Towers for pumped storage, for cooling thermal stations, and for increasing the efficiency of gas turbines. Similarly, the potential profits from selling water to fish ponds were not included. These may reduce net electricity prices by as much as 2-3 cents. Solar towers may also be used as an interim solution, supplementing gas turbines with solar energy for up to one third of the power generation. In this case, the formal cost for an average Kw is only one fourth of this number. According to the developers of this technology, in the future, the solar tower will be able to store heat at a cost of \$30 per kWh. Deducting such storage up to once a year, will increase the cost of kWh by no more than 1 cent, and is much more attractive than a backup system of natural gas

Chapter 3

The Industry Sector

3.1 Introduction

In 1996 the industrial sector in Israel emitted some 18,500 Ktons CO₂ of which 60% originated from fuel combustion and 40% from electricity consumption. The total electricity consumption by the industry sector in 1990 (according to national statistics) was 5655 million kWh, over one quarter of the total electricity produced. In 1996 industry consumed 8571 million kWh, constituting almost 30% of total electricity produced.

Consumption of electricity by the major industrial segments in 1990 and in 1996 is shown in table 3.1

Table 3.1: Electricity consumption of major industrial segments

Segment	1990 Electricity consumption (million kWh)	1996 Electricity consumption (million kWh)	Average growth %/year
Chemicals	1384	2011	5.5
Food	728	982	4.4
Mining	553	892	7.1
Metal products	499	674	4.1
Non metallic minerals	356	707	10.2
Textile	350	498	5.0
Plastics and rubber	274	517	9.5
Electrical and electronics	273	579	11.4
Metals	234	296	3.5
Paper	108	291	15.4

The factorized average growth rate was 6.381 %

3.2 Projections for the future

The high average growth rate was due to the large immigration from Russia and the high rate of growth of the economy during that period and is not expected to be as large in the coming decade.

Of these segments the food segment is expected to grow proportionally to the population growth. The textile segment is expected to decrease to half its current size. The export oriented chemicals and electrical segments will grow faster than the increase in the population size.

The largest industrial users of fuels/and or electricity in Israel are:

1. The oil refineries at Haifa and Ashdod.

The refineries used 663,000 tons of fuel oils for heating and internal electricity generation in 1990. This amounts to 5.8% of the crude oil processed.

If natural gas is imported by 2010, as expected, the refineries will use about the same amount of crude as in 1990, and its electricity and fuel uses will be about the same as in 1990.

2. Users of electrochemical energy for the production of chlorine, caustic and magnesium. These are Electrochemical Industries at Acco, Machteshim near Be'er Sheva, The Bromine Co. at the Dead Sea and the Dead Sea Works.

The Dead Sea Works has started production of magnesium. It can reach production of 50,000 tons by 2010. The electricity usage per kg of magnesium is 18-25 kWh. Assuming that the new Dead Sea Works process is twice as efficient as the older processes, still the electricity use of the magnesium plant alone in 2010 can reach 500,000 MWh. However, the byproduct of the magnesium plant is chlorine, and the increased production will cause

the closure of the chlorine plants, saving about 300,000 MWh per year.

3. The producers of cement and lime. These are Nesher cement works at 3 locations and lime production by Stone and Lime Co. in many locations and Negev Chemicals in one location.

Lime production in Israel in 1996 was 210,000 tons. It is expected to grow proportionally to the increase in population. The production of a ton of lime generates 0.786 ton of CO₂ from the decomposition of limestone and 0.982 ton of CO₂ from the combustion of fuel, or a total of 1.768 ton of CO₂ per ton of lime.

Cement production in Israel was 2.868 million tons in 1990 and 6.204 million tons in 1995. The average yearly growth rate was 16.4%. The high growth rate was due to the fast growth of the Palestinian market and to the large immigration from Russia. Expansion plans are for 0.7 million tons in 1999 and 0.7 million tons in 2003. It is assumed that most of the Palestinian market will be lost by that time, and the additional increase in production by 2010 will be negligible. The amount of CO₂ produced per ton of cement clinker, without any mitigation measures is about 0.5 tons by decomposition of carbonates and 0.75 tons from combustion of fuels.

The 1990 electricity use by the largest industrial consumers (according to the Israel Electric Co. statistics) is presented in table 4.2.

Table 3.2: Largest industrial consumers of electricity

Company	Location	Electricity usage (M kWh)
Fertilizers and Chemicals	Haifa	110
Haifa Chemicals	Haifa	82
Periclase	Rotem	48
Electrochemical Industries	Acco	197
Machteshim	Be'er Sheva	121
Haifa Refineries	Haifa	94
* Bromine Co.	Dead Sea	57
Negev Phosphates	Rotem	74
Petrochemicals Co.	Haifa	106
* Exclusive of own generated electricity.		

Most of the electricity usage at Fertilizers and Chemicals was for the ammonia plant compressors. The ammonia plant was closed in 1997. No new ammonia plants are expected to be built in Israel.

Haifa Chemicals has built a plant, similar to its Haifa plant at Rotem, and is expected to grow by a similar amount again by 2010.

The petrochemicals plant's production is expected to triple the 1990 rate by 2010.

The other companies in the table above are assumed not to grow by more than 25% by 2010.

3.3 Mitigation options

3.3.1 CO₂ originating from fuel combustion

The 1996 CO₂ emissions from the industry sector were estimated at 11 million tons of

CO₂ from fuel combustion and 7.7 million tons of CO₂ from electricity consumed, totaling 18.7 million tons CO₂.

Due to the slow down in the economy we project a 3% increase in the consumption of fuels per year from 1996 to 2010. This will bring up the unmitigated projection for 2010 to 15.3 million tons of CO₂ from fuel combustion.

There are no formal figures for total CO₂ emissions by the industry sector for 1990. However, the last decade was distinguished by fast growth of the industry and we may extrapolate backward at 6.4% a year to 7 million tons of CO₂.

Therefore, the amount to be mitigated is the difference between the amounts of CO₂ expected in 2010 and the amounts of CO₂ in 1990: 8.1 million tons of CO₂ and CO₂ equivalent gases from fuel combustion.

Mitigation options of CO₂ emissions within the industry sector are as follows:

1. Higher energy fuels

Changeover to natural gas from fuel oil is practical only to plants close to the future gas pipelines. The largest user of fuel oil, the refineries, cannot switch to natural gas, since the fuel they use internally is generally the heaviest fuel that cannot be sold externally. If the government will finance a pipeline to Rotem and the Dead Sea, the plants there could switch to natural gas. Conversion from fuel oil to natural gas will decrease CO₂ emission by 30%.

2. Changing the technology of cement and lime plants

The CO₂ produced by cement plants comes from the decomposition of carbonates (about 69% of the raw material) and from the combustion of fuels.

Considerable savings in the use of fuel in cement plants can be achieved by switching from the wet process used until recently, to a dry process and to the addition of aggregated ashes to the cement mix.

The savings of energy by switching from the wet to the dry process are 53%. Savings of both energy and CO₂ from decomposition of carbonates can be achieved by the addition of coal ashes, which may be added up to 30% in the final mixture.

The cement plant in Haifa and in Hartuv, both based on the wet process, produce 23% of all cement produced in Israel. The plant in Ramle was switched to the dry process in 1999 and it is anticipated that the other plants will be switched to the dry process as well..

Only minor improvements in the efficiency of lime plants are feasible, due to their relatively small size.

3.3.2 CO₂ originating from electricity consumption

In 1990 electricity consumption by the industry was 5,500 million kWh. CO₂ emissions were 4.55 million tons. In the year 2010 it is projected to be between 11,000 and 13,000 million kWh (according to several projections by the IEC). We will use the middle figure of 12,000 million kWh. Assuming no mitigation measures are implemented in the power generation sector, CO₂ emissions are expected to be 11.8 million tons in the year 2010.

Electricity is consumed by the industrial sector for two purposes; industrial manufacturing processes and air conditioning of space. A large fraction of energy is used by the high tech industry and by other industries for air conditioning purposes.

HVAC (Heating, Ventilation and Air Conditioning) systems consume sizable amounts of energy, which are associated with the production of CO₂ and other greenhouse gases. A significant portion of this energy may be conserved and the CO₂ emission reduced through co-generation. Electric power generation produces large amounts of reject heat. When this power is generated at the power plant, the reject heat is lost; generation of electric power locally, at the site, makes it possible to take advantage of the waste heat for heating and cooling. Co-generation systems may be practical for commercial size HVAC systems such as hotels, hospitals, office buildings and public buildings. The potential to decrease CO₂ emissions ranges from 0.375 kg CO₂ per kWh cooling in conventional cooling systems to 0.165 kg CO₂ per kWh cooling and 0.114 kg CO₂ per kWh cooling in co-generation cooling systems and hybrid air conditioning respectively. The technical and quantitative background data for these results are presented in the appendix.

For a thorough discussion of the means and mitigation measures that significantly reduce energy consumption in buildings for heating and air conditioning see chapter 4: Energy savings in buildings.

Energy savings in large buildings can range between 25 - 40%. Assuming that heating and air conditioning account for 50% of energy consumption within the industry sector, implementing energy savings measures may enable a decrease of 2.5 million tons of CO₂ in the year 2010.

3.4 Summary

Our assumed objective is to reduce CO₂ and CO₂ equivalent emissions to the 1990 level by 2010.

The desired total savings in CO₂ equivalent emissions by the industry sector by 2010 are 7.01 million tons of CO₂

1. Cement plants . For 7.6 million tons of cement in 2010, switch to dry process (which has started) and introducing the maximum 30% of coal ashes will decrease CO₂ emissions to a total saving of 4.161 million tons.

2. Switch to natural gas at the Dead Sea and Rotem. For about 250,000 tons of fuel, the savings in CO₂ emissions will be about 100,000 tons.

3. Oil refineries . Since no increase in the capacity of the refineries is expected by 2010, the 3% per year increase assumed for all the industry should be deducted. Translated into CO₂ emissions, this equals 800,000 tons.

4. Efficiency improvement in many plants may add savings of additional 200,000 tons of CO₂.

Table 3.3: Expected reductions in CO₂ emissions:

Industrial activity million tons of CO₂ Cement plants 4.16 Switching to natural gas 0.1

Refineries 0.8 Other 0.2 Total 5.26

Leaving a deficit of the industry sector of 2.84 million tons.

With respect to reduction of CO₂ emissions from electricity consumption, it is estimated that energy savings for the purpose of comfort thermal conditions within buildings is 25 - 40%. Such a magnitude of savings can be achieved by green building as specified in chapter 4 and in cases of large industrial parks, by using more efficient heating and cooling systems as specified in the appendix

A reduction of up to 40% of emissions resulting from electricity consumption by the industry sector in the year 2010 is equal to 4.7 million tons CO₂. With respect to emissions in 1990, the situation would be a deficit of 2.5 million tons CO₂.

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Appendix A

Energy savings in buildings

A.1. Qualitative classification of building parameters

A qualitative classification of the range of effect of design parameters, within the various types of living units in the different climatic zones, points to the more and less significant parameters. Table A.1 provides qualitative data about the degree of importance of each of the design parameters within three climatic regions in Israel.

Table A.1: Comparison of ranges of effect of design parameters on energy saving in buildings.

Region C A B Jerusalem Tel Aviv Ramat David Apartment type 4 facades
roof/
pillar 2 facades

middle 4 facades
roof/
pillar 2 facades

middle 4 facades
roof/
pillar 2 facades

middle Design Parameter \ Insulation Type S I S I S I S I S I Building wall insulation
symbol 110 \f "Monotype Sorts" \s 12 n symbol 117 \f "Monotype Sorts" \s 12 u symbol
110 \f "Monotype Sorts" \s 12 n symbol 117 \f "Monotype Sorts" \s 12 u symbol 110 \f
"Monotype Sorts" \s 12 n 0 Building roof insulation symbol 110 \f "Monotype Sorts" \s 12
n symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n Floor
insulation on pillar story symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f
"Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n Wall color symbol 117
\f "Monotype Sorts" \s 12 u symbol 117 \f "Monotype Sorts" \s 12 u 0 0 0 0 symbol 117 \f
"Monotype Sorts" \s 12 u symbol 117 \f "Monotype Sorts" \s 12 u symbol 117 \f

"Monotype Sorts" \s 12 u 0 0 0 Roof color symbol 117 \f "Monotype Sorts" \s 12 u
symbol 117 \f "Monotype Sorts" \s 12 u symbol 110 \f "Monotype Sorts" \s 12 n symbol
117 \f "Monotype Sorts" \s 12 u symbol 117 \f "Monotype Sorts" \s 12 u symbol 110 \f
"Monotype Sorts" \s 12 n Air infiltration symbol 110 \f "Monotype Sorts" \s 12 n symbol
110 \f "Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f
"Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f
"Monotype Sorts" \s 12 n symbol 117 \f "Monotype Sorts" \s 12 u 0 symbol 110 \f
"Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f
"Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n Building ventilation on
summer nights symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts"
\s 12 n symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n
symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n symbol
110 \f "Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f
"Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f
"Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n Increasing exterior wall
surface symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n
symbol 110 \f "Monotype Sorts" \s 12 n 0 symbol 110 \f "Monotype Sorts" \s 12 n symbol
117 \f "Monotype Sorts" \s 12 u symbol 117 \f "Monotype Sorts" \s 12 u symbol 117 \f
"Monotype Sorts" \s 12 u symbol 110 \f "Monotype Sorts" \s 12 n symbol 117 \f
"Monotype Sorts" \s 12 u 0 0 Building orientation symbol 110 \f "Monotype Sorts" \s 12
n symbol 110 \f "Monotype Sorts" \s 12 n symbol 117 \f "Monotype Sorts" \s 12 u 0
symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n symbol
117 \f "Monotype Sorts" \s 12 u 0 symbol 110 \f "Monotype Sorts" \s 12 n symbol 117 \f
"Monotype Sorts" \s 12 u symbol 117 \f "Monotype Sorts" \s 12 u 0 Solar building
deviation from south symbol 117 \f "Monotype Sorts" \s 12 u symbol 117 \f "Monotype
Sorts" \s 12 u 0 0 symbol 117 \f "Monotype Sorts" \s 12 u symbol 117 \f "Monotype
Sorts" \s 12 u 0 0 symbol 117 \f "Monotype Sorts" \s 12 u 0 0 0 Building proportions 0 0
symbol 117 \f "Monotype Sorts" \s 12 u 0 0 0 0 0 0 0 0 0 Solar building proportions
symbol 110 \f "Monotype Sorts" \s 12 n 0 symbol 117 \f "Monotype Sorts" \s 12 u 0
symbol 117 \f "Monotype Sorts" \s 12 u 0 symbol 117 \f "Monotype Sorts" \s 12 u 0 0 0 0
0 Wall shading symbol 117 \f "Monotype Sorts" \s 12 u 0 0 0 0 0 0 0 0 0 0 Roof shading
symbol 117 \f "Monotype Sorts" \s 12 u 0 symbol 117 \f "Monotype Sorts" \s 12 u symbol
117 \f "Monotype Sorts" \s 12 u symbol 117 \f "Monotype Sorts" \s 12 u symbol 110 \f
"Monotype Sorts" \s 12 n Window shading in summer symbol 117 \f "Monotype Sorts" \s
12 u symbol 117 \f "Monotype Sorts" \s 12 u symbol 117 \f "Monotype Sorts" \s 12 u
symbol 117 \f "Monotype Sorts" \s 12 u symbol 110 \f "Monotype Sorts" \s 12 n symbol
110 \f "Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f
"Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f
"Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f
"Monotype Sorts" \s 12 n Non-shading windows in winter symbol 110 \f "Monotype
Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s
12 n symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n
symbol 110 \f "Monotype Sorts" \s 12 n 0 0 symbol 110 \f "Monotype Sorts" \s 12 n
symbol 110 \f "Monotype Sorts" \s 12 n symbol 110 \f "Monotype Sorts" \s 12 n symbol
117 \f "Monotype Sorts" \s 12 u Increasing solarly level/ external shutter symbol 110 \f

[illegible]

S - standard

- 2- 5-10 symbol 117 \f "Monotype Sorts" \s 12 u
I - improved
3- 10-15 symbol 110 \f "Monotype Sorts" \s 12 n
4- >15 symbol 110 \f "Monotype Sorts" \s 12 n

The climatic regions:

Zone A: the coastal plain (represented by the Tel Aviv climate); zone B: the inner plain and the valleys (represented by the Ramat David climate) and zone C: the mountain area (represented by the Jerusalem climate).

Region Temperature (C 0)

Relative Humidity (%) January August Maximum in summer A. Coastal (Tel Aviv) 10.2 - 17.5 24.5 - 29.7 75 B. Inner plain and the valleys (Ramat David) 6.7 - 16.9 22.2 - 33.1 65 C. Mountain (Jerusalem) 4.5 - 12.2 18.5 - 30.3 60

Based on table A.1 it is possible to classify the parameters into several qualitative groups carrying specific traits within all or some of the climatic zones or within all or some of the building types:

- 11312Design parameters that have strong effects unrelated to a given climatic zone. E.g. Air infiltration and building ventilation on summer nights.
- 11312Design parameters whose effect is strong only in a given climatic zone. E.g. Window shading in summer, or variations in window area (particularly those facing west) when they have no external shutter. The effect of these parameters is very significant in the hot-humid Tel Aviv climate, but moderate in the temperate-cool Jerusalem climate.
- 11312Design parameters whose effect is strong regardless of the apartment type and its various design parameters. E.g. Window shading in the summer in Tel Aviv, or air infiltration in Jerusalem.
- 11312Design parameters whose effect is strong only in apartments of a certain type and dependent on the values of other design parameters. E.g. Non-shading of windows in winter and increasing the solarly level of the apartment, whose effect is very strong, principally in roof apartments.
- 11312Design parameters whose effect is weak to moderate regardless of climate or other design parameter values. E.g. Non-solar building proportions, wall shading and color.

A.2. Quantitative classification of the maximal energy savings by design parameter within different climatic regions in Israel

The data is presented in descending order according to the degree of energy savings. The numbers in parentheses express the maximal possible change in kWh/year per square meter floor, unless otherwise specified.

Jerusalem: a roof apartment or on pillars 4 facades

The standard building

· 11312 Parameters with a great effect (over 20 kWh/year per square meter) Increasing the southern window surface area, namely the building solarly level. The window is with an external shutter that provides good shading in summer and night insulation in winter

(35) Air infiltration (33) Non-shading of windows in winter (30) Roof insulation (23)

Varying the building exterior wall surface area (21) Floor insulation in the first-story apartment on pillars (20).

· 11312 Parameters with a large effect (over 10 and up to 20 kWh/year per sqm)

Insulation of the building walls (17) The building orientation(16) Solar building proportions (15) Building ventilation on summer nights (3.5 degrees C). Shading windows in summer (1.5 degrees C).

· 11312 Parameters with a moderate effect (more than 3 and up to 10 kWh/year per sqm)

Solar building deviation from due south (9) Wall color (8) Roof color (7) Varying the surface area of the western window with an interior shutter (7) Varying the surface area of the eastern window with an interior shutter (6) Double glazing (5% or 10% glazing on main facade) (3-7) Wall shading (5) Shading of a medium-color roof (4) Varying the surface area of the western window with an exterior shutter (4) Varying the area of the eastern window with an exterior shutter (3) Varying the surface area of the northern window with an interior shutter (3)

· 11312 Parameters with a small effect (below 3 kWh/year per sqm) Varying the surface area of the northern window with an external shutter that provides good shading in summer and night insulation in winter (1) Non-solar building proportions (1).

Jerusalem: roof apartment or on pillars

Improved building

· 11312 Parameters with a great effect (over 20 kWh/year per sqm) Air infiltration (30) Non-shading of windows in winter (26) Building ventilation on summer nights (4.8 degrees C)

· 11312 Parameters with a large effect (over 10 and up to kWh/year per sqm) Increasing the southern window surface area, namely the building solarly level (15) The building orientation (15) Varying the area of the exterior walls (10). Shading windows in summer (2 degrees C).

· 11312 Parameters with a moderate effect (over 3 and up to 10 kWh/year per sqm) Solar building deviation from due south (5) Roof color (5) Varying the surface area of the western window with an interior shutter (5) Varying the surface area of the eastern window with an interior shutter (4) Varying the surface area of the western window with an exterior shutter (4) Double glazing (3-6) Varying the surface area of the northern window with an interior shutter (3) Varying the surface area of the eastern window with an exterior shutter (3) Wall color (3)

· 11312 Parameters with a small effect (below 3 kWh/year per sqm) Shading of a medium-color roof (2) Wall shading (2) Non-solar building proportions (1) Varying the surface area of the northern window with an exterior shutter that provides good shading in summer and night insulation in winter (1) Solar building proportions (5).

Jerusalem: apartment on an intermediate floor 2 facades

The standard building

- 11312 Parameters with a great effect (over 20 kWh/year per sqm) Air infiltration (25) Building ventilation on summer nights (6.9 degrees C).
- 11312 Parameters with a large effect (over 10 and up to kWh/year per sqm) Varying the exterior wall area of the building (15) Non-shading of windows in winter (13). Shading windows in summer (1.5 degrees C).
- 11312 Parameters with a moderate effect (over 3 and up to 10 kWh/year per sqm) Varying the surface area of the southern window with an interior shutter (7) Building walls insulation (5) Building orientation (5) Varying the surface area of the southern window with an exterior shutter (4) Non-solar building proportions (4) Varying the surface area of the western window with an interior shutter (4) Double glazing (2-5) Varying the surface area of the eastern window with an interior shutter (3)
- 11312 Parameters with a small effect (below 3 kWh/year per sqm) Varying the surface area of the western window with an exterior shutter (1) Solar building deviation from due south (2) Varying the surface area of the northern window with an exterior shutter (1) Varying the surface area of the eastern window with an exterior shutter (1) Varying the surface area of the northern window with an exterior shutter (1) Wall color (1) Wall shading (.5) Non-solar building proportions (.5)

Jerusalem: apartment on an intermediate floor 2 facades

The improved building

- 11312 Parameters with a great effect (over 20 kWh/year per square meter) Building ventilation on summer nights (7.8 degrees C).
- 11312 Parameters with a large effect (over 10 and up to kWh/year per square meter) Air infiltration (20). Shading windows in summer (1.5 degrees C).
- 11312 Parameters with a moderate effect (over 3 and up to 10 kWh/year per square meter) Non-shading of windows in winter (9)
- 11312 The effect of all other design parameters is small.

Tel Aviv: roof apartment or on pillars 4 facades

The standard building

- 11312 Parameters with a great effect (over 20 kWh/year per sqm) Non-shading of windows in winter (24) Shading of windows in summer (24) Air infiltration (20)
- 11312 Parameters with a large effect (over 10 and up to kWh/year per sqm) Building walls insulation (19) Roof insulation (17) Floor insulation of the story on pillars (13) The building orientation (13) Increasing the surface area of the southern window, namely the solarly level of the building (12) Varying the external wall area of the building (10) Roof color (10) Building ventilation on summer nights (2.1 degrees C).
- 11312 Parameters with a moderate effect (over 3 and up to 10 kWh/year per sqm) Varying the surface area of the southern and northern windows with an interior shutter (9) Solar building deviation from due south (6) Varying the surface area of the northern

window with an interior shutter (5)

.. 11312 Shading of the medium-color roof (5) Double glazing (2-5) Variation in the area of the eastern window with an interior shutter (3) Solar building proportions (3).

.. 11312 Parameters with a small effect (below 3 kWh/year per sqm) Variation in the area of the northern, eastern and western windows with exterior shutters (2) Wall color (2) Non-solar building proportions (1) Wall shading (1).

Tel Aviv: roof apartment or on pillars 4 facades

The improved building

.. 11312 Parameters with a great effect (over 20 kWh/year per sqm) Shading of windows in summer (29) Non-shading of windows in winter (20) Air infiltration (20) Building ventilation on summer nights (2.9 degrees C).

.. 11312 Parameters with a large effect (over 10 and up to 20 kWh/year per sqm) Varying the surface area of the western window with an interior shutter providing partial shading in summer (13) The building orientation (12).

.. 11312 Parameters with a moderate effect (over 3 and up to 10 kWh/year per sqm) Varying the external wall area (8) Varying the surface area of the eastern window with an interior shutter (8) Varying the surface area of the northern window with an interior shutter (7) Roof color (7) Varying the surface area of the southern window with an exterior shutter (6) Solar building deviation from due south (5) Shading of the medium-colored roof (4) Varying the surface area of the northern window with an exterior shutter (4) Double glazing (3-5).

.. 11312 Parameters with a small effect (below 3 kWh/year per sqm) Wall shading (2) Size of the eastern and western windows with external shutters (2) Solar building proportions (1.5) Non-solar building proportions (1) Wall color (1).

Tel Aviv: apartment on an intermediate floor 2 facades

Standard building

.. 11312 Parameters with a great effect (over 20 kWh/year per sqm) Building ventilation on summer nights (6.3 degrees C).

.. 11312 Parameters with a big effect (over 10 and up to kWh/year per sqm) Window shading in summer (19) Varying the surface area of the western window with an interior shutter (19) Varying the surface area of the eastern window with an interior shutter (15) Varying the surface area of the southern window with an interior shutter (13) Varying the surface area of the northern window with an interior shutter (10) Varying the surface area of the western and eastern window (10) with an exterior shutter.

.. 11312 Parameters with a moderate effect (over 3 and up to 10 kWh/year per square meter) Variation in the area of the southern window with an exterior shutter (9) Variation

in the area of the northern window with an exterior shutter (8) Exterior building wall area variation (8) Building orientation (5) Air infiltration (4) Wall color (3) Wall insulation (3) Solar building proportions (3).

· 11312 Parameters with a small effect (below 3 kWh/year per sqm) Building proportions Solar building deviation from due south (2) Double glazing (1-2) Wall shading (1) Increasing the building solarly level (0) Non-shading of windows in winter (0).

Tel Aviv: intermediate floor apartment 2 facades

Improved building

· 11312 Parameters with a great effect (over 20 kWh/year per sqm) Building ventilation on summer nights (6.4 degrees C).

· 11312 Parameters with a large effect (over 10 and up to kWh/year per sqm) Varying the surface area of the western window with an interior shutter (19) Shading windows in summer (18) Varying the surface area of the eastern window with an interior shutter (15) Varying the surface area of the southern window with an interior shutter (14) Varying the surface area of the northern window with an interior shutter (11) Varying the surface area of the western window with exterior shutter (12) Varying the surface area of the eastern window with an exterior shutter (10).

· 11312 Parameters with a moderate effect (over 3 and up to 10 kWh/year per square meter) Varying the surface area of the southern window with an exterior shutter (14) Varying the surface area of the northern window with an exterior shutter (9) Variation in the exterior wall area of the building (7) Wall color (3).

· 11312 Parameters with a small effect (below 3 kWh/year per sqm) Building orientation (2) Air infiltration (2) Building proportions (2) Solar building deviation from due south (2) Double glazing (1-2) Wall shading (1) Increasing the building solarly level (0) Non-shading of windows in winter (0).

A3. Energy Efficiency in HVAC Systems for Commercial-Size Buildings

HVAC (Heating, Ventilation and Air Conditioning) systems consume sizable amounts of energy, which are associated with the production of CO₂ and other greenhouse gases. A significant portion of this energy may be conserved and the CO₂ emission reduced through Co-Generation. Electric power generation produces large amounts of reject heat. When this power is generated at the power plant, the reject heat is lost; generation of electric power locally, at the site, makes it possible to take advantage of the waste heat for heating and cooling. Co-generation systems may be practical for commercial size HVAC systems such as hotels, hospitals, office buildings and public buildings. This article explains the principles of co-generation, estimate the reduction in CO₂ emission and give some typical examples.

Figure 1 describes a conventional-type air-conditioning system employing a vapor-compression chiller with a typical COP (coefficient of performance) of 3.5. The

electric power for the chiller is produced at a coal-fired power plant as shown, with a typical efficiency of 40%. 1.0 Ton of coal delivered to the power plant, with a typical caloric value of 6,000 kcal/kg, produces 6,977 kWh of heat which is converted to 2,791 kWh of electric power and 4,186 kWh of waste heat at about 40 °C. The associated emission of CO₂ is 3.667 Tons. The chiller employs this electric power to produce 9,768 kWh of cooling (typically by producing chilled water at about 7 °C, suitable for both sensible cooling and dehumidification) and rejects 12,559 kWh of waste heat at ambient temperature. The resulting CO₂ production is thus 0.375 kg per kWh of cooling.

Figures 2 and 3 describe two conventional-type heating systems. Figure 2 shows an oil-fired furnace or steam boiler employing light oil with a typical caloric value of 10,000 kcal/kg, at a combustion efficiency of 85%. 1.0 Ton of oil delivered to the furnace produces 9,884 kWh of heating, and 1,744 kWh of waste heat through the stack. The associated emission of CO₂ is 3.106 Tons. Figure 3 shows a different type, more energy-efficient heating system based on a vapor-compression heat pump with a typical COP of 4.0. The required electric power is generated at a coal-fired power plant under identical conditions to those of Figure 1. For the same input, the heat pump produces 11,164 kWh of heating at about 45 °C. The resulting CO₂ productions are thus 0.314 kg and 0.328 kg per kWh of heating, respectively, for the furnace (Figure 2) and the heat pump (Figure 3).

Figure 4 describes a co-generation HVAC system which can reduce significantly both the energy requirements and the CO₂ emission by generating the electric power locally and utilizing the reject heat. A diesel engine employing 1.0 Ton Diesel fuel with a typical caloric value of 10,000 kcal/kg, generates 4,070 kWh of electric power and 7,558 kWh of reject heat at a typical conversion efficiency of 35%. The associated emission of CO₂ is 3.106 Tons. The electric power drives a vapor compression chiller to produce 14,245 kWh of cooling at a COP of 3.5. In the winter, one may use the same electric power to drive a heat pump for heating, as in the system of Figure 3. The reject heat may be employed for heating in the winter or for cooling in the summer. by employing an absorption chiller at a typical COP of 0.6, additional cooling in the amount of 4,535 kWh may be produced from the waste heat. The data in Figure 4 shows that the total amount of CO₂ production for the cooling system shown may be 0.165 kg per kWh of cooling, a significant reduction from the value of 0.375 kg per kWh of cooling associated with the conventional system of Figure 1. The energy requirements are reduced as well.

A different system of co-generation in HVAC may be considered which separates the sensible and latent loads in air conditioning and uses desiccants to take care of the latter. Figure 5 illustrates a conventional situation where a vapor compression chiller with a typical COP of 3.5 employs 100 kW of electric power from the Utility to produce 350 kW of cooling at about 7 °C, suitable for both sensible cooling and dehumidification. The air conditioned space has a typical load profile requiring 40% latent and 60% sensible cooling. This system is essentially the same as the one of Figure 1 and as we have seen, the resulting CO₂ production is 0.375 kg per kWh of cooling.

The situation may be improved by employing the hybrid system described in Figure 6. The sensible and latent loads are separated out, and the vapor compression chiller is now responsible for the sensible part only. It is therefore sufficient for the chiller to produce the required 210 kW of cooling at a higher 15 °C, resulting in a higher COP of 4.0. The latent load of 140 kW is handled by a desiccant - a hygroscopic material which removes the humidity from the air and must be regenerated (dried) before it can be used again. This is done in co-generation mode by driving the chiller with a Diesel engine (directly or indirectly) and using the engine waste heat for desiccant regeneration. The total resulting CO₂ production is 0.114 kg per kWh of cooling, a significant reduction from the system of Figure 5. Energy requirements are reduced as well.

Figure 1 Conventional Cooling System

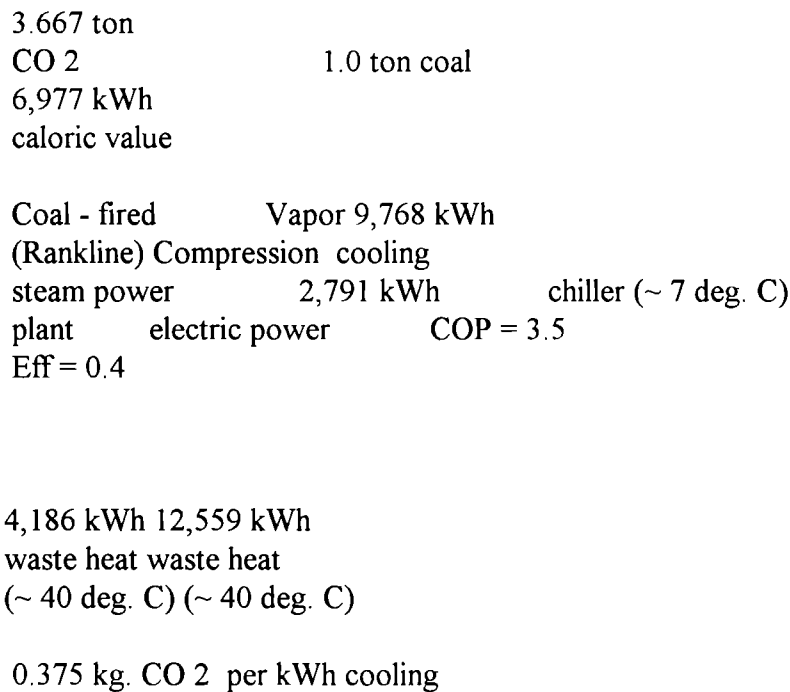
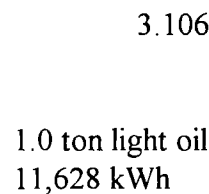


Figure 2: Conventional Heating System



caloric value

Oil - fired
furnace or
steam boiler
Eff = 0.85
9,884 kWh

heating

1,744 kWh
waste heat
(stack)

0.314 kg. CO₂ per kWh heating

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Figure 3: Conventional Heating System

3.667 ton
CO₂ 1.0 ton coal
6,977 kWh
caloric value

Coal - fired Vapor 11,164 kWh
(Rankline) Compression heating
steam power 2,791 kWh chiller (~ 45 deg. C)
plant electric power COP = 4.0
Eff = 0.4

4,186 kWh 8,373 kWh
waste heat waste heat
(~ 40 deg. C) (~ 40 deg. C)

0.328 kg. CO₂ per kWh cooling

Figure 4: Co - Generation Cooling Systems

3.106 ton
CO₂ 1.0 ton coal
11,628 kWh 14,245 kWh
caloric value cooling
4,070 kWh (~ 7 deg. C)
Diesel electric power Vapor
engine - Compression
driven chiller
generator COP = 3.5 18,315 kWh
Eff = 0.35 12,093 kWh waste waste heat
heat (~ 40 deg. C) (~ 40 deg. C)

7,558 kWh Absorption chiller 4,535 kWh cooling
reject heat COP = 0.6 (~ 7 deg. C)

0.165 kg. CO₂ per kWh cooling

Figure 5: Conventional Air Conditioning

350 kW Conditioned space
100 kW Vapor cooling 100 TR (350 Kw)
electric power Compression (~ 7 deg.C) 60% sensible load
from Utility Chiller 40% latent load
COP = 3.5
@ 1.314 kg CO₂
per kWh electric

450 kW
waste heat
(~ 40 deg. C)

0.375 kg CO₂ per kWh cooling

Figure 6: Hybrid Air Conditioning

210 kW Conditioned space
52.5 kW Vapor cooling 100 TR (350 Kw)
electric power Compression (~ 15 deg.C) 60% sensible load
from Diesel Chiller 40% latent load
COP = 4.0
@ 0.763 kg CO₂
per kWh electric
140 kW
262.5 kW Desiccant dehumidification
waste heat system (~ 40 deg. C) Reject heat
from Diesel

@ 0.763 kg CO₂
per kWh electric

0.114 kg CO₂ per kWh cooling
Appendix B

B1. Considerations in the decision making process about Transportation Control Measures (TCMs)

In order for an authority to choose a TCM to implement it needs to know:

- 11312How travelers will respond to a given TCM?
- 11312What greenhouse gas emission reduction effect can be expected from a given TCM?
- 11312What are the expected benefits from such reductions?
- 11312Which of all TCMs are the most cost-effective and easy to implement?

Unfortunately, the available tools and information necessary to perform evaluation and answer these questions are limited, and the error associated with such tools is often larger than the effect to be measured.

The actual nature and magnitude of the impact of transportation on global warming are subjects of considerable disagreement, and the benefit of CO₂ reduction are difficult or impossible to quantify (Cambridge Systematics, 1997)

TCMs should not be assessed exclusively on the basis of their potential to reduce emissions/greenhouse gas effect and the associated agency costs to implement and operate. In the U.S. it has been shown that TCMs frequently are stated to be cost-ineffective when only emission reduction impacts are considered, and it is not unusual for TCMs to have benefit-cost ratios of up to ten when other relevant impacts are included as part of the evaluation process (Cambridge Systematics, 1983 and Apogee Research, 1994).

Other than their air quality impacts TCMs should be evaluated on their effect on:

- 11312direct cost of the implementation of the TCM including new facilities, new services (like extended transit service) and operating and administration costs.
- 11312change in maintenance and operating cost due to shift in demand and/or supply
- 11312saving in vehicle operating and maintenance expenses
- 11312land use and changes in land values
- 11312indirect costs
- 11312Reduce congestion
- 11312Noise and aesthetics
- 11312travel time differences (some users may improve their travel time while other may increase their travel time)
- 11312social and community impacts
- 11312economic impacts
- 11312noise impacts
- 11312safety impacts

- 11312land use and economic development
- 11312energy consumption

A lot has been written about the problem of cost benefit analysis of transportation project and how to consider some of these many factors in the analysis. A TCM can be viewed as a transportation project in this sense, except that the problems are more difficult because our understanding of the consequences of such measure lags behind our understanding of the consequences of new transportation infrastructures projects. Our inability to correctly evaluate the benefits from TCM complicated our ability to prioritize them.

While the long-term benefits of large scale program like the U.S. federal motor vehicle emissions control program on carbon monoxide and ozone levels can be seen by examining several years' worth of air quality monitoring data (Shiftan et. al 1996), it has proven to be considerably more difficult to statistically relate changes in air quality to the implementation of specific fuels, vehicle inspection/maintenance, or transportation management programs. While there are many efforts to evaluate the air quality benefits of TCMs most of these efforts rely on some assumption of participation rate. However, our understanding of peoples' response to TCM and the long run effect of such measures is far from being satisfactory for the purpose of evaluating the benefits of such measure. This view is shared by many recent researchers. For example, Knapp et. Al (1995) in a study for the U.S. Federal Highway Administration investigated issues related to the evaluation and monitoring of TCM impacts and concluded that none of the methods available can evaluate all the TCMs. They also argue that this fact, and the difficulties with TCM participation rate estimation and TCM program evaluation, limits the ability to evaluate the regional impacts of TCMs. In a more recent study, that represent the state of the art and the practice in this area Envair/Cabmridge Systematics (1998) conclude that achieving the goal of relating the effects of specific transportation control measures and other mobile source air quality control measures to changes in ambient air quality levels remains elusive.

Previous papers have extensively listed potential TCMs. These include the efforts by Salamon (***), Comsis (1993) and Shiftan and Suhrbier (1997). TCMs can be classified in different ways. The two main classifications are regulatory versus voluntary, and the "push" versus "pull". Regulatory TCMs represents traditional "command-and-control" type actions that involve passage of a law or regulation to require a change in behavior. Voluntary TCMs induce such a change through some process of providing alternative choices or restricting existing alternatives. The later is the "push" and "pull" classification. Pull TCMs represent TCMs that induce a change through providing new alternatives or improving existing more environmental alternatives. Push TCMs represent TCMs that make the use of single occupancy vehicle less attractive by restrictions and charges. Most of the TCMs are targeted at reducing VKT.

Few TCMs are targeted at specific areas through other means like vehicle technology and traffic operation. Some of the TCMs are useful for the short run like traffic improvement and ridesharing programs, while some are strategies for the long run like land use/growth management policies. Another possible classification concerning the action taken is the

authority level making the decision. Some TCMs like parking restrictions and physical measures will usually be initiated by local authorities, while pricing and taxation will usually be carried at the state level.

While the classifications discussed above overlay in the sense that a TCM can belong to any combination of these dimensions an effort was made to classify the wide range of TCMs to seven main groups according to the type of action they involve as follows:

- . 1.Regulatory TCMs
- . 2.Mobility Improvements
- . 3.Travel Demand Management
- . 4.Market Based Mechanism
- . 5.Land Use and Growth Management
- . 6.Traffic Operation and Flow Improvements
- . 7.Vehicle Technology

Within this classification regulatory TCMs are kept separate because of their different nature but each of the TCMs in this group can be placed in one of the other groups. Mobility Improvements are aimed at shifting mode away from single occupancy vehicle. Travel demand management, market based mechanism and land use measures can all be viewed as one block aiming to reduce VKT. It is possible to include market based mechanism and land use measures under the general group of travel demand management but they are kept separated because of the wide range of options they represent. Traffic operation and flow improvements aim more at the supply side. Vehicle technology aim at changing technology instead of changing behavior.

Some TCMs may complement each other and their combined benefit will be larger than the sum of the individual benefits while other may compete and their combined benefit will be less than the sum of benefits from the individuals' benefits. An example for competing TCMs is HOV lanes and transit improvements. Both measures will attract single occupancy vehicle to shift mode. HOV lanes may even cause some transit users to shift to HOV. An example for complementing TCMs is transit improvements and parking restrictions. The introduction of transit improvements by themselves can not have a significant effect on mode choice as people will always prefer the convenience of the private car. However, with the combination of parking restriction and any other "push" measures on the use of private car like congestion pricing they can be more effective. It is difficult to evaluate the effect of an individual measure, it is further more complicated to evaluate the effect of a package of measures.

In Europe a current effort is taking place under the European Commissions' Directorate General VII project DANTE: Design to Avoid the Need to Travel in Europe. As part of this project Marshall and Banister (1997) reviewed the level of implementation of 64 different TCMs in seven European countries. Marshall and Banister also focused on the implementation of particular packages of measures by means of case studies in three cities. For example, the city of Enschede in the Netherlands implemented a variety of TCMs

including restrictions on car use in the city center, extending and improving cycle network, and raising awareness about car use. Measures included:

- 11312closure of streets in the city center for cars
- 11312reduction in the number of parking spaces
- 11312extension of bicycles path including paths to bypass bus stops and intersections
- 11312advanced stop lanes at traffic lights to make cars wait behind cyclists
- 11312cycle priority by detection loops and green lights for cyclist in all directions twice during a complete cycle
- 11312guarded bicycle parking
- 11312press releases and information stands at local events
- 11312information packages (leaflet about negative effects of car and information about other alternatives)
- 11312reduced fare by public transport
- 11312discounts at shops when traveling by bicycle

The results show that the measures were successful in reducing car travel to the city center and increase bicycle mode share by Enschede residents but not by visitors from beyond Enschede.

In the U.S. a number of metropolitan areas are required by the federal Clean Air Act to begin implementing TCM during the next several years. Many states and metropolitan planning organizations have therefore factored the influence of these travel control measures into their long-range forecasts of regional travel demand. In assessing and synthesizing these forecasts, the Department of Transportation found that they predict annual growth in motor vehicle travel on a national basis to be about 10 percent lower than what might otherwise be expected (TRB, 1997).

While our estimate of the effects of TCM is always questionable, it is clear that a good policy program to reduce VKT should be based on packages of various TCM combining push and pull measures and target both the short and long run. A comprehensive land use transportation plan should be established, with growth management and mix of land uses that will minimize travel. This type of land use will be better served by transit and therefore investments in transit will be more effective. For a TCM package to be effective it has some form of road pricing and other effective restricting measures like parking availability.

Many cities attempted to implement integrated transport policies, using a combination of measures to reduce traffic and encourage the use of more energy-efficient means of transport. Usually, these attempts are hard to assess because it is difficult to judge what would have occurred if the policies had not been implemented. In terms of the maximum possible reduction it is interesting to observe the experience in Singapore. Since the early 1970s, Singapore adopted a variety of TCM including road pricing using an area licensing scheme and other auto and usage taxes. Ang (1992) estimated that the impact of this combination of measures reduced gasoline consumption on the island by 42%. This reduction can be considered the maximum possible effect by combination of measures in a politically supportive environment and limited dense and congested area. It is unlikely that these level of impacts can be achieved in Israel.

B2. CALCULATIONS OF CO₂ EMISSION ESTIMATES

Estimate of CO₂ emission from gasoline vehicles

1 The carbon content in the gasoline was calculated on the basis of fuel consumption in Israel.

The gasoline consumption in 1996: 2,029,200 ton

Fuel (gasoline) density: 0.75 kg/litre

Number of passenger cars in Israel in 1996: 1,174,166

Average mileage in 1996: 17,000 km

Average fuel consumption of passenger cars: 10.7 km/litre.

Total fuel (gasoline) consumption of passenger cars:

Unknown

Average carbon content in the gasoline: 86%

Carbon content: C mass = 1,203,246 ton

2 The total emissions of the following substances, from passenger cars in Israel, 1996, were estimated by [5]:

CO mass : 417,000 ton

Unknown 3,830,000 ton

HC mass : 57,000 ton of H 1,85 C (as measured by FID)

3 The carbon content (C) in these emissions was calculated by the molecular weight:

Unknown

4 The relative difference between the two estimates of carbon contents in emissions of passenger cars:

Unknown

This rather low value is an indication of the validity of the two different estimates.

5 The percentage of CO₂ in the carbon balance of the fuel, Unknown is calculated on the basis of the data according to (3). The percentage of carbon associated with CO₂ in the total carbon emissions, Unknown is given by:

Unknown

Taking 86% carbon content in the average gasoline, as above:

Unknown

6 The amount of CO₂ emissions are calculated by:

Unknown

where m_f is the annual gasoline consumption.

The total fuel consumption of the various gasoline vehicles categories in Israel are listed in Table 1. The above equations were used to calculate the total CO₂ emissions, and the results appear in Table 1 too.

The estimate of total CO₂ emissions from passenger cars in Israel, 1996, calculated on the basis of fuel consumption, is (from Table 1) 3,642,400 ton. The estimate based on the emission coefficients, cf. (2) above, is 3,830,000 ton. The relative difference is:

Unknown

Estimate of CO₂ emissions from diesel vehicles

The calculation of CO₂ emissions from diesel vehicles is based on the assumption that Unknown = 90%. Therefore:

Unknown

where $m_f(d)$ is the annual diesel fuel consumption.

The results of CO₂ emissions which appear in Table 2, are based on the values of $m_f(d)$ in this Table, and calculated by the above equation.

Comparison of CO₂ emissions by diesel and LPG buses

Public transportation in Israel is based almost entirely on diesel vehicles (mainly buses), therefore comparative analysis of buses conversion to LPG operation is described in detail here.

The main assumptions that have been used:

- LPG is mainly propane;
- Efficiency of engine operation is equal for both diesel fuel and LPG;
- Average carbon content in diesel fuel is 86%;
- Percentage of carbon associated with CO₂ in the total carbon emissions is:
= 90% of diesel fuel

Unknown = 82% of LPG = Unknown of gasoline because in both cases the engine operates with stoichiometric mixture.

Carbon content in propane:

Heat value of LPG is lower than that of diesel fuel:

$$\text{LHV}_d = 35.7 \text{ MJ/l}$$

$$\text{LHV}_{\text{LPG}} = 23.6 \text{ MJ/l}$$

Therefore, for equal energy supply to the engine:

1.513 liter of C₃H₈ is needed compared to 1 liter of diesel fuel.

In mass units:

1 kg of diesel fuel $\leftrightarrow$ 0.919 kg of LPG.

Estimation of CO₂ emission is performed according to the method described in detail in the Appendix.

For diesel fuel:

$$\text{CO}_2 \text{ mass}(d) = 2.838 * m_f(d) = 2.838 * 1 = 2.84 \text{ kg}$$

For LPG:

Unknown

Unknown

CO₂ reduction in case of LPG use is:

Unknown

Cost aspects of conversion of diesel buses to LPG operation

There is only scarce information in the literature about actual or estimated costs of investment and operation of public transportation based on gas engines. All following estimates have been performed based on only two references, [1,2], and therefore can not aspire to be of high accuracy and reliability.

According to reference [1], the initial cost of a new LPG bus is about 150,000 ECU (symbol 187 \f "Symbol" \s 12 » \$170,000) 10% more than a conventional diesel bus, [2]. Therefore, additional investment for bus purchase is about \$17,000 per bus.

The cost of a complete LPG filling station for up to 300 buses with overground fuel tanks, including piping, pumps, fuel meter, hoses and nozzles is about 97,000 ECU, [1].

Therefore, the additional cost per bus is: symbol 187 \f "Symbol" \s 12 » 330 ECU (\$370).

Estimation of investment, which is needed for adaptation of a workshop, can be taken from [2]. It is about 14,000,000 S (symbol 187 \f "Symbol" \s 12 » \$1,150,000) for a workshop servicing 150 buses. Therefore, the cost per bus is about \$7,700.

Summarizing all mentioned above, the value of additional initial investment per LPG bus is estimated as \$25,070. This sum does not includes cost of manpower training, special national legislation, etc. The total initial investment can be estimated as \$26,000/bus (in case of conversion of some hundreds of buses).

It will be possible to estimate operational costs of LPG use in buses only after decision by the Israeli Government about the pricing and taxation of automotive LPG.

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2. Hans Schodl, Wiener Stadtwerke Verkehrsbetriebe. Autobusbetrieb mit Flüssiggas.

Appendix C: A Dynamic Model of the Economy

() (1) Equation.2

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Equation.2

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Equation.2

symbol 0 \f "Times New Roman" \s 12 _) symbol 0 \f "Times New Roman" \s 12 _ 13)
Equation.2

Where: GDP_t = Gross domestic product in year t.

symbol 100 \f "Symbol" \s 12 d = Annual GDP growth rate.

POP_t = Population in year t.

symbol 103 \f "Symbol" \s 12 g = Annual population growth rate.

CO_{2,t} = Emission in year t.

symbol 115 \f "Symbol" \s 12 s = Emission growth rate.

K = Terminal year emission level.

T = Number of planning periods.

TAC_t = Total abatement cost, year t.

AAC_t = Average abatement cost, year t.

MAC_t = Marginal abatement cost, year t.

TR_t - Emission tax revenues in year t.

symbol 68 \f "Symbol" \s 12 D CSt = Change in consumer surplus in year t.

symbol 68 \f "Symbol" \s 12 D Qt = Change in energy consumption in year t.

symbol 68 \f "Symbol" \s 12 D Pt = Change in unit energy price in year t.

TC_t = Total cost in year t.

PGDP_t = Total cost as a percentage of GDP.

Eqs. (1) - (3) specify GDP at year t for a given economic growth rate, symbol 100 \f "Symbol" \s 12 d ; population at year t for a given population growth rate, symbol 103 \f "Symbol" \s 12 g , and GHG emission level at year t for a given annual pollution growth rate, symbol 115 \f "Symbol" \s 12 s , respectively. Together, eqs. (1)-(3) determine how the economy evolves over time without any intervention. Although one can a sensitivity analysis with different parameter values, in the present analysis a zero growth rate in GDP per capita was assumed, which implies that the GDP growth rate equals the population growth rate. Specifically, a growth rate of 2.2% was used, based on various predictions (Bank Hapoalim, 1998). We also assumed that the annual increase in the GHG emissions

will follow the annual growth rate of the economy, i.e., 2.2% per annum; a reasonable first-approximation assumption.

Eq. (4) fixes the terminal condition. As detailed above, we analyzed two scenarios: the first one sets the emission level in 2010 at the 1990 level, i.e., the total emission in 2010 of GHG-equivalent gases should reach 48.10 million tons. The second scenario sets emission levels to their per capita 1990 level, implying an aggregate emission level of 80.08 million tons.

Eq. (5) describes the path of emission level over the planning period, noting that it specifies moving from base to target year in equal annual reduction steps. The annual abatement effort is proscribed in eq. (6), which states that annual abatement should be the difference between the emission levels in the business as usual case and those specified for the scenario under examination.

Goulder and Mathai (1998) have recently proposed the functional form given by eq. (7) for estimating abatement costs:

Equation.2

Where: TAC_t = Total abatement cost in year t .

$CO2_t$ = Emission in year t (business as usual, baseline scenario)

A_t = Abatement effort (in CO_2 equivalent units) in year t

M , α_1 and α_2 are parameters.

This form has the desirable property that marginal abatement cost tends to infinity as abatement approaches 100% of the baseline emission. Furthermore, the parameters M , α_1 and α_2 are chosen so that the following requirements are satisfied: (1) A 25% pollution reduction in 2020 should entail a cost in the range of 0.5% to 4% of global GDP [based on EPRI (1994), extrapolated to the global economy]; (2) The discounted (at 5%) value of global abatement costs required in order to attain a CO_2 concentration of 550 ppvm by 2200 is roughly \$600 billion (Manne and Richels, 1997). It has been shown (Goulder and Mathai, 1998) that the parameter values that best meet these requirements are $M=83$, $\alpha_1=3$ and $\alpha_2=2$. Inserting these values into eq. (7), gives the total cost estimate, from which average [eq. (8)] and marginal [eq. (9)] cost can be derived.

Assuming a carbon tax mechanism is used to reach the desired abatement levels, eq. (10) determines the tax revenues in year t . Therefore, multiplying total emission in year t by the marginal abatement cost (which, by assumption, is equal the tax rate) gives the tax revenues for that year.

As explained above, abatement cost is not the only cost imposed upon the economy. The reduction in energy consumption due to the shift in the energy supply function (and consequently the rise in energy prices, by the amount of the tax) causes a decrease in consumer surplus. Knowledge of the price elasticity of demand for energy (symbol 63 \f "Courier New" \s 12 ?) enables the economist to estimate this welfare loss to society [eq. (11)]. There are a handful of studies which attempted to econometrically estimate this elasticity. We have decided to use in this study a value of symbol 63 \f "Courier New" \s 12 ? = -0.5, which is appropriate for the medium-run (Poterba, 1991), with short-run and long-run elasticities -0.11 and -0.82, respectively. Using Poterba's estimate of the effect of

a tax on the price of energy supply, we have calculated the loss in consumer surplus by approximating a linear function in the range of the price change range (i.e., estimating the area of a triangle instead of an integral of the area under the function).

Eq. (12) sums abatement cost and consumer surplus loss, giving the grand total cost for the given scenario, and eq. (13) presents this cost figure as a percentage of the GDP in year t .

Appendix D: Essentials of policies to reduce GHG emissions in other countries

D1: The Dutch strategy to reduce GHG emissions

Reduction strategies

The main instruments the Netherlands government has decided to apply in order to achieve a CO₂ emission reduction are:

- 11312standards and regulations
- 11312financial and fiscal incentives
- 11312long term (negotiated) agreements between government and industrial and non - industrial sectors
- 11312the environmental action plan of the energy distribution companies, partly financed by a surcharge on gas and electricity prices
- 11312public awareness
- 11312research and development

Initial targets that will provide reduction of CO₂ emissions include:

- 11312Increase of energy efficiency by 33% from 1996 to 2020.
- 11312Increase the share of renewable energy by 3% until 2000 and by 10% until 2020.
- 11312Increase combined heat and power capacity to 8000MW in 2000.

The energy sector is to achieve the goals of higher efficiency by heat distribution plans and new, more efficient plants via investment plans of power generators. It is to achieve an increase of average efficiency from 40 % in 1990 to 43% in 2000.

Also it is expected to add 10% wood in 2 coal - fired plants in 2000 subject to an agreement between the government and the energy sector, decreasing 0.4 Mton of CO₂ emission.

In 1990 the largest sources of CO₂ in the Netherlands were energy transformation (30%) and industry (29%). Transport and residential sectors contributed 16% and 13%

respectively. Since 1990 various policy measures have been implemented aiming at the target for 2000. Yet CO₂ emissions increased by 2.8% from 1990 to 1994 and preliminary figures for 1996 suggest a significant increase of 3.9%. Therefore the Dutch government has decided on additional measures to those mentioned above, that will ensure the achievement of the targets set.

Co-generation

By the year 2000 co-generation will make an important contribution to energy efficiency - some 8000MW (40% of total capacity). Given various conditions it is expected that co-generation will produce 14,000MW in the year 2020. The largest autonomous growth will be in industrial co-generation.

Renewable energy

Implementing the Renewable energy action programme will enable the Netherlands to achieve the target of 10% renewable energy by 2020. The programme consists of the following steps:

- broadening the range of fiscal instruments (see fiscal incentives), a low 6% VAT tariff on renewable - based electricity and a refund of the regulatory energy tax for renewable energy users (30 million NLG)
- providing extra R&D budgets (raised to 95 million NLG) and participation in European research
- demonstration and introduction projects
- support to the distribution sector
- setting up a Renewable Energy Project Bureau
- providing adequate payments for delivery of electricity generated from renewable resources by private operators to the public sector
- a mandated minimum portion of renewable energy in total electricity supply to captive consumers from 2001 and onwards, if the above mentioned measures do not achieve the required results.

Regulatory Energy Tax

A tax on natural gas, electricity and oil consumption which raises the prices for small scale energy consumption by 15% to 20%. The tax is paid by all consumers except the greenhouse horticulture sector which is exempt from the tax on natural gas. Since the tax is intended to induce energy conservation, revenues are recycled back into the economy through relief in other taxes. Use of renewable energy is exempted from this tax.

Fiscal incentives

Investments in energy conservation and in renewable energy are encouraged through a

number of provisions in the corporate income tax. These include an energy investment tax credit, free depreciation of certain kinds of energy and environment related investments, VAMIL scheme (22 million NLG in 1995 to 35 million in 2000) allows the discretionary depreciation of environmentally - friendly investments, Green investment (12.5 million NLG in 1996 to 15 million in 2000) is a tax concession which allows private individuals to invest in projects which foster environmental protection, including nature and woodland conservation, EIA (energy investment deduction) starting in 1997 with a budget of 125 million NLG.

Budgets and fiscal incentives

The Dutch government has allocated 204 million NLG for energy conservation programmes and 93 million NLG for renewable energy projects.

The industry sector is to achieve its targets of 20% efficiency improvement in 2000 via energy saving. This will be done by an increase of combined heat and power, energy management (good housekeeping and monitoring) and new technologies, all subject to long term agreements that account for 90% of energy use by industry, fiscal incentives and R,D&D. For the light industry manufacturing industry the long term agreements is not a viable strategy and therefore targets will be achieved by setting standards in environmental licences, namely, a regulatory approach.

These will be attained via:

- 11312 standards and regulations
- 11312 regulation mg energy tax for small scale energy consumption
- 11312 CO2 reduction plan - funding from 750 mln budget
- 11312 other financial/fiscal incentives:
 - 11312 free depreciation
 - 11312 green investments
 - 11312 energy investment tax credit
 - 11312 environment qaqi action plan
 - 11312 public awareness campaigns
 - 11312 research and development and demonstration

The strategy in the transport sector, aimed at reducing CO2 emissions by 10% by the year 2010 relative to 1986, consists of three tracks:

1. measures addressing the sources (technical measures such as improving fuel efficiency of cars), although the potential of the Dutch market to influence this issue alone is small. These include mainly subsidies for energy saving in traffic and transport and programmes on more quiet, cleaner and efficient transport in urban areas and wide scale

introduction of econometers, board computers and cruise controls in cars.

. 2. policy on mobility . Various measures and programmes are implemented with the aim of reducing the number of vehicle - km travelled.

. 3. measures addressing driving behavior such as increase in fuel prices, stricter control of speed limits, stimulation of more efficient driving and purchase behavior, and stimulation of other transport modes as alternatives for long distance trips.

Speed limit has achieved a reduction of 1.5% CO₂ emission of total road transport. Possible measures on the optimal fuel mix (petrol, diesel and LPG) and others, including the introduction of econometers, are currently under review. As of July 1997 excise duties on motor fuels has been increased while the fixed tax for car owners has been decreased in particular for small cars.

The residential and service sector has already taken several steps to save energy consumption, which will further pursued. These include: improving insulation and insulation standards, intensifying the Energy Performance Standard (setting limits to the allowable energy use for heating and hot water in homes and other buildings), demonstration and fiscal incentives for very energy efficient buildings.

Special attention is attributed to the relationship of new building with energy infrastructure in locations where the demand for new dwellings is to be met in the short term.

The Dutch assume that quality improvements in new construction will lead to market trends to upgrade existing buildings, including their energy efficiency. These will be achieved by LTAs (long term agreements) with rental agencies in the social housing sector and with relevant organizations for renting and maintaining office buildings. The improvements in energy efficiency targets are 30% in the year 2000 relative to 1989.

Energy efficient heating systems and appliances, levies, public education and labeling are and will be a means of inducing energy conscious (purchasing) behaviour. Subject to the Environmental Action Plans (MAP) the energy distribution companies (gas and electricity) are organized in a body which is to achieve specific targets in terms of CO₂ reduction for small scale end users of energy. According to the Energy Saving Appliances Act labelling has been introduced for refrigerators, freezers, washing machines and tumble dryers; minimum efficiency standards have been introduced for refrigerators, freezers and central heating boilers. Similar minimum efficiency standards will be introduced for a wide range of appliances and applications, either via regulations or voluntary agreements.

D2: The German strategy to reduce GHG emissions AGL.: MR Schafhausen

Sb.: AR Simon

BSb.:

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- 3) Im Feld Darstellung entfernen sie aus symbol 254 \f "Wingdings" \s 12 Verborgener Text
- 4) Bestätigen Sie den OK-Button

Anschrift1 Betreff Anlage
In 1990 Germany emitted 1,014,155 million tons of CO₂. In 1996 the amount of emitted gas fell to 910,000 million tons CO₂ emissions in Germany decreased by 10.3 % between 1990 and 1996. The decrease, which was continuous between 1990 and 1995 (minus 11.8 %), was interrupted by a temperature-related increase of CO₂ emissions during the unusually cold winters of 1995/1996 and 1996/1997.

Germany's aim is to reduce CO₂ emissions by the year 2005 by 25 % compared to emissions in 1990.

From 1990 to 1996, the ratio of energy-related CO₂ emissions to gross domestic product (GDP) decreased by about 19% in Germany. This indicates further severance of the link between economic growth and CO₂ emissions. Between 1990 and 1996, per-capita CO₂ emissions were reduced by 13.3 %.

Two studies aimed at assessing the possibility of achieving CO₂ emissions, agree in their finding that a 15-17 % reduction of energy-related CO₂ emissions will be achieved by the year 2005 with the set of measures already adopted by the Federal Government. In accordance with these findings, the authors suggest that additional measures are required to attain the Federal Government's CO₂ reduction objective.

With respect to recommendation of additional measures, it should be noted that the underlying studies were unable to take account of some important measures that are now showing their effect. These measures include:

- reduced subsidies for the use of domestic hard coal in power generation Whether this will help reduce CO₂ emissions by the year 2005 - and if so, to what extent - depends on what substitute energies are used in future. It is not possible at present to provide precise data on the extent of any relevant CO₂ reductions that may now be occurring.
- the concept for continuation of employment-promoting investments; one of this concept's important aims is to support the construction industry (about 5.5 million tonnes of CO₂ reductions by the year 2005).
- the amendment of the motor vehicle tax, which is expected to accelerate replacements of motor vehicles on the road.
- subsidies for owners of energy-efficient homes (Niedrigenergieh user), and use

of energy-efficient technologies in the framework of subsidies for housing construction (in each case, about 0.4 million tonnes of CO₂ reductions by the year 2005).

Finally, it is necessary to take into account the CO₂ reduction potentials that will result from the Federal Government's activities in the area of waste management. The contribution of waste management measures is estimated at 15 - 24 million tonnes of CO₂ reductions by the year 2005.

- 11312 Refinement of German industry's declaration on global warming prevention. Inclusion of additional associations, taking into account the relevant monitoring data (additional reductions of 10-20 million tonnes of CO₂).
- 11312 Promotion of the use of renewable energies (5 - 7 million tonnes of CO₂).
- 11312 Amendment of the Thermal Insulation Ordinance (Wärmeschutzverordnung) and of the Ordinance on Heating Systems (Heizungsanlagen-Verordnung), with the ultimate aim of an Energy Saving Ordinance; better enforcement of regulations for existing buildings (conditional provisions of the Thermal Insulation Ordinance and the Ordinance on Heating Systems, or of the future Energy Saving Ordinance), including information campaigns with continuation and expansion of existing funding programmes for overcoming barriers to investment (especially in the eastern German Länder) and for initiating additional early measures, depending on the rapidity and extent of implementation, 16 - 24 million tonnes of CO₂.
- 11312 Greater use of combined heat and power generation systems by industry and local authorities (cooperation between companies and local authorities in the heat/power generation sector) (30-60 million tonnes of CO₂).
- 11312 Training programmes, counselling and public awareness campaigns (4 - 8 million tonnes of CO₂).
- 11312 Increased efforts to inform the public about and raise awareness of energy-efficient driving (3 - 5 million tonnes of CO₂).

In addition, Germany is considering the introduction of route-based tolls for trucks, for reasons that include a fair allocation of route costs, traffic prevention and shifting transports to more environmentally compatible modes of transport.

A central element of Germany's concept with regard to further decreases in motor-vehicle fuel consumption is the German Automobile Industry's (VDA) voluntary commitment from 1995.

D3: The Japanese strategy to reduce GHG emissions

1. Introduction of More Efficient Thermal Electric Power Generation

Until now, countermeasures for improving efficiency have also been promoted for economic reasons, and the efficiency has been improved by increasing the capacity of power-generating facilities, raising the temperatures and pressures used to produce steam, and introducing combined-cycle systems. As a result, the combined heat efficiency of

thermal power plants (gross) improved from about 24% in the mid-1950s to about 37% in the mid-1960s, and now to about 39% in the mid-1990s.

Countermeasures for coal-fired power plants

Compared with other fossil fuels, coal emits high amounts of carbon dioxide per unit energy and is therefore in particular need of efficiency-improving measures. One of the effective ways to control carbon dioxide emissions from coal-fired plants is to introduce ultra-super-critical (USC) technology, pressurized fluidized-bed combustion (PFBC) technology, or integrated coal-gas combined cycle (IGCC) technology every time a new facility is built or an old facility is replaced. In addition, the Japan Development Bank has established a system of lowinterest financing for the construction of high-efficiency coal-fired thermal power plants.

Countermeasures for LNG power plants

Because LNG emits less carbon dioxide per unit energy than those of other fossil fuels, its aggressive use in power generation is another effective way to combat global warming. Current combined-cycle systems (which combine the use of gas and steam turbines) have achieved a heat efficiency in excess of 48% (with a gas-turbine intake temperature in the 1,300 °C class). Furthermore, technical development is currently being pursued with the aim of achieving a heat efficiency of 50% or higher by further raising the gas-turbine intake temperature. In addition, the Japan Development Bank has established a system of lowinterest financing for the construction of high-efficiency LNG-fired thermal power plants.

Development of Efficient Energy Supply Systems

High-efficiency energy supply systems currently under technical development include: more efficient power generation and electrothermal supply systems that improve overall efficiency, energy storage systems that boost the efficiency of facility operations; and systems that make use of dispersed energy sources.

Work on these various technologies is being conducted on:

1. Superconducting Technologies

Practical superconducting technologies are being developed to enable the expansion of power-source capacities, and to alleviate problems (such as locating power-line construction sites and suffering increased power loss during transmission) that are encountered as power plants are built further away from the areas where the energy is consumed. Research and development is also being carried out on superconducting generators, total systems, and refrigeration systems.

2. Distributed Electrical Energy Storage System

Studies are being conducted on ways of controlling carbon dioxide emissions throughout the entire power supply and consumption system by improving the efficiency of power storage technologies. Specifically: developing power storage systems that use the high-performance characteristics of lithium batteries; reassessing low-efficiency

storage systems such as pumped-water power generation plants located in the mountains far from where the power is consumed; establishing power storage plants that use NaS batteries and other technologies that can be located close to consumers; and encouraging consumers to install their own highefficiency storage systems.

Introduction of energy sources that produce little or no carbon dioxide emissions

1. Nuclear Power

Development and Use of Nuclear Power Premised on the Assurance of Safety

Nuclear power has already been one of Japan's main sources of electricity, accounting for 29.4% of total power output in fiscal 1995.

2. Hydroelectric Power

Given Japan's steep, mountainous topography, hydroelectric power is Japan's greatest domestic energy resources, and also has the advantage of not emitting carbon dioxide. In fiscal 1996, Japan possessed a hydroelectric power-generating capacity of approximately 44.4 million kW, representing about 19.0% of total capacity

3. Geothermal Power

Japan's wealth of volcanic activity makes geothermal power another valuable source of clean energy that does not produce carbon dioxide, sulfur oxide, or nitrogen oxide. As of fiscal 1996, Japan had a geothermal power-generating capacity of 530,000 kW, accounting for 0.2% of total capacity

Efforts are currently being made to develop the following technologies- investigative technologies that will reduce the risks associated with finding new geothermal power resources; technologies that enable the use of such potential energy sources that have not yet been exploited as medium-hot water and hot dry rocks, and deep geothermal resource survey and extraction technologies that will have an immediate effect in expanding the production capacities of existing geothermal sites. In these and other ways, the amount of electricity generated by geothermal means is expected to expand.

4. Development and Dissemination of New Energy Sources

The expansion and dissemination of solar power and other new energy sources is being made in various fields on the basis of the Basic Guideline for New Energy Introduction and as part of the New Sunshine Project.

4.1 Solar and Solar-thermal Power Generation

As of the end of March 1996, Japan had a solar power generating capacity of about 39,000 kW. Cost is the main obstacle to further dissemination. Efforts are therefore being made to lower costs and to offer incentives for the initial introduction of solar power.

To promote the introduction of solar power generating systems, the government offers large-scale assistance for residential solar systems and supports the introduction of such systems in public facilities. It has also compiled a manual to encourage regional public organizations to introduce solar power systems, and is conducting research concerning various applications for solar power, including noise barrier walls and other road-related

facilities, and beverage vending machines. Also, efforts are being made to raise public awareness of the purchasing system for surplus electricity that power companies have established through the use of special time-of-day residential lighting contracts; to use the purchasing system more fully; and to improve the practicality of solar power generation systems that are built into construction materials.

4.2 Wind Power Generation

Research has been conducted on 100 kW wind-activated power plants, and the technology for small and midsize wind-activated power plants has essentially been established. Applications, however, are still limited to testing and research, isolated islands, and demonstrations, with a total generating capacity of about 9,500 kW as of the end of March 1996.

Japan's unique climatic and geographical conditions offer limited potential for wind power generation.

4.3 Waste Power Generation

Improvement in generating efficiency would permit an expansion of waste-generated power output capacity, making waste a more viable alternative to fossil fuels. Four types of technology currently hold promise as practical ways to improve generating efficiency: (1) high-temperature, high-pressure waste power generation; (2) super refuse power generation (waste power generation combined with gas turbine); (3) refuse derived fuel (RDF) power generation; and (4) steam spray type waste power generation (conventional type of waste power generation). Japan aims to introduce these technologies to expand the nation's total waste-fired generating capacity to about 2 million kW by the year 2000 and to about 4 million kW by the year 2010.

As part of its efforts to establish more waste-fired power generating facilities, the central government provides support to regional public organizations for the construction, expansion and renovation of facilities, as well as for the construction of plants that convert waste into solid fuel.

4.4 Fuel Cells

Field tests are currently being conducted on phosphoric acid fuel cells and molten carbonate fuel cells with the aim of developing new technologies, improving equipment, and enhancing performance. Although phosphoric acid fuel cells are not yet in full-fledged use, they are currently generating 30,000 kW in Japan, which is more than in any other country.

4.5 Ocean Energy

Various kinds of wave power-generation technologies are being developed, including: floating oscillating-water-column systems; shore-fixed systems; pendulum systems; and wave-energy-absorption breakwater systems that convert the energy of the waves into the flow of air. Approximately 1,000 wave-activated generators are currently used on navigational buoys etc. in

Japan.

Regarding ocean-thermal-conversion power-generation systems, closed cycle technologies are being developed that use ammonia and other media. Although demonstration operations have been completed at a pilot plant, it seems unlikely that a power plant based solely on this technology will be economically feasible. As for open-cycle systems that use seawater as the direct working fluid, basic research has been conducted in an effort to improve condenser performance.

4.6 Biomass Energy

Most of the current work focuses on technologies for producing ethanol and other alcohols by using microorganisms and enzymes and on separating and concentrating biomass fuel by means of a membrane process.

4.7 Hydrogen Energy

Elemental technical development is being pursued on the use of hydrogen energy, an extremely clean secondary energy source that generates no carbon dioxide when burned.

Measures to Support the Dissemination of New and Renewable Energy Supply Systems
Various financial, tax, and systemic support measures have been formulated that

1) promote cogeneration, solar power, and other new energy technologies that are already basically established but not yet adequately disseminated because of their high costs; 2) promote the installation of facilities that level energy demand; and 3) promote the regional introduction of new energy systems.

The national government plans to quickly establish the market autonomy of solar power generation by providing large-scale assistance over a concentrated period of time with the aim of greatly reducing costs through the effects of mass production. Also, efforts are being made to promote the use of the power companies' surplus power purchasing menus, which make use of optional time-of-day pricing contract, and studies are being pursued to promote the practical application of solar power generating systems that are built into construction materials.

(1) Financial and Tax Measures

The Japan Development Bank and other lending institutions offer low-interest, long-term financing to operators who install solar, wind, cogeneration and other new energy systems.

Similarly, a program of tax incentives that promotes investment in the structural improvement of energy supply systems has been established to encourage the installation of such facilities as: solar power generation facilities, wind power generation facilities; equipment that uses geothermal heat; equipment that uses solar heat; fuel cells; waste power generation equipment; and gas turbines used in combined-cycle generation systems. In addition, tax reductions on fixed assets are available for certain types of facilities that utilize localized energy sources such as solar and wind power.

Subsidies are also available to regional public organizations that adopt a positive stance toward introducing new energy systems in an extensive and concentrated manner. Also,

an interest subsidy system has been adopted for local development and use of new and renewable energy promoted by local public organizations and/or private organizations.

(2) Deregulation and Other Systemic Measures

Japanese electric power companies are subject to regulations based on the Electricity Utilities Industry Law, including a requirement to receive government approval for the construction plans of structures used for electric power generation. In 1990, however, these regulations were relaxed for solar, wind and fuel-cell power generation plants with regard to such requirements as notification of construction plans and appointment of main engineers.

Progress has been made on establishing guidelines for technical requirements for interconnecting commercial electric power systems with power generating facilities. In October 1995, an overall review of the guidelines was conducted and requirements were clarified to ensure a higher degree of transparency and fairness.

In February 1994, a purchasing menu was established for surplus electricity produced by such dispersed sources as solar, wind, waste, and cogeneration power-generation facilities.

Measures to Control Demand (Including Load Leveling)

Demand-side management (DSM), which sets different electricity usage fees depending on the time of day, has been introduced to accommodate the difference between daytime and nighttime energy demand. In addition, energy storage systems such as pumped storage generators and thermal storage tanks are being used, and studies are being conducted on a new power storage system adjacent to the area where the power is consumed such as seawater-pumped-storage generators and compressed-air-storage gas turbine generators. Technologies being researched for future use include super heat-pump energy collection systems that store waste heat and other forms of heat at high densities, and dispersed-type power storage batteries.

Other activities aimed at leveling out power loads include: the implementation of interest subsidies, low-interest loans, and tax incentives (through a program that promotes investment in the structural improvement of energy supply systems) for thermal-storage air conditioning systems and gas air conditioning systems-, and the testing of load-centralized control systems that permit the energy supplier to directly control the equipment of energy consumers.

Improving the Efficiency of Petroleum Refining

Progress is being made in introducing heat recovery systems and advanced energy-efficient equipment designed to improve the operating efficiency of present refineries. New oil refining technologies, including new high-performance catalysts, are being developed, and systematically introduced whenever existing facilities are renovated. Studies are also being conducted on replacing railway tank cars and tank trucks with pipelines in order to improve the long-term efficiency of the distribution system for petroleum products, reduce energy consumption, and control carbon dioxide emissions.

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