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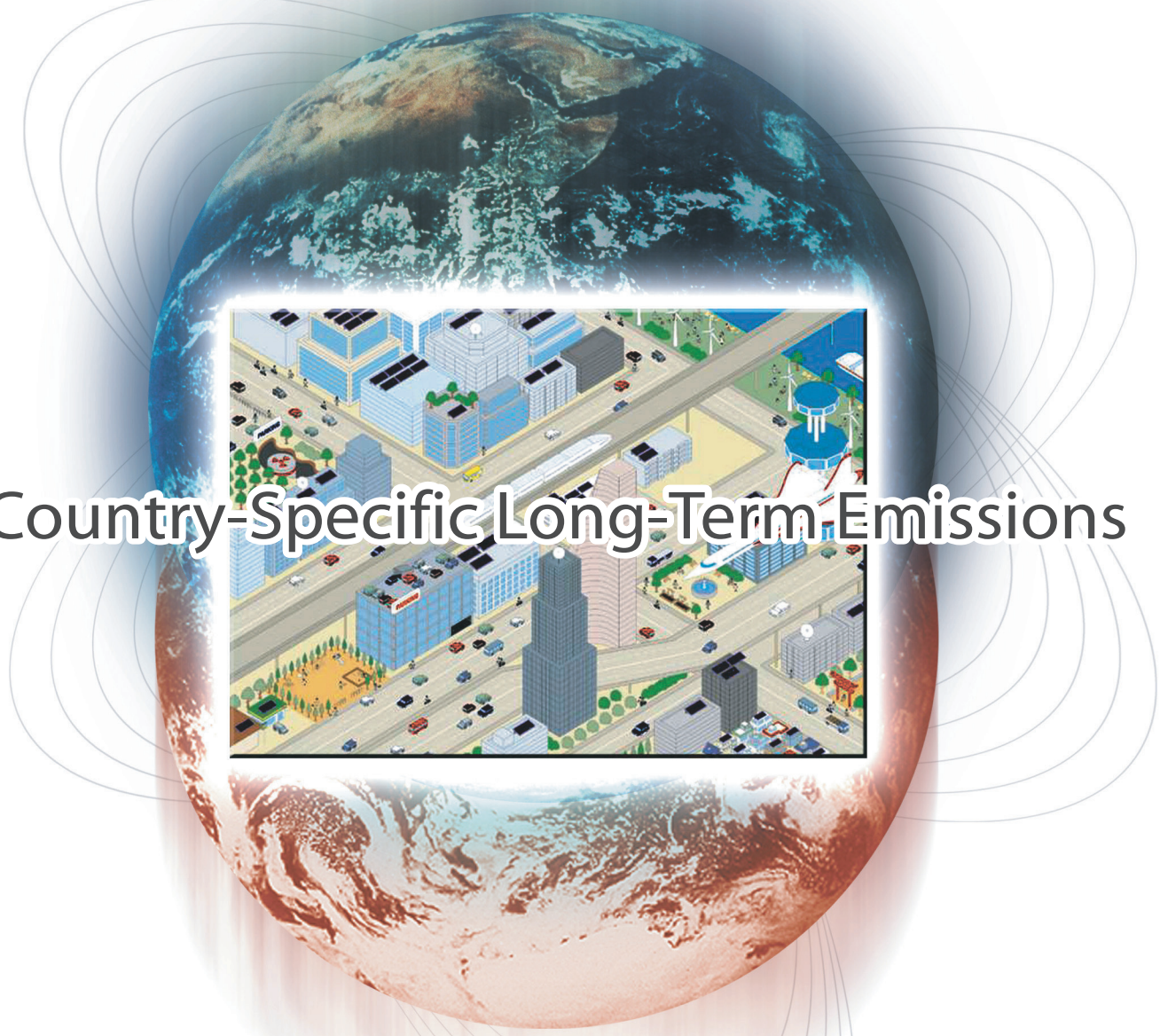

Country-Specific Long-Term Emissions

Scenario Study Team

Japan Low Carbon Society Scenarios Toward 2050

Research Project on
"Establishing of Methodology to Evaluate Middle to Long term Environmental Policy Options toward Low Carbon Society in Japan"
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Country-Specific Long-Term Emissions

Table of Contents

Introduction

According to IPCC's latest findings global warming increases at a higher pace than expected. For instance, it has recently been found that ice sheet has been melting widely in the world. In order to avoid catastrophic global warming it is relevant for policy-makers to establish a target of atmospheric carbon dioxide emission or concentration. One of the indicative targets is that in order to limit the global temperature rise to less than 2°C from the pre-industrial level, the global carbon dioxide emission during 2050-2100 should be half or less than the current value. Medium to long-term (2050) GHG emission reduction strategies have already been appraised in some countries such as the UK, Germany and France, with GHG reductions of 60%, 80% and 75%, respectively. Currently, in Japan, the National Institute for Environmental Studies and the Kyoto University are jointly assessing a 60 to 80% GHG reduction by 2050. This project is called "Japan Low Carbon Society Scenarios toward 2050".

The scope of this report is to compile the country-specific scenarios toward low carbon society and to arrange them in a common format in order to better assess the different national approaches. It deals with more than 10 countries' scenarios, such as EU countries, North America, Oceania and Asia, where these concerns have entered policy debates.

This report has been prepared in the hope that it would be useful for concerned researchers and policy-makers and provide helpful insights when designing analogous scenarios for other countries.

Country-Specific Long-Term Emissions

European Union's GHG atmospheric concentration stabilization target of 450-550 ppmv CO_2 and the temperature rise target of 2°C by 2050 have become an international standard. To meet this target long-term scenarios and strategies have already been reported at the national level in countries such as the UK, Germany and France with GHG reductions of 60%, 80% and 75%, respectively. Furthermore, in Japan, the National Institute for Environmental Studies and the Kyoto University are jointly assessing a 60 to 80% GHG reduction by 2050.

However, it is not an easy task to achieve that kind of drastic reductions. Carbon dioxide reductions can be expressed in terms of GDP, energy intensity (EI) and carbon intensity of energy (CI). Assuming a uniform GDP growth-rate of 1% over the next 50 years, the CO_2 reduction scenarios for 2050 can be represented in a two-dimensional chart, as shown in Figure 1 for the UK, Germany, France and Japan. The CO_2 reduction isoquants in Figure 1 are only appropriate when the above assumptions are met. Furthermore, also represented in the same figure are the EI and CI annual average variation rates for the following periods: 1960-2000 and 1990-2000. Every country but Japan has experienced a decreasing annual average EI and CI in the periods hereby considered. Japan's EI absolute value is relatively lower than that of the UK, Germany or France. Though, in the second period (1990-2000) there has been a shift in consumption patterns due to the preference for full-size cars -with a significant impact in the GHG emissions related to transportation- and an expansion in energy consumption stemming from an increase in the quantity of home appliances.

The Ministry of Economy, Trade and Industry of Japan has developed emission reduction scenarios until 2030. If the EI and CI rates considered in those scenarios are extrapolated up to 2050, and the GDP assumptions remain the same, i.e., 1% annual rate, then the maximum CO_2 reduction is slightly lower than 40%. In contrast, the UK, Germany and France scenarios report

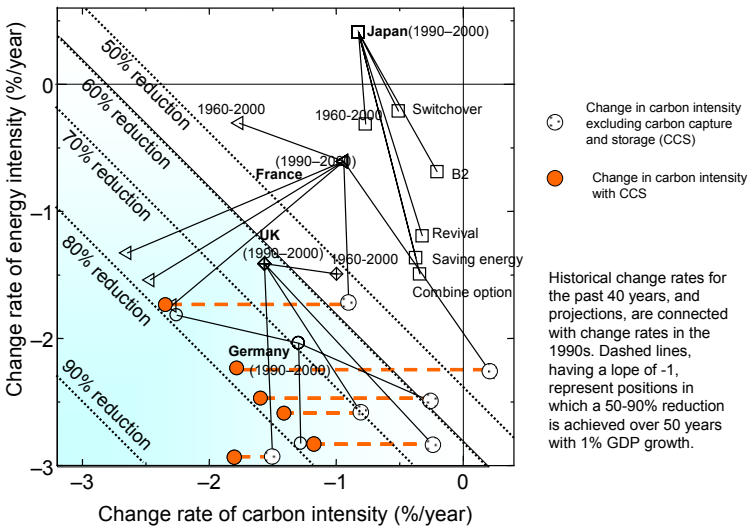

Figure 1 Relationships between CO_2 reduction targets and aggregate energy intensity/carbon intensity.

about 80% reduction. It has to be noted that the UK's scenarios consider higher GDP growth-rates, 2.25% and 3%. The forecasted CO_2 reductions under such assumptions are around 60%. The above-mentioned UK scenarios with a 1% GDP growth-rate hypothesis lead, ceteris paribus, to an increase in CO_2 reductions from 60% to 80%. An 80% reduction in CO_2 emissions requires a change in the combined EI and CI annual rate of about -4%, which is an enormous challenge given the past trends, as illustrated in Figure 1.

This report compiles the demanding country-specific emission scenarios. Table 1 shows a detailed list of the scenarios covered in this report. In some European Union countries emission scenarios toward low carbon society have been recognized officially by governments, while in most countries emission scenarios have not been considered by the governments or are confined to semi-formal proposals by research institutes. In order to avoid catastrophic global warming in the future, it is absolutely essential that countries all over the world consider of emission scenario strategies in their national policies. For this purpose researches on development of emission scenarios toward low carbon society should be carried out not only in Japan or European countries but also in developed countries that have not ratified the Kyoto protocol, and in the developing countries as well.

Table 1 Summary of strategies for low-carbon society

Country	Organization	Report / Project	Emission Target
UK	Royal Commission on Environmental Pollution	Energy - The Changing Climate	60% reduction in national CO_2 emissions from fossil fuel combustion relative to the 1998 level in 2050
UK	Department of Trade and Industry	Energy White Paper	60% reduction in national CO_2 emissions from current level (or more precisely by 58% from 1997 levels). This would lead to 2050 emissions of 64 million tonnes of carbon (MtC).
UK	Tyndall Centre	Decarbonising the UK	A true 60% reduction in national CO_2 emissions by 2050
Czech	Ministry of Environment	National Climate Change Plan	30 % reduction in national GHG emissions relative to 2000 levels in 2020
Finland	Finnish Agency for Technology and Innovation	CLIMTECH programme	The abatement levels studied for the year 2030 were 0%, –10%, –20% and –30% from the 1990 level. All the six GHGs included in the Kyoto protocol were considered in the scenarios.
France	French Interministerial Task Force on Climate Change	Reducing CO_2 emissions fourfold in France by 2050	75% reduction in national GHGs emissions relative to the 1998 level in 2050
Germany	Deutscher Bundestag	Enquete Commission on Sustainable Energy Supply	40% reduction in GHG emissions in the industrialised nations (i.e. also in Germany) by 2020, 50 % by 2030 and 80 % by 2050, relative to 1990
Netherlands	National Institute for public Health and the Environment et al.	COOL Project	50-80% reduction in national GHG emissions by 2050 relative to 1990 level
Sweden	Swedish Environmental Protection Agency	Swedish Climate Strategy Summary	At least 4 per cent (expressed as an average for the period 2008-2012) lower in national GHG emissions relative to 1990 level. Make the national GHG emissions total less than 4.5 tonnes per capita per annum by 2050 and the emissions continue to decrease thereafter.
Canada	Natural Resources Canada	Energy Technology Futures 2050	-
Canada	ICF Consulting	Long Term Energy and Climate Strategic	-
USA	U.S. Department of Energy	Scenarios for a Clean Energy Future	-
USA	ArgonneNL/EPA/GPN	Engines of Growth	-
China	Energy Research Institute	Energy and GHG Emission Scenario of China	-
India	Indian Institute of Management et al.	Global Climate Change Stabilization Regimes and Indian Emission Scenarios	550 ppmv global concentration stabilization
Australia	The Australia Institute	Long-Term Greenhouse Gas Scenarios	60 % reduction in national GHG emissions by 2050 relative to 1998-99 levels
Australia	WWF Australia et al.	A Clean Energy Future for Australia	50 % reduction in national CO_2 emissions from the stationary energy sector relative to 2001 level by 2040
JAPAN	Citizens' Open Model Projects for Alternative and Sustainable Scenarios [NGO]	Citizens' Open Model Projects	-
JAPAN	Japan Atomic Industrial Forum	2050 Nuclear Vision and Roadmap	60% reduction in CO_2 emissions relative to 2010 level (based on Kyoto protocol) in 2050
JAPAN	Ministry of Economy, Trade and Industry	Energy supply and demand outlook to 2030	-
JAPAN	Ministry of Economy, Trade and Industry	Strategic Technology Roadmap (Energy Sector)	Make the CO2 emission intensity per GDP to be 1/3 in 2050 and less than 1/10 in 2100 compared to current level.

<table>
<tr><th colspan="2">[UK] Energy - The Changing Climate</th></tr>
<tr><td>Organizations</td><td>Royal Commission on Environmental Pollution (RCEP)</td></tr>
<tr><td>Year</td><td>2000 (Release year)</td></tr>
<tr><td>Target Year</td><td>2050</td></tr>
<tr><td>Model</td><td>-</td></tr>
<tr><td>Stabilization Level</td><td>CO_2: 550 ppmv</td></tr>
<tr><td>Emission Target</td><td>60% reduction in national CO_2 emissions from fossil fuel combustion relative to the 1998 level in 2050</td></tr>
<tr><td>Policies</td><td>Development of alternative sources and reductions in energy demand; Phase out of nuclear power stations by 2025; Expanding the contribution from renewable sources well beyond 10% of electricity supply; Sophisticated management of heat and CHP; Protection and expansion of carbon sinks through reforestation and land use policies; Introduction of a carbon tax which should apply upstream and cover all sectors; Promotion of investment on Energy Research and Development; Development of electricity distribution and transmission network; A long term programme to bring about major reductions in the energy requirement of buildings; Creation of a national trading scheme; Establishment of a sustainable energy agency</td></tr>
<tr><td>Emission Scenarios</td><td>Four scenarios, as shown in Table 2, were constructed to illustrate the options available for balancing energy demand and supply by 2050 if the UK is to reduce CO_2 emissions from the burning of fossil fuels by 60%.

Table 3 confirms that in scenarios 2-4 CO_2 emissions in 2050 from fossil fuel combustion would be reduced by 60% from their level in 1997. In scenario 1 the reduction would be slightly smaller, at 57%. This discrepancy was not regarded as significant in view of the uncertainty attached to many of the assumptions in the scenarios.

Table 2 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>scenario 1</td><td>No increase on 1998 demand, combination of renewables and either nuclear power stations or large fossil fuel power stations with CO_2 capture and storage.</td></tr><tr><td>scenario 2</td><td>Demand reductions, renewables (no nuclear power stations or routine use of large fossil fuel power stations).</td></tr><tr><td>scenario 3</td><td>Demand reductions, combination of renewables and either nuclear power stations or large fossil fuel power stations with CO_2 capture and storage.</td></tr><tr><td>scenario 4</td><td>Very large demand reductions. Renewables (no nuclear power stations or routine use of large fossil fuel power stations).</td></tr></table></td></tr>
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Table 3 CO_2 emissions (RCEP 2000)

		scenario 1	scenario 2	scenario 3	scenario 4
use of fossil fuel in back-up plants (GW annual average rate)		11.6	9.5	7.5	7.5
use of fossil fuels in peak-lopping plant (GW annual average rate)		2.3	2.3	1.5	1.5
overall reduction in carbon dioxide emissions under scenario (% reduction from 1997)	using gas only in back-up plants	57	60	60	60
	using coal and gas at a ratio of 1:2 in back-up plants and in plants to meet peak demand	56	58	59	60

Economic Impact	-
Reference	Royal Commission on Environmental Pollution (RCEP), 2000, Energy – The Changing Climate, 22nd Report : http://www.rcep.org.uk/newenergy.htm

<table>
<tr><th colspan="2">[UK] Energy White Paper</th></tr>
<tr><td>Organizations</td><td>Department of Trade and Industry (DTI)</td></tr>
<tr><td>Year</td><td>2003 (release year)</td></tr>
<tr><td>Target Year</td><td>2050</td></tr>
<tr><td>Model</td><td>MARKAL</td></tr>
<tr><td>Stabilization Level</td><td>CO_2: 550 ppm</td></tr>
<tr><td>Emission Target</td><td>UK put itself on a path towards a reduction in CO_2 emissions by 60% from current level (or more precisely by 58% from 1997 levels). This would lead to 2050 emissions of 64 million tonnes of carbon (MtC).</td></tr>
<tr><td>Policies</td><td>Stimulation of the growth in renewables energy (to supply 20% of UK electricity in 2020); Development of options for cleaner coal technologies and for carbon capture and storage; Carbon emissions trading scheme; Energy efficiency improvement in business, public sectors, and in households; Energy efficiency improvement of products and buildings; Improvements in efficiency and lower carbon fuels in transport; Liberalisation of energy markets</td></tr>
<tr><td>Emission Scenarios</td><td>Three scenarios (BL, WM, and GS) were developed. The latter two following the themes and general trends developed by the Energy Futures Task Force of DTI's Technology Foresight Programme. For each of the three scenarios, three runs of the model were undertaken with different levels of carbon abatement. The model responds to these emission constraints by choosing combinations of fuels and technologies that reduce emissions at least cost, while still meeting the useful energy demands. See Table 4 for details on the scenarios.

Figure 2 shows the carbon emissions under the reference scenarios. Under the Baseline scenario the fall is 22% and under the WM and GS scenarios emissions decline by 11% and 33% respectively. Figure 3 shows the sectoral emissions under the Baseline group of scenarios. The results of the abatement scenarios show that all sectors have a role if emissions reductions are to be achieved at the lowest cost.

Table 4 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>Baseline (BL)</td><td>The current values of society remain unchanged and policy intervention in support of environmental objectives is pursued in a similar way to now (GDP growth 2.25% per year).</td></tr><tr><td>World Markets (WM)</td><td>Based on individual consumerist values. A high degree of globalization and scant regard for the global environment (GDP growth 3% per year) Continued innovation is expected with "clean and efficient" fossil fuel technologies (to some extent, fuel cells for distributed generation and transport). People use some of their greater wealth to improve the region in which they live.</td></tr><tr><td>Global Sustainability (GS)</td><td>Based on the predominance of social and ecological values. Strong collective environmental action and globalization of governance systems (GDP growth 2.25% per year). An "environmental bias" in the direction of innovation (fuel cell vehicles and hybrids, etc.). A much stronger incentive for – with induced</td></tr></table></td></tr>
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	cost reductions in – carbon sequestration technologies, including IGCC with CO_2 sequestration. The costs of hydrogen production are also reduced, both from fossil fuels and renewables.
BL45,WM45, GS45	45% reduction of CO_2 emission based on each scenario.
BL60,WM60, GS60	60% reduction of CO_2 emission based on each scenario.
BL70,WM70, GS70	70% reduction of CO_2 emission based on each scenario.

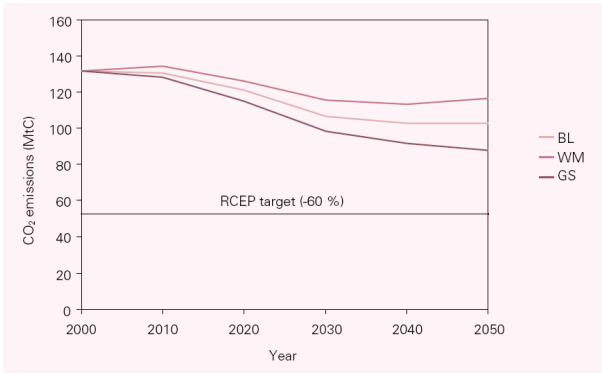

Figure 2 Carbon emissions under the reference scenarios (DTI 2003b)

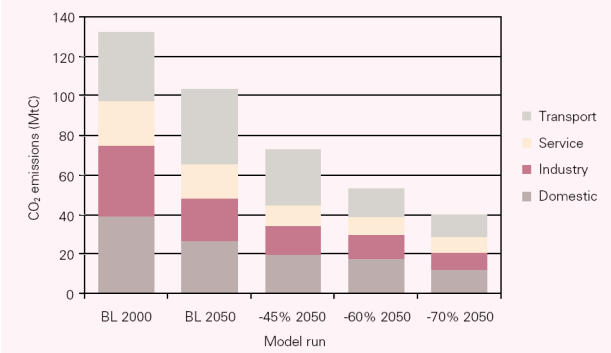

Figure 3 Sectoral emissions under the Baseline group of scenarios (DTI 2003b)

Economic Impact	The cost of reducing CO_2 emissions by 60% by 2050 was in the range of £200-300 per tonne of carbon. GDP in 2050 was reduced by 0.5-2.0%, equivalent to an average annual reduction of between 0.01 and 0.02 percentage points from a business as usual GDP growth rate of 2.25% per annum.
Reference	• Department of Trade and Industry (DTI), 2003a, Energy White Paper - Our energy future - creating a low carbon economy: http://www.dti.gov.uk/files/file10719.pdf • Department of Trade and Industry (DTI), 2003b, Economics Paper No.4 - Options for a low carbon future: http://www.dti.gov.uk/files/file14769.pdf

<table>
<tr><th colspan="2">[UK] Decarbonising the UK</th></tr>
<tr><td>Organizations</td><td>Tyndall Centre</td></tr>
<tr><td>Year</td><td>2005 (release year)</td></tr>
<tr><td>Target Year</td><td>2050</td></tr>
<tr><td>Model</td><td>-</td></tr>
<tr><td>Stabilization Level</td><td>CO_2: 550 ppmv</td></tr>
<tr><td>Emission Target</td><td>A true 60% reduction in national CO_2 emissions by 2050</td></tr>
<tr><td>Policies</td><td>Backcasting; Supply of renewable and clean energy; Sustainable energy in the built environment; Sustainable transportation; Carbon sequestration, capture and storage; Domestic tradable quotas</td></tr>
<tr><td>Emission Scenarios</td><td>The bottom-up process developed for generating the Tyndall integrated scenarios has resulted in a suite of scenarios that do not lend themselves to simple characterisation, whether in terms of energy supply, demand, innovation, efficiency or economic growth. Consequently, to encourage the users of the scenarios to interpret them within a more inclusive context, they have been allocated neutral descriptors. Within this report the five scenarios are referred to as Red, Blue, Turquoise, Purple and Pink, with Orange representing the present day as shown in Table 5.

All of the Tyndall integrated scenarios achieve the UK government's 60% 2050 CO_2 target. For today and each scenario, the sectoral CO_2 emissions are illustrated in Figure 4.

Table 5 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>The Red Scenario</td><td>The Red Scenario is a high economic growth and low energy demand scenario in which the level of economic growth is slightly greater than today and results in a 2050 economy nearly five times larger than that of today.</td></tr><tr><td>The Blue Scenario</td><td>The Blue Scenario is a modest economic growth and modest energy demand scenario in which the contribution to national wealth of the commercial sector is almost matched by the expansion of the public sector.</td></tr><tr><td>The Turquoise Scenario</td><td>The Turquoise Scenario is a medium economic growth, medium energy demand scenario with the economy growing at a rate similar to that of today.</td></tr><tr><td>The Purple and Pink Scenarios</td><td>The Purple and Pink Scenarios are high economic growth, high demand supply scenarios. Whilst the purple and pink scenarios share the same demand side characteristics, they differ in how that demand is met.</td></tr></table></td></tr>
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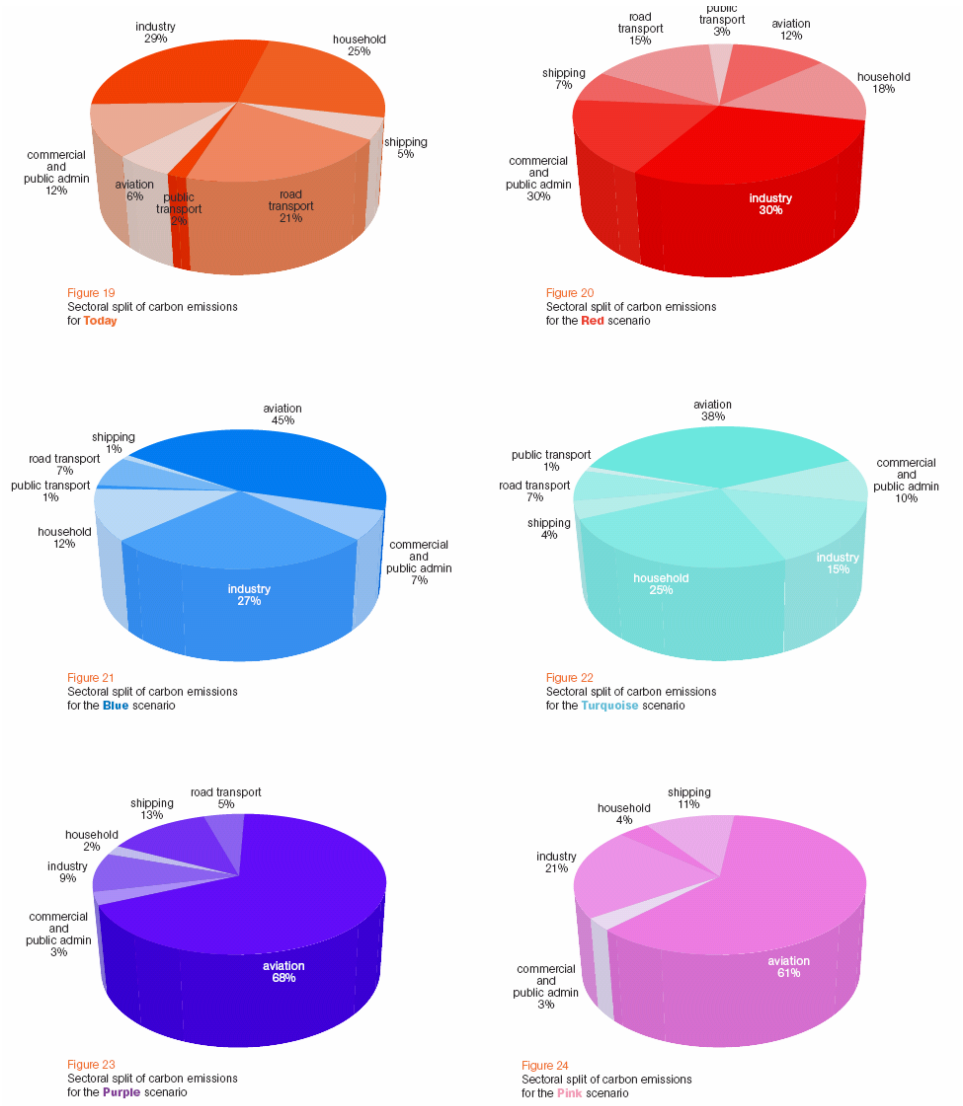

Figure 4 Sectoral emissions under the Baseline group of scenarios (Tyndall Centre 2005)

Economic Impact	-
Reference	Tyndall Centre, 2005, Decarbonising the UK – Energy for a Climate Conscious Future: http://www.tyndall.ac.uk/media/news/tyndall_decarbonising_the_uk.pdf

[Czech] National Climate Change Plan	
Organizations	Ministry of Environment
Year	2004 (release year)
Target Year	2020
Model	-
Stabilization Level	-
Emission Target	30 % reduction in national GHG emissions relative to 2000 levels in 2020
Policies	Policy Processes and Outreach - Strategic Planning
Emission Scenarios	-
Economic Impact	-
Reference	Ministry of Environment, 2004, National Climate Change Plan (2004): http://www.env.cz/www/archiv.nsf/pages/B22AD2E5347CF135C1256E4C0053BF2B?OpenDocument

<table>
<tr><th colspan="2">[Finland] CLIMTECH programme</th></tr>
<tr><td>Organizations</td><td>Finnish Agency for Technology and Innovation (TEKES)</td></tr>
<tr><td>Year</td><td>1999 – 2002 (project term)</td></tr>
<tr><td>Target Year</td><td>2040</td></tr>
<tr><td>Model</td><td>TIMES (The Integrated MARKAL-EFOM System)</td></tr>
<tr><td>Stabilization Level</td><td>-</td></tr>
<tr><td>Emission Target</td><td>The abatement levels studied for the year 2030 were 0%, –10%, –20% and –30% from the 1990 level. All the six GHGs included in the Kyoto protocol were considered in the scenarios.</td></tr>
<tr><td>Policies</td><td>Renewable energy sources and distributed energy production; Energy efficiency and industry; Non-CO_2 GHGs; Capture and utilisation of CO_2; Development of models and systems; Commercialisation; tax and subsidy system; CO_2 emission trading</td></tr>
<tr><td>Emission Scenarios</td><td>The total study horizon of the scenarios was chosen to be 2000–2040, of which the focus was set on the years 2010, 2020 and 2030. The main interest was in the longer term beyond the Kyoto period. In addition to 'Kyoto' scenario, two possible future development paths were characterized for the scenarios. See Table 6 for details on the scenarios. Emission reduction targets were assumed both for the Kyoto period 2008–2012 and for the year 2030. The GHG abatement levels studied for the year 2030 were 0%, -10%, -20% and -30% from the 1990 level. Table 7 shows the summary of the differences in the main scenario assumptions.

Figure 5 shows the GHG emissions by main category between 1990 and 2030 in the scenarios with base emission targets. Until the year 2010 there are only small differences between scenarios. In conformity with global trends, emissions from energy production and transports have the strongest tendency to increase in Finland due to increasing electricity use and transportation volumes. Without new emission targets beyond Kyoto, the emissions from energy production would increase continuously until 2030. On the other hand, in the scenarios with the 20% reduction target most of the additional emission reduction measures would, indeed, take place in energy production, in particular in the Conventional scenario.

Table 6 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>'Kyoto' scenario</td><td>Only the Kyoto emission target was assumed to remain in force.</td></tr><tr><td>'Conventional' development: scenario</td><td>International measures for climate change mitigation evolve slowly. There is no major push for the development and commercialisation of cleaner technologies. As a result, the penetration of new energy technologies is slow and depends highly on economic policy instruments.</td></tr><tr><td>'Optimistic' development: scenario</td><td>Accelerated climate change mitigation measures lead to boosted development and employment of cleaner technologies, both in the international context and within Finland. Increased funding for both R&D and promotion of technologies reducing emissions is thereby implicitly assumed.</td></tr></table></td></tr>
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Table 7 Summary of the differences in the main scenario assumptions (TEKES 2003)

Scenario	Short name	Technology development	GHG emission reduction in 2030		Basis of policy instruments	
			Base	Variants	by 2010	by 2030
Kyoto	Kyoto	conventional	0%	–	current taxes and subsidies	current taxes and subsidies
Conventional development	Conv.	conventional	–20%	–10%, –30%	current taxes and subsidies	tax on GWP, all sectors
Conventional, CO_2 trade	Conv.-ET	conventional	–20%	–	current taxes and subsidies	tax on non-tradable GWP
Optimistic development	Opt.	boosted	–20%	–10%, –30%	current taxes and subsidies	tax on GWP, all sectors
Optimistic, CO_2 trade	Opt.-ET	boosted	–20%	–	current taxes and subsidies	tax on non-tradable GWP

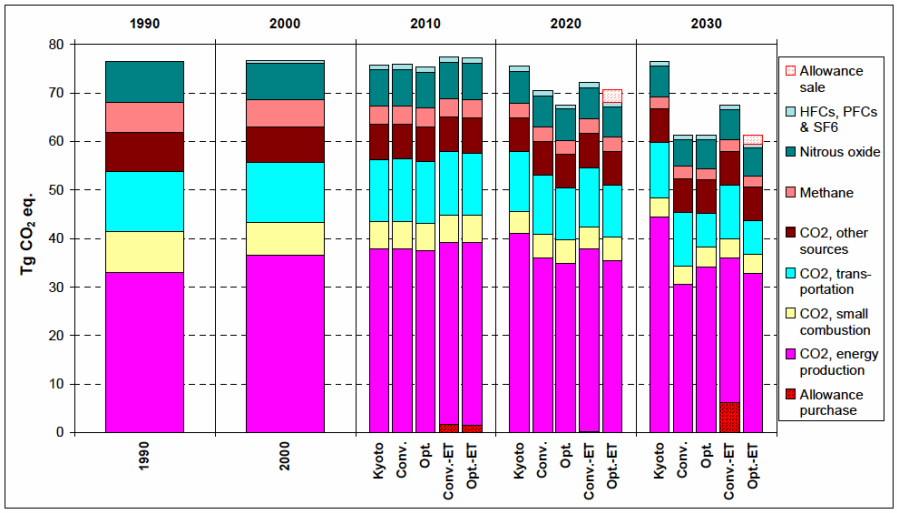

Figure 5 GHG emissions by main category between 1990 and 2030 in the scenarios with base emission targets. Scenario variants including CO_2 emission trade are marked with the suffix 'ET' (TEKES 2003).

Economic Impact	The tighter the emission abatement goals are the wider becomes the cost difference between the Conventional and Optimistic scenarios. With the 20% reduction target the difference in costs is almost 500 M€ per annum in 2030, and with the 30% target the difference is increased to about 800 M€.
Reference	Finnish Agency for Technology and Innovation (TEKES), 2003, The role of technology development in greenhouse gas emission reduction – Case of Finland, Presentation at the International Energy Workshop, 24-26.6.2003, IIASA: http://www.etsap.org/worksh_6_2003/2003P_lehtilla.pdf

<table>
<tr><th colspan="2">[France] Reducing CO_2 emissions fourfold in France by 2050</th></tr>
<tr><td>Organizations</td><td>French Interministeriel Task Force on Climate Change (MIES)</td></tr>
<tr><td>Year</td><td>2004 (release year)</td></tr>
<tr><td>Target Year</td><td>2050</td></tr>
<tr><td>Model</td><td>-</td></tr>
<tr><td>Stabilization Level</td><td>CO_2: 450 ppmv</td></tr>
<tr><td>Emission Target</td><td>The goal of the project is to reduce CO_2 concentrations in the atmosphere to less than 450 ppmv. In order to meet this goal, the current level of 6 billion tC should be reduced to 3 billion tC as soon as possible. First efforts to reduce emissions could involve setting a target of 5 billion tC in 2050 which would correspond to a quota of 0.5 tC per capita per year for a world population of around 10 billion in 2050. Transposing emission levels of 0.5 tC per capita in 2050 to a total population in France of 64 million yields the result of 32 MtC (105.23 MtC in 2000). Thus, fourfold reduction in national GHG emissions by 2050 is required.</td></tr>
<tr><td>Policies</td><td>Energy conservation; Improved energy efficiency; Development of Renewables; Storing electricity; Converting to the hydrogen economy</td></tr>
<tr><td>Emission Scenarios</td><td>Scenarios for technology options, as shown in Table 8, are analyzed. The bottom five variants are all in line with the factor 4 emission reduction target and combine large-scale progress in energy efficiency and fuel switching in energy used for heat production purposes, transport and electricity generation.

Figure 6 shows the CO2 emissions per sector and per (variants) scenarios. The Figure shows that the impact of measures aimed at the factor 4 reduction target implemented in the transport sector can be gauged (32 MtC in 2050).

Table 8 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>w/o Eco</td><td>A variant without any progress in energy efficiency beyond the average performance of equipment already on sale and without further changes in fuel-switching trends.</td></tr><tr><td>Eco w/o fuel switching</td><td>A variant with improved energy efficiency but with no change in the different shares of the individual types of energy in the total energy mix, compared to the previous variant.</td></tr><tr><td>Supply</td><td>A variant involving a supply-driven response to the climate constraint, i.e. responding by fuel switching mainly in favour of nuclear generated electricity but without any further progress in energy efficiency.</td></tr><tr><td>Gas turb</td><td>A variant to use of gas turbines to produce electricity instead of nuclear power.</td></tr><tr><td>F4 nuclear</td><td>A variant with increased nuclear development and take-up of electricity in all uses, including transport.</td></tr><tr><td>F4 RcogN</td><td>A variant combining the use of nuclear energy with the development of combined heat and power production,</td></tr></table></td></tr>
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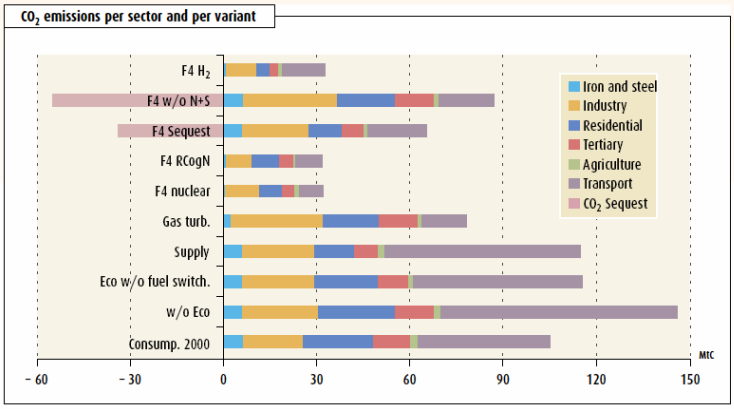
	and renewables. F4 Sequest — A variant involving maintaining large-scale fossil fuel use and including CO_2 sequestration, which eases the constraints of fuel switching, especially in the transport sector. F4 w/o N+S — A variant involving abandoning nuclear power with sequestration of CO_2. F4 H2 — A variant involving the setting up of a hydrogen production network using nuclear power.  | MtC	2000	w/o Eco	Eco w/o fuel switch.	Supply	Gas turb.	F4 Nucl	F4 RCogN	F4 Sequest	F4 w/o N+Seq	F4 Hydrogen
---	---	---	---	---	---	---	---	---	---	---
Iron/steel	6.11	5.89	5.85	5.88	2.24	0.40	0.55	5.81	6.26	0.58
Industry	19.26	24.32	23.31	23.05	29.54	10.82	8.37	21.46	30.08	9.71
Residential	22.76	24.96	20.43	12.84	18.21	7.36	8.72	10.67	18.66	4.30
Tertiary	11.88	12.39	9.68	7.79	12.35	4.14	4.74	6.93	12.61	3.02
Agriculture	2.45	2.15	1.66	2.15	1.40	1.58	0.73	1.25	1.41	0.98
Transport	42.77	76.38	54.62	63.17	14.55	7.87	8.72	19.34	18.01	14.02
CO_2 Sequest								- 33.63	- 54.68	
Total	105.23	146.08	115.54	114.88	78.30	32.17	31.83	31.84	32.35	32.61	 Figure 6 CO_2 emissions per sector and per (variants) scenarios (MIES 2004)
Economic Impact	From an economic point of view (e.g. Energy expenditure), F4 scenarios are evaluated to be effective.
Reference	French Interministeriel Task Force on Climate Change (MIES), 2004. Reducing CO_2 emissions fourfold in France by 2050 - Introduction to the debate: http://www.effet-de-serre.gouv.fr/fr/etudes/Facteur4-ang%20BAT.pdf

<table>
<tr><th colspan="2">[Germany] Enquete Commission on Sustainable Energy Supply</th></tr>
<tr><td>Organizations</td><td>Deutscher Bundestag</td></tr>
<tr><td>Year</td><td>2002 (release year)</td></tr>
<tr><td>Target Year</td><td>2050</td></tr>
<tr><td>Model</td><td>Models developed by the Wuppertal Institute for Climate, Environment, Energy (WI), the Institute of Energy Management and Efficient Energy Use (IER), and PROGNOS AG, Basle.</td></tr>
<tr><td>Stabilization Level</td><td>-</td></tr>
<tr><td>Emission Target</td><td>The goal of the project is to reduce GHG emissions in the industrialised nations (i.e. also in Germany) by 40% by the year 2020, by 50% by the year 2030 and by 80% by the year 2050, relative to 1990.</td></tr>
<tr><td>Policies</td><td>Efficient energy use; Combined heat and power; Storage of CO_2; Fuel switch from coal to oil in mid-term (to hydrogen in long-term); Facilitation of market access for renewables; Eco-taxes; Nuclear power phased out</td></tr>
<tr><td>Emission Scenarios</td><td>In order to assess the prospects of sustainable development up to the year 2050, the commission has examined economic and technological capability as well as options for practical and political action. To this end, the commission developed 14 scenarios and variations for Germany, with different assumptions and implementation perspectives. See Table 9 for details on the scenarios.

Figure 7 shows the primary energy consumption by the year 2050, according to various scenarios.

Table 9 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>Reference</td><td>• Continuation of the current energy policy (“business as usual”)
• Eco-tax only until 2003
• Constant energy tax in real terms</td></tr><tr><td>Efficient Conversion (UWE)</td><td>• Accelerated effort to increase the efficiency of the use of fossil fuels
• More stringent energy regulation
• Continuous increase in energy taxes
• Separation and storage of CO_2 in repositories</td></tr><tr><td>RES/EEU Initiative (RRO)</td><td>• Accelerated efforts to increase the efficiency in all fields of application
• Greater use of renewables
• Continuous increase in energy taxes
• 50 per cent share of renewables by 2050</td></tr><tr><td>Fossil-Nuclear Energy Mix (FNE)</td><td>• Construction of new clear power stations after 2010
• Moderate implementation of energy conservation policy</td></tr></table></td></tr>
</table>

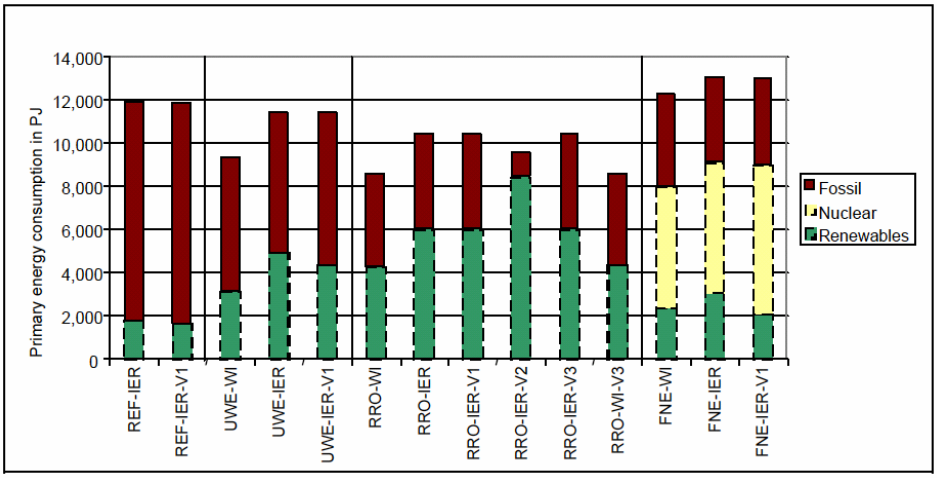


Figure 7 Primary energy consumption by the year 2050, according to various scenarios (Deutscher Bundestag 2002)

Economic Impact	The system costs of the reference scenario and its variant will amount to 9.2 or 9.1 per cent of GDP by the year 2050. In the target scenario that does not include the use of nuclear energy, this value will increase by between 0.3 per cent (RRO scenario of WI) and 1.2 per cent (RRO scenario Var.1 of IER) by the year 2050. Is the fossil-nuclear scenarios, the cost differences range between –0.5 and +0.3 percentage points relative to the reference scenario. This means that – as a percentage of GDP – the system costs of the RRO scenario will be about at the same level by the year 2050 as they are today.
Reference	Deutscher Bundestag, 2002, Enquete Commission on Sustainable Energy Supply, Against the Background of Globalisation and Liberalisation -Summary of the Final Report-: http://www.wupperinst.org/download/renewables/enquete-summary.pdf

<table>
<tr><th colspan="2">[Netherlands] COOL Project</th></tr>
<tr><td>Organizations</td><td>Wageningen University; Free University of Amsterdam; National Institute for Public Health and the Environment; et al.</td></tr>
<tr><td>Year</td><td>1999 – 2001 (project term)</td></tr>
<tr><td>Target Year</td><td>2050</td></tr>
<tr><td>Model</td><td>-</td></tr>
<tr><td>Stabilization Level</td><td>CO_2: 450 ppmv
CO_2 eq: 550 ppmv</td></tr>
<tr><td>Emission Target</td><td>50-80% reduction in national GHG emissions by 2050 relative to 1990 level</td></tr>
<tr><td>Policies</td><td>Policy recommendations by participatory integrated assessment; Backcasting</td></tr>
<tr><td>Emission Scenarios</td><td>Two future images of the Netherlands in 2050, both of which sketch a society that has been able to reduce its GHG emissions by 80%, were developed. The images/visions are based on two scenarios used by IPCC, which have been quantified with respect to the Dutch situation. See Table 10 for details on the scenarios.

Table 10 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>Vision A</td><td>Internationally oriented “Global Village.” Dynamic worldwide economic development, free market, and high consumption levels. Individualistic. Economic value is important. Own interest first. Little government regulation.</td></tr><tr><td>Vision B</td><td>Regionally oriented, world trade blocs. Characterized by moderate growth and less dynamism. Sociable, family oriented. Economic value is environmentally minded. Own interest first. Distribution of wealth, social equity. Strong government.</td></tr></table></td></tr>
<tr><td>Economic Impact</td><td>-</td></tr>
<tr><td>Reference</td><td>Wageningen University et al., 2002, Climate OptiOns for the Long term - Final Report Volume A COOL – Synthesis Report: http://www2.wau.nl/cool/reports/COOLVolumeAdef.pdf</td></tr>
</table>

[Sweden] Swedish Climate Strategy Summary	
Organizations	Swedish Environmental Protection Agency
Year	2000 (release year)
Target Year	2050
Model	-
Stabilization Level	GHG: 550 ppm
Emission Target	Swedish emissions of GHG are to be at least 4% lower in 2010 -expressed as an average for the period 2008-2012- than they were in 1990 (at least 8% stricter than Sweden's EU-Kyoto Protocol commitments). By 2050, GHG emissions in Sweden should total less than 4.5 tonnes of CO_2eq per capita per annum and emissions should continue to decrease thereafter. *) Recently, the Swedish Government has made a decision to set a medium-term climate target of -25% by 2020, compared with emissions in 1990.
Policies	Climate policy; Energy policy programme; Local investment programme; Environmentally oriented product policy; Settlement; Refuse policy
Emission Scenarios	-
Economic Impact	-
Reference	• Swedish Environmental Protection Agency, 2003, The Swedish Climate Strategy Summary Gov. Bill 2001/02:55: http://www.regeringen.se/content/1/c4/11/55/fbd1d28b.pdf • Ministry of Sustainable Development, 2006, Fact Sheet: National climate policy in global cooperation: http://www.regeringen.se/content/1/c6/06/47/23/ccbef4cd.pdf

<table>
<tr><th colspan="2">[Canada] Energy Technology Futures 2050</th></tr>
<tr><td>Organizations</td><td>Natural Resources Canada (NRCan)</td></tr>
<tr><td>Year</td><td>-</td></tr>
<tr><td>Target Year</td><td>2050</td></tr>
<tr><td>Model</td><td>NRCan's InterFuel Substitution Demand Model</td></tr>
<tr><td>Stabilization Level</td><td>-</td></tr>
<tr><td>Emission Target</td><td>Not defined</td></tr>
<tr><td>Policies</td><td>Alternative and renewable energy; Biotechnologies; Electricity generation; Electricity transmission & storage; GHG management (capture, disposal and re-use); Hydrogen; Illumination; Mobility; Process heating; Space conditioning; Stationary drives</td></tr>
<tr><td>Emission Scenarios</td><td>The ETF (Energy Technology Future) Team selected and named the scenarios as shown in Table 11.

Figure 8 shows the estimates of the GHG emission levels. The Life Goes On scenario approximates the emission levels in the Business As Usual Forecast. The Come Together scenario has GHG emission levels closest to the 2050 "GHG Budget" for Canada.

Table 11 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>Life Goes On: Reference</td><td>Reference. Restricted markets limit the flow of goods and information. Slow to adopt new technology. Investment in research and development lags. Industry focuses on cutting costs through increment investments. Focus is on the standard of living and other social considerations.</td></tr><tr><td>Grasping at Straws</td><td>Adopt a series of no regrets actions including the rapid deployment of a variety of off-the-shelf technologies. Moving technologies on the shelf generate short term benefits, but R&D investment is limited. Energy is regionally diverse.</td></tr><tr><td>Taking Care of Business</td><td>Built on its expertise in information systems, high-voltage electrical transmission and distribution, and its natural resource endowment. Social and environmental issues are secondary to expanded economy and prosperity. Information technologies and high leads to rapid innovation and capital stock turnover.</td></tr><tr><td>Come Together</td><td>A GHG responsive, proactive world with open market. There is a strong cohesion of views among government, industry, and the public regarding environmental issues. New technologies are applied in innovative ways. The rapid pace of innovation and integration of technologies provide a winder range of problem-solving options.</td></tr></table></td></tr>
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	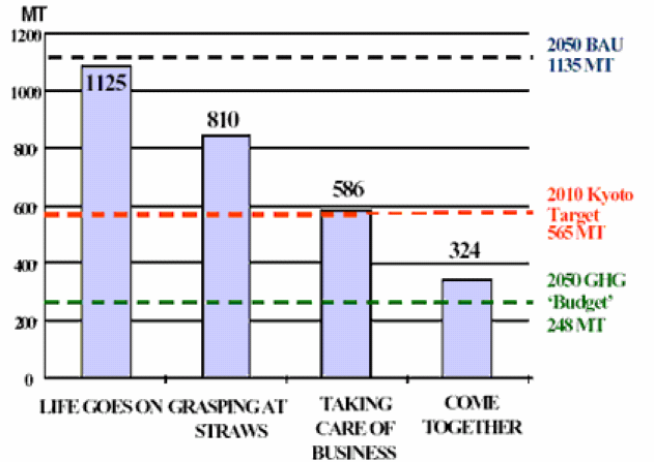 Figure 8 Estimates of the GHG emission levels (NRCan -)
Economic Impact	-
Reference	Natural Resources Canada (NRCan), (-), Energy Technology Future 2050

[Canada] Long Term Energy and Climate Strategies for Canada	
Organizations	ICF Consulting
Year	2005 (release year)
Target Year	2050
Model	-
Stabilization Level	-
Emission Target	Not defined
Policies	Carbon Capture; Truck efficiency improvement; EE in Oil and Gas Sector; Cogeneration; Electricity Intensity Improvements; Urban Form; Wind power, Personal vehicle fuel efficiency
Emission Scenarios	Two scenarios, as shown in Table 12, are developed. Figure 9 shows the GHG Emissions by sector.
Economic Impact	-
Reference	ICF Consulting, 2005, Long Term Energy and Climate Strategies for Canada

Table 12 Scenario list

Scenario	Contents
Baseline	
Wedges	CO_2 reduction wedges (i.e. counter-measures such as carbon capture) are included.

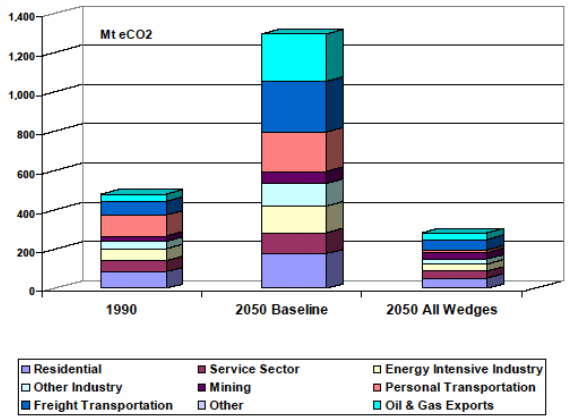

Figure 9 GHG emissions by sector (ICF Consulting 2005)

<table>
<tr><th colspan="2">[USA] Scenarios for a Clean Energy Future</th></tr>
<tr><td>Organizations</td><td>The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (DOE)</td></tr>
<tr><td>Year</td><td>2000 (release year)</td></tr>
<tr><td>Target Year</td><td>2020</td></tr>
<tr><td>Model</td><td>CEF-NEMS model</td></tr>
<tr><td>Stabilization Level</td><td>-</td></tr>
<tr><td>Emission Target</td><td>Not defined</td></tr>
<tr><td>Policies</td><td>-</td></tr>
<tr><td>Emission Scenarios</td><td>The structured development of energy scenarios allows a way to examine a range of public policies and to consider alternative possibilities. The CEF study develops three scenarios as shown in Table 13.

Figure 10 shows the carbon emission reductions, by sector. By 2020, carbon emissions in the Advanced scenario are 30 to 32% lower than in the BAU forecast. These emission reductions are nearly three times those of the Moderate scenario. This much stronger performance of the Advanced scenario results from the focus of many of its policies on the use of low-carbon energy resources.

Table 13 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>Business-as-Usual (BAU)</td><td>The BAU scenario assumes a continuation of current energy policies and a steady, but modest pace of technological progress.</td></tr><tr><td>Moderate</td><td>Defined by policies that are consistent with increasing levels of public commitment and political resolve to solving the nation's energy-related challenges.</td></tr><tr><td>Advanced</td><td>Defined by policies that are consistent with increasing levels of public commitment and political resolve to solving the nation's energy-related challenges. Establishment of a domestic carbon trading system. Permits are sold annually in a competitive auction run by the federal government. The carbon emissions annual limit is set so that the permit price equilibrates at $50/tC (in 1997$) throughout the period. A $25/tC case is also analyzed. The second key policy mechanism for all of the sectors is the doubling of federal government appropriations for cost-shared RD&D in efficient and clean energy technologies.</td></tr></table></td></tr>
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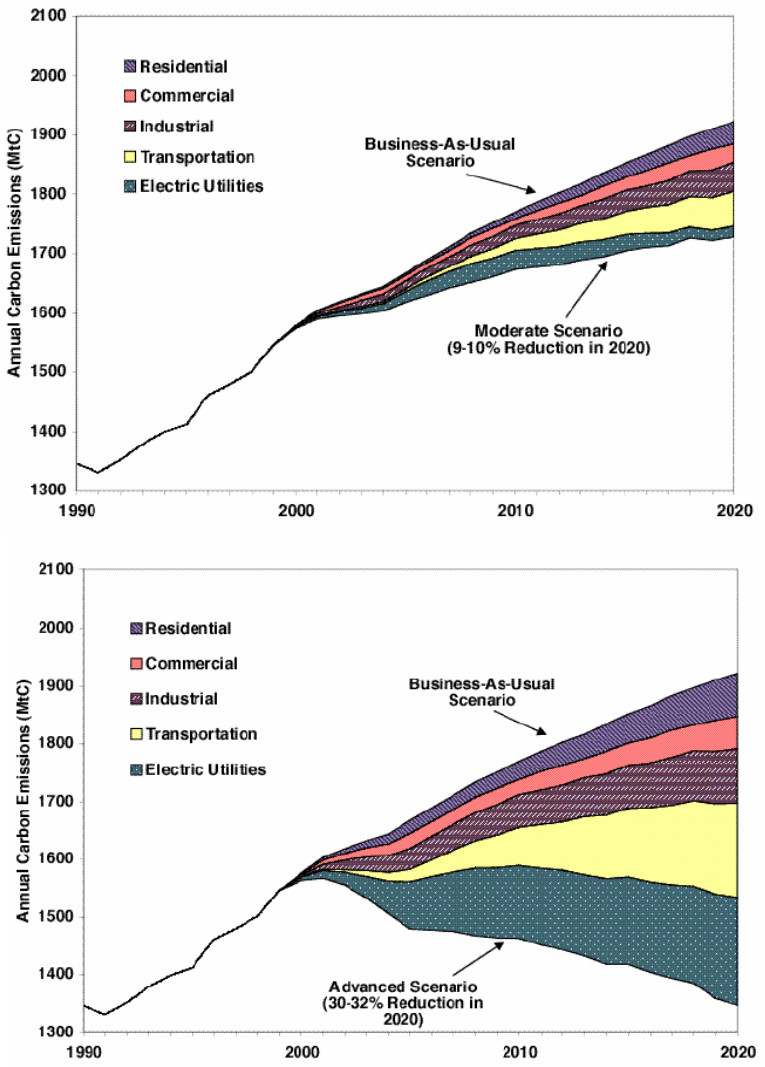


Figure 10 Carbon emission reductions, by sector
(Upper panel: the Moderate Scenario; Lower panel: the Advanced Scenario) (DOE 2000)

Economic Impact	The net effect is that by 2020 the Advanced scenario's energy bill is $23 billion lower than that in the Moderate scenario and $124 billion lower than in the BAU forecast, even with the costs of carbon permits included.
Reference	The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (DOE), 2000, Scenarios for a Clean Energy Future: http://www.ornl.gov/sci/eere/cef/index.htm

<table>
<tr><th colspan="2">[USA] Engines of Growth</th></tr>
<tr><td>Organizations</td><td>Argonne National Laboratory; U.S. Environment Protection Agency; Global Business Network</td></tr>
<tr><td>Year</td><td>2004 (release year)</td></tr>
<tr><td>Target Year</td><td>2050</td></tr>
<tr><td>Model</td><td>AMIGA</td></tr>
<tr><td>Stabilization Level</td><td>-</td></tr>
<tr><td>Emission Target</td><td>Not defined</td></tr>
<tr><td>Policies</td><td>Promote diversity in energy supply; Decrease U.S. dependence on foreign oil; Improve U.S. energy security; Increase efficiency in all energy-intensive sectors of the economy through the introduction of conservation measures and advanced technologies; Accelerate capital stock turnover particularly in the electricity and transportation sectors; Sustain economic growth; Decrease CO_2 emissions resulting from energy supply and use</td></tr>
<tr><td>Emission Scenarios</td><td>Four basecase scenarios have been developed representing a diverse range of future worlds to explore the driving forces and critical uncertainties that may shape U.S. energy markets and the economy for the next fifty years. More can be learned from these scenarios if a strategic challenge sufficient to motivate major change in the behavior of key actors is introduced. The response to this challenge can then be simulated and tracked in three additional scenarios. See Table 14 for details on the scenarios.

Figure 11 shows the total carbon emission in the basecase and policy scenarios. In Challenge and Response scenarios big impacts of implementing policies to limit CO_2 emissions are observed.

Table 14 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>The Official Future</td><td>A reference scenario reflecting conventional wisdom about the future patterns of U.S. energy supply and demand.</td></tr><tr><td>Cheap Energy Reigns Supreme</td><td>A scenario in which abundant and inexpensive supplies of oil and gas continue to fuel the engines of economic growth in America.</td></tr><tr><td>Big Problem Ahead</td><td>A chaotic, event-driven scenario.</td></tr><tr><td>Technology Drives the Market</td><td>A scenario in which a variety of forces converge to reshape the market architecture of the U.S. energy sector.</td></tr><tr><td>Cheap Energy Reigns Supreme: Challenge and Response</td><td>Implementation of the postulated policies in this scenario has immediate and lasting impacts.</td></tr><tr><td>Big Problems Ahead: Challenge and Response</td><td>The pattern of impacts resulting from implementing the set of policies and measures in this scenario is broadly similar to the pattern observed in the Cheap Energy Reigns Supreme: Challenge and Response case. However, the</td></tr></table></td></tr>
</table>

	magnitudes of these impacts are different in the two cases.
Technology Drives the Market: Challenge and Response	The implementation of national emissions-control policies has additional significant impacts. As in the Cheap Energy Reigns Supreme and Big Problems Ahead scenarios, the transportation and electric power sectors experience the most significant impacts in the respective "challenge and response" cases.

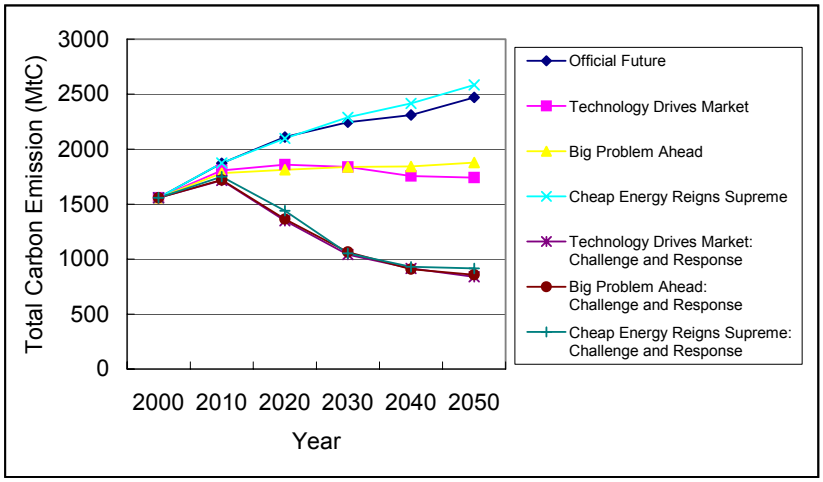


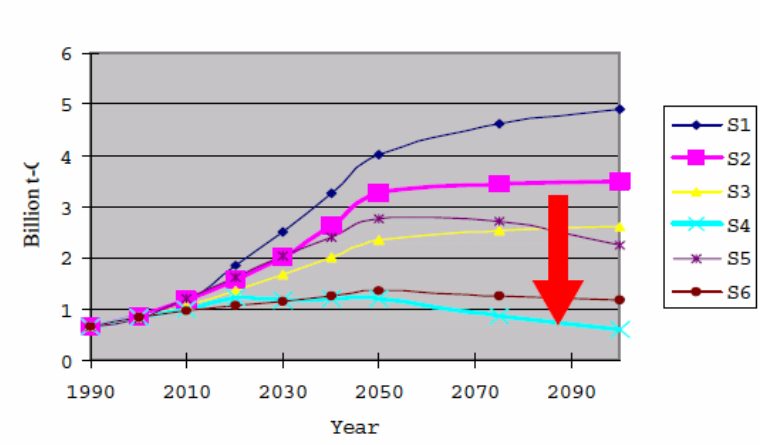
Figure 11 Total carbon emission in the Basecase and Policy Scenarios

Economic Impact	• Each of the basecase scenarios involves continued and sustained economic growth - U.S. GDP grows at 2.4 - 2.8 percent per year from 2000 to 2050. This demonstrates that in scenarios without substantial policy intervention, strong GDP growth can be sustained either by low energy prices or by continuing investment in advanced technology. • Despite the introduction of policies to promote capital stock turnover and to limit CO_2 emissions, GDP in the Challenge and Response cases reaches approximately the same level in 2050, as is achieved in the their respective basecase scenarios. The projected differences are only 0.3 to 1.3 percent after 50 years.
Reference	Argonne National Laboratory et al. (Argonne NL), 2004, Engines of Growth: Energy Challenges, Opportunities, and Uncertainties in the 21st Century: http://www.ari.vt.edu/hydrogen/Resources/BackDoc/Doc/engines_growth.pdf

<table>
<tr><th colspan="2">[China] Energy and GHG Emission Scenario of China</th></tr>
<tr><td>Organizations</td><td>Energy Research Institute (ERI)</td></tr>
<tr><td>Year</td><td>2005 (year of publication)</td></tr>
<tr><td>Target Year</td><td>2100</td></tr>
<tr><td>Model</td><td>IPAC-emission model</td></tr>
<tr><td>Stabilization Level</td><td>-</td></tr>
<tr><td>Emission Target</td><td>Not defined</td></tr>
<tr><td>Policies</td><td><Social Efficiency Change>
Various policies relative to value added such as price policy, national plan for key industry, promote well working market;
Market oriented policies, national development policies;
Public education, price policies;
Transport development policies, public education
<Technology progress>
Technology R&D promotion, market oriented policies, international collaboration;
Market oriented policies, environmental regulation;
National energy industry policies, import & export policies, tax system</td></tr>
<tr><td>Emission Scenarios</td><td>A set of scenario storylines was formulated for China by defining several key driving factors such as GDP growth, population, energy efficiency improvement, etc. All emission scenarios, as shown in Table 15, were developed under B2 scenario.

Figure 12 shows CO_2 emissions in China by the year 2050.

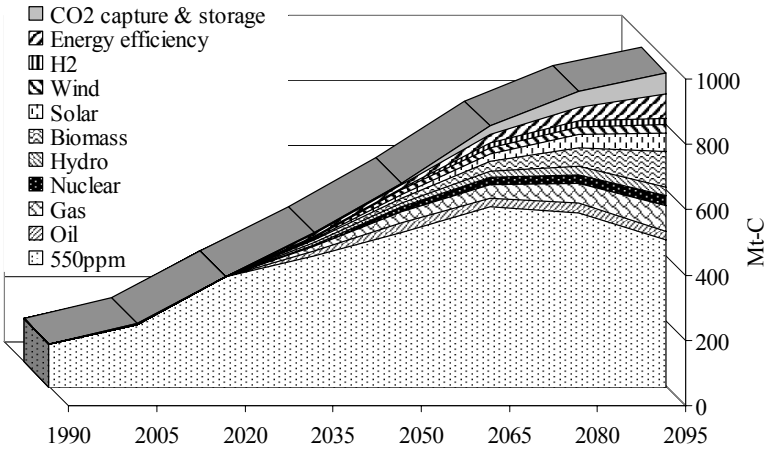
Table 15 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>Traditional development scenario (S1)</td><td>Future energy and environmental development follows the experience of industrialized countries during their initial stage of industrialization.</td></tr><tr><td>Conventional scenario (S2)</td><td>Economic development and energy industry follow the experience of China in last several decades.</td></tr><tr><td>Energy policy intervention scenario (S3)</td><td>Energy industry is promoted by governmental planning, emphases on clean energy and improvement of energy efficiency.</td></tr><tr><td>Environment driven scenario (S4)</td><td>Based on the understanding of domestic environmental problems, much more environmental policies will be introduced besides existing energy and environmental policies.</td></tr><tr><td>Tiger development scenario (S5)</td><td>A higher economic growth is assumed.</td></tr><tr><td>Gray development scenario (S6)</td><td>A lower economic growth is assumed.</td></tr></table></td></tr>
</table>

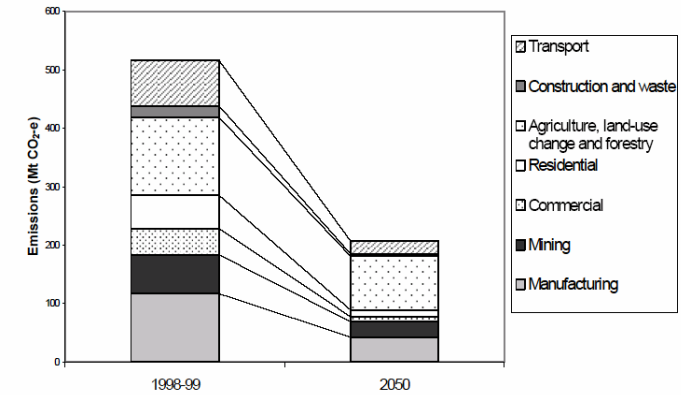
	 Figure 12 CO_2 emissions in China (ERI 2005)
Economic Impact	-
Reference	Energy Research Institute (ERI), 2005, Energy and GHG Emission Scenario of China, Proceeding of the Second Conference on Climate Change in China, Beijing in 2003: http://www.e2models.com/papers/ghgchina.pdf

<table>
<tr><th colspan="2">[India] Global Climate Change Stabilization Regimes and Indian Emission Scenarios</th></tr>
<tr><td>Organizations</td><td>Indian Institute of Management; Reliance Industries Limited; UNEP Riso Center; Maulana Azad National Institute of Technology; National Institute for Environmental Studies</td></tr>
<tr><td>Year</td><td>2005 (year of publication)</td></tr>
<tr><td>Target Year</td><td>2095</td></tr>
<tr><td>Model</td><td>MiniCAM model</td></tr>
<tr><td>Stabilization Level</td><td>CO_2: 550 ppmv</td></tr>
<tr><td>Emission Target</td><td>550 ppmv global concentration stabilization</td></tr>
<tr><td>Policies</td><td>Carbon tax; New and emerging technologies; Replacement of coal in all possible industries and technologies</td></tr>
<tr><td>Emission Scenarios</td><td>The future states of India's development were visualized as four scenarios differentiated by the type of governance (A: centralization or B: decentralization) and the extent of market integration (liberalization and integration with global markets; 1: high and 2: fragmented). Four Indian (referred with prefix I) scenarios are named IA1, IA2, IB1 and IB2 to follow IPCC SRES scenarios. Besides, the scenario with B2 as baseline and 550ppm stabilization was constructed. See Table 16 for details on the scenarios.

Figure 13 shows a possible portfolio of technologies to achieve mitigation required in India to meet to global 550ppmv stabilization. The analysis with the stabilization scenario at 550ppm for IB2, Indian emission scenario, shows a mitigation of 53% of emissions in 2095 and 31% in cumulative emissions for 105 years.

Table 16 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>IA1</td><td>The type of governance: centralization
The extent of market integration: high</td></tr><tr><td>IA2</td><td>The type of governance: centralization
The extent of market integration: fragmented</td></tr><tr><td>IB1</td><td>The type of governance: decentralization
The extent of market integration: high</td></tr><tr><td>IB2</td><td>The type of governance: decentralization
The extent of market integration: fragmented
The reference (BAU) scenarios</td></tr><tr><td>B2-ppm550</td><td>A scenario with B2 as baseline and 550ppm stabilization</td></tr></table></td></tr>
</table>

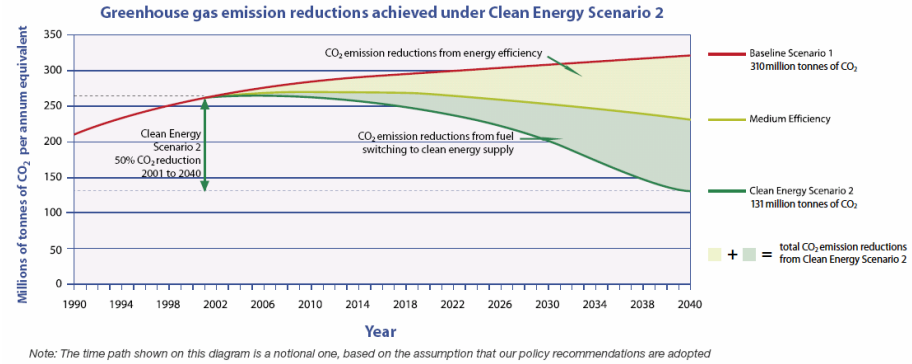
	 Figure 13 A possible portfolio of technologies to achieve mitigation required in India to meet global 550ppmv stabilization (IIM 2005)
Economic Impact	-
Reference	Indian Institute of Management et al. (IIM), 2005, Global Climate Change Stabilization Regimes and Indian Emission Scenarios - Lessons for Modelling of Development Country Transitions, Environmental Economics and Policy Studies, Springer, Special, Issue : -

[Australia] Long-Term Greenhouse Gas Scenarios	
Organizations	The Australia Institute
Year	2002 (year of publication)
Target Year	2050
Model	-
Stabilization Level	-
Emission Target	60 % reduction in national GHG emissions by 2050 relative to 1998-99 levels
Policies	
Emission Scenarios	Australia's GHG emissions under current conditions and those envisaged in the deep cuts scenario are presented in Figure 14.  Figure 14 GHG emissions by sector under the deep cuts scenario (TAI 2002)
Economic Impact	-
Reference	The Australia Institute (TAI), 2002. Long-Term Greenhouse Gas Scenarios - A pilot study of how Australia can achieve deep cuts in emissions, Discussion Paper Number 48: http://www.tai.org.au/WhatsNew_Files/WhatsNew/DP48sum.pdf

<table>
<tr><th colspan="2">[Australia] A Clean Energy Future for Australia</th></tr>
<tr><td>Organizations</td><td>Australian Energy Performance Contracting Association; Australian Business Council for Sustainable Energy; Australian Gas Association; Australian Wind Energy Association; Bioenergy Australia; Renewable Energy Generators of Australia; WWF Australia</td></tr>
<tr><td>Year</td><td>2004 (release year)</td></tr>
<tr><td>Target Year</td><td>2040</td></tr>
<tr><td>Model</td><td>-</td></tr>
<tr><td>Stabilization Level</td><td>-</td></tr>
<tr><td>Emission Target</td><td>50 % reduction in national CO_2 emissions from the stationary energy sector relative to 2001 level by 2040</td></tr>
<tr><td>Policies</td><td>Policies urgently needed include:
• Substantially increase the Mandatory Renewable Energy Target (MRET);
• Mandate strict greenhouse intensity limits on any proposal to build a new coal-fired power station or to refurbish an existing one - these limits would require less CO_2 emissions per unit of electricity sent out than the best existing combined cycle natural gas power station;
• Implement national mandatory minimum energy and greenhouse performance standards and labelling for all appliances and equipment with capacity to use 50 watts or greater of electricity. Make standards increasingly stringent every 5 years;
• For all commercial buildings mandate minimum energy and greenhouse performance standards based on the Australian Building Greenhouse Rating Scheme;
• Mandate that a solar, heat pump or solar compatible natural gas hot water system with low standby losses be installed in every proposal for a new or substantially renovated residential building;
• Establish a target for cogeneration and provide grants on a dollar for dollar basis to assist in funding feasibility studies for specific projects;
• Change the MRET regulation to encourage dedicated tree energy crops for the purpose of growing biomass fuel on land that was cleared before 1990;
• Provide specific support for the development of a biomass roadmap for Australia and its implementation;
• Consult widely on, develop and implement consistent planning guidelines across all levels of government for the establishment of wind farms;
• Revise the National Electricity Code to ensure distributed generators receive fair network access and pricing, considering location of generators and time of day of generation.</td></tr>
<tr><td>Emission Scenarios</td><td>Several scenarios are developed.. Three of them are shown in Table 17.

Figure 15 shows the GHG emission reductions achieved under Clean Energy Scenario 2. Clean Energy Scenario 2 brings 50 % reduction in national CO_2 emissions from the stationary energy sector relative to 2001 level in 2040.

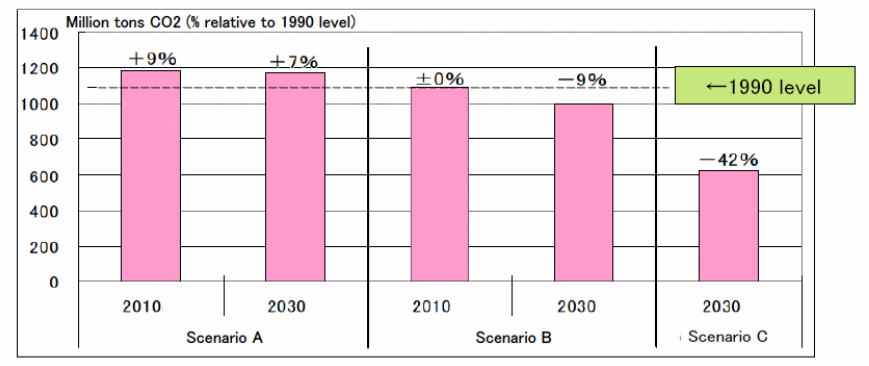
Table 17 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>Baseline Scenario 1</td><td>GHG emissions increase by 21 percent to 310 million tonnes.</td></tr><tr><td>Clean Energy Scenario 2</td><td>GHG emissions decrease by 50 percent to 131 million tonnes.</td></tr><tr><td>Medium Efficiency</td><td>This scenario demonstrates that with effective new policies, energy demand such can be contained to</td></tr></table></td></tr>
</table>

	only 25 percent increase between 2001 and 2040 –achieved through the widespread implementation of cost effective energy efficiency improvement.  Figure 15 GHG emission reductions achieved under Clean Energy Scenario 2 (WWFA 2004b)
Economic Impact	In the long term, as oil becomes scarce, electricity prices are likely to rise in the Baseline Scenario as well, dragging up the prices of natural gas and exportable coal. Environmental taxes or levies, or a substantial amount of capture and underground storage of CO_2 from coal-fired power stations, could double the price of coal-fired electricity. So, under a range of circumstances, our Clean Energy Scenarios could be less expensive than the Baseline Scenario in 2040.
Reference	• WWF Australia et al. (WWFA), 2004a, A Clean Energy Future for Australia: http://wwf.org.au/publications/clean_energy_future_report.pdf • WWF Australia et al. (WWFA), 2004b, A Clean Energy Future for Australia (summary): http://wwf.org.au/publications/clean_energy_future_summary.pdf

<table>
<tr><th colspan="2">[Japan] Citizens' Open Model Projects</th></tr>
<tr><td>Organizations</td><td>Citizens' Open Model Projects for Alternative and Sustainable Scenarios (COMPASS) [NGO]</td></tr>
<tr><td>Year</td><td>2003 (release year)</td></tr>
<tr><td>Target Year</td><td>2030</td></tr>
<tr><td>Model</td><td>Economic, Simulation, Top-Down Model</td></tr>
<tr><td>Stabilization Level</td><td>-</td></tr>
<tr><td>Emission Target</td><td>Not defined</td></tr>
<tr><td>Policies</td><td>Reducing environmental risks; Renewable energy and energy saving; Economical recovery by industries with environmental strategies, and creating true affluence immeasurable by GDP. Aim to lead the world with environmental technologies and policies; Phasing out nuclear power; post-materialism</td></tr>
<tr><td>Emission Scenarios</td><td>Three scenarios, as shown in Table 18, are developed.

Figure 16 shows the CO_2 Emissions from Energy Consumption. Compared with the 1990 emission level, emissions in 2030 will be 107 under Scenario A, 91 under Scenario B, and 58 under Scenario C. Scenario C will help make CO_2 emissions constant. Under Scenario B, CO_2 emissions in 2010 will be at the 1990 level. Combined with cuts in CFC substitutes and other efforts, Japan would be able to achieve its Kyoto Protocol target.

Table 18 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>Scenario A</td><td>This scenario explores what will happen if the current structure (economic, industrial, energy supply and demand) grows linearly. This is what (Advisory Committee for Natural Resources and Energy) ACNRE calls its "Reference Case."</td></tr><tr><td>Scenario B</td><td>This scenario overcomes industrial hollowing by making the environmental industry into the next-generation strategic industry, and attempts to achieve both economic vitalization and environmental conservation within the present socioeconomic framework.</td></tr><tr><td>Scenario C</td><td>This scenario anticipates socioeconomic changes in the 21st century, during which the achievements of the IT revolution will become apparent, and post-materialism will make headway in the developed countries.</td></tr></table></td></tr>
</table>

	 Figure 16 CO_2 Emissions from energy consumption (COMPASS 2004)
Economic Impact	In scenario B the cumulative government debt will be 3.4 times GDP (scenario A 4.5 times). In scenario C the 2030 GDP will be about that of 1985.
Reference	Citizens' Open Model Projects for Alternative and Sustainable Scenarios (COMPASS), 2004, Citizens' Open Model Projects for Alternative and Sustainable Scenarios: http://www.isep.or.jp/shimin-enecho/presen_pdf/COMPASS_finalreport_en050428.pdf

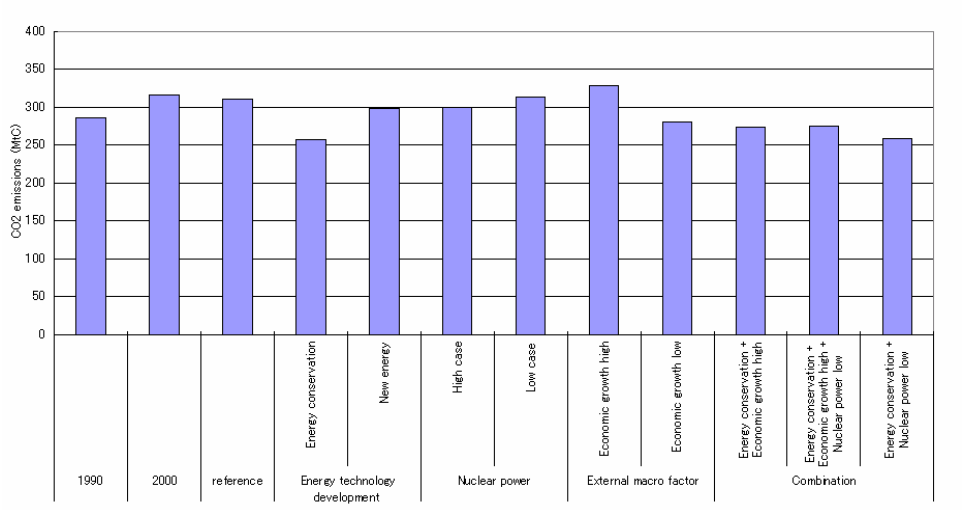
<table>
<tr><th colspan="2">[Japan] 2050 Nuclear Vision and Roadmap</th></tr>
<tr><td>Organizations</td><td>Japan Atomic Industrial Forum (JAIF)</td></tr>
<tr><td>Year</td><td>2004 (release year)</td></tr>
<tr><td>Target Year</td><td>2050</td></tr>
<tr><td>Model</td><td>MARKAL</td></tr>
<tr><td>Stabilization Level</td><td>-</td></tr>
<tr><td>Emission Target</td><td>60% reduction in CO_2 emissions relative to 2010 level (based on Kyoto protocol) in 2050</td></tr>
<tr><td>Policies</td><td>Thermal utilization of nuclear energy; Renewable energy; CO_2 capture and storage</td></tr>
<tr><td>Emission Scenarios</td><td>In order to examine the long-term meaning of nuclear power utilization, two scenarios were drawn up as show in Table 19.

Table 19 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>Expansion</td><td>Nuclear energy utilization is expanded in the future.
Thermal utilization of nuclear energy is utilized in 2020.</td></tr><tr><td>Phase out</td><td>Nuclear energy utilization is phased out in the future.
Renewable energy available scale is going to expand.
CO_2 capture and storage technology is utilized.</td></tr></table></td></tr>
<tr><td>Economic Impact</td><td>Energy supply cost in the “phase out” scenario rises 22% from that in the “Expansion” scenario in 2050.</td></tr>
<tr><td>Reference</td><td>Japan Atomic Industrial Forum (JAIF), 2004, 2050 Nuclear Vision and Roadmap [in Japanese]: http://www.jaif.or.jp/ja/news/2004/1202vision.pdf</td></tr>
</table>

<table>
<tr><th colspan="2">[Japan] Energy supply and demand outlook to 2030</th></tr>
<tr><td>Organizations</td><td>Ministry of Economy, Trade and Industry (METI)</td></tr>
<tr><td>Year</td><td>2005 (release year)</td></tr>
<tr><td>Target Year</td><td>2030</td></tr>
<tr><td>Model</td><td>-</td></tr>
<tr><td>Stabilization Level</td><td>-</td></tr>
<tr><td>Emission Target</td><td>Not defined</td></tr>
<tr><td>Policies</td><td>Energy conservation; Heat pump; New energy; Fuel cells; Dispersed-type energy; Nuclear power</td></tr>
<tr><td>Emission Scenarios</td><td>Various scenarios toward 2030, as shown in Table 20, were developed and a sensitivity analysis was performed.

Figure 17 shows the CO_2 emissions in various cases.

Table 20 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>Reference case</td><td>The reference scenario. Based on the current technical system and polices, economic society, population structure, and market pursues in a similar way to now.</td></tr><tr><td>Energy technology development case</td><td>Energy efficiency and new energy develops largely compared to the reference case. Following two cases are analyzed.
・ Energy efficiency development case
・ New energy development case</td></tr><tr><td>Nuclear power case</td><td>A case in which the number of nuclear power stations increases compared to that of the reference case.
・ Nuclear power high case: 16 new plants
・ Nuclear power low case: 7 new plants</td></tr><tr><td>External macro factor case</td><td>A case in which uncertainty due to external macro factor trend is taken into account.
・ Economic growth: high case & low case
・ Oil price: high case & low case</td></tr><tr><td>Another supposed case</td><td>A case that deals with issues that are impossible to be taken into account in the model. These issues are investigated by separating them from the model.</td></tr><tr><td>Combination case</td><td>A case which combines the energy efficiency development case and economic growth high case, or nuclear power low case, or both of them.
・ Energy efficiency development case
+ Economic growth high case
・ Energy efficiency development case
+ Nuclear power low case</td></tr></table></td></tr>
</table>

	• Energy efficiency development case + Economic growth high case + Nuclear power low case  Figure 17 CO_2 Emissions in various cases
Economic Impact	-
Reference	Ministry of Economy, Trade and Industry (METI), 2005, Energy supply and demand outlook to 2030 [in Japanese]: http://www.meti.go.jp/report/downloadfiles/g50328b01j.pdf

<table>
<tr><th colspan="2">[Japan] Strategic Technology Roadmap (Energy Sector)</th></tr>
<tr><td>Organizations</td><td>Ministry of Economy, Trade and Industry (METI)</td></tr>
<tr><td>Year</td><td>2006 (release year)</td></tr>
<tr><td>Target Year</td><td>2100</td></tr>
<tr><td>Model</td><td>-</td></tr>
<tr><td>Stabilization Level</td><td>Not defined</td></tr>
<tr><td>Emission Target</td><td><Assumption of resource constrains (global)>
While the world economy continues to grow, if CO_2 emissions can be maintained at the same level as the current condition, CO_2 emission intensity per GDP (annual CO_2 emissions / GDP) should improve as follows, compared to the current status:
・1/3 in 2050
・Less than 1/10 in 2100 (more improvement after is considered)
<Condition of the consideration of technologies in Japan>
Based on the consideration that we have achieved the maximum level of the efficiency improvement until today, we assume that we will continue to lead the world also in the future. Therefore, we set the same level of intensity improvement rate as the one derived for the assumption of the environment constraints above (global).</td></tr>
<tr><td>Policies</td><td>Backcasting; Constraints for fossil resources and the environment; Use of fossil resources with CO_2 capture and sequestration; Use of nuclear energy; Use of renewable energy combined with ultimate energy-saving; Energy-saving; Highly efficient utilization; Self-sustaining; Improvement of conversion efficiency</td></tr>
<tr><td>Emission Scenarios</td><td>Case studies by setting an extreme condition on the energy supply and demand structure were executed as shown in Table 21.

Table 21 Scenario list
<table><tr><th>Scenario</th><th>Contents</th></tr><tr><td>CASE A</td><td>Maximum use of fossil resources such as coal combined with CO_2 capture and sequestration</td></tr><tr><td>CASE B</td><td>Maximum use of nuclear energy</td></tr><tr><td>CASE C</td><td>Maximum use of renewable energy combined with ultimate energy-saving</td></tr></table></td></tr>
<tr><td>Economic Impact</td><td>-</td></tr>
<tr><td>Reference</td><td>Ministry of Economy, Trade and Industry (METI), 2006, Strategic Technology Roadmap (Energy Sector) ~ Energy technology Vision 2100~ : http://www.iae.or.jp/2100/main.pdf</td></tr>
</table>

Appendix: References Concerning Long-Term Emission Scenarios

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METI: Ministry of Economy, Trade and Industry (http://www.meti.go.jp/)
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- Beyond Kyoto Energy Dynamics and Climate Stabilisation (2002)
- Oil Crises & Climate Challenges - 30 Years of Energy Use in IEA Countries (2004)
- Energy to 2050 Scenarios for a Sustainable Future (2005)
- Projected Costs of Generating Electricity -- 2005 Update (2005)
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Shell (http://www.shell.com/home/)

- Energy Needs, Choices and Possibilities: Scenarios to 2050 (2001)
- The new Shell Global Scenarios to 2025 (2005)
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Exxon Mobile (http://www.exxonmobil.com/corporate/)
· The Outlook for Energy - A View to 2030 (2005)

Goldman Sachs (http://www.gs.com/)
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· Energy for Tomorrow's World - Acting Now (-)
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· Branch Points: Global Scenarios and Human Choice (1997)
· Bending the Curve: Toward Global Sustainability (1998)
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WBCSD: World Business Council for Sustainable Development (http://www.wbcsd.org/)
· Toward a sustainable paper cycle (1996)
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· Building a Better Future: Innovation, technology and sustainable development (2000)
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· Move. Sustain (2002)
· Sustainability in the Electricity Utility sector (2002)
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"Research Project on Establishing of Methodology to Evaluate Middle to Long term Environmental Policy Options toward Low Carbon Society in Japan (Japan Low Carbon Society Scenarios toward 2050)" (FY2004-2008)

The first great step to prevent global warming was taken by Kyoto Protocol which came into effect on Feb.16, 2005. But it is necessary to reduce GHG (Greenhouse gases) emissions drastically to stabilize climate change. Japan is also required to assess its long-term global warming policy. A large part of social infrastructure is likely to be replaced by 2050. It would be possible to propose concrete policy packages including institutional change, technology development, and lifestyle change toward low carbon society.

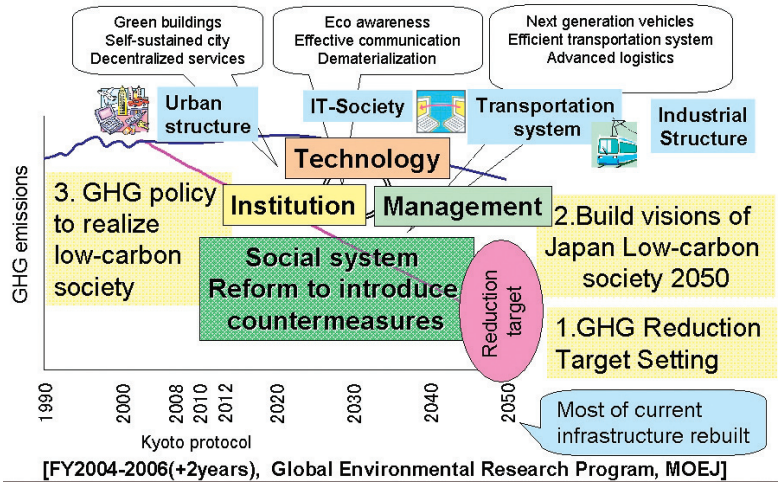
This project focuses on the following issues: 1) long-term scenario development study to integrate environmental options consistently using simulation models, 2) long-term GHG reduction target setting considering effectiveness and validity, and 3) assessment of environmental options considering future socio-economic conditions in a) urban system, b) information technology (IT) society, c) transportation system, and d) industrial change. We have the above 6 sub projects consisting of research experts in those areas and develop social and technically consistent middle and long-term global warming policy. To show probable paths toward a low carbon society in Japan which is compatible with economic development, would enhance public interest and lead to social and lifestyle changes. We propose to offer the latest research findings.

We have simulated the required GHG reduction for Japan. We have investigated the scenarios toward 2050 with back-casting method. The desired Japan 2050 future images with 60-80% GHG reduction will be set and the path considering economic impact, technological possibility, institutional and lifestyle change will be simulated objectively and consistently.

[Researchers]

Project Leader: Shuzo Nishioka (NIES)

Team Leader: Mikiko Kainuma(NIES) for scenario study, Norichika Kanie(TITech) for target setting, Keisuke Hanaki (University of Tokyo: UT) for urban system, Jun Fujimoto(UT) for ICT (Information and Communication Technology) based society, Yuichi Moriguchi(NIES) for transportation system, Yoshifumi Fujii(Bunkyo University) for industrial change, and about 50 other researchers.



[FY2004-2006(+2years), Global Environmental Research Program, MOEJ]

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2050

http://2050.nies.go.jp

Further information: http://2050.nies.go.jp/

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