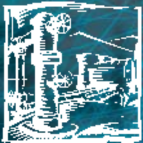
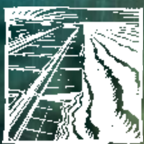
INTERNATIONAL ENERGY AGENCY



RENEWABLES IN GLOBAL ENERGY SUPPLY

An IEA Fact Sheet



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OECD

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The purpose of the Renewable Energy Fact Sheet is to present the current status of renewable energy markets as well as the IEA scenarios for future development of these technologies.

Disclaimer

The Renewable Energy Fact Sheet was prepared jointly by the Energy Statistics Division and the Renewable Energy Unit of the International Energy Agency, in collaboration with the Economic Analysis Division and Energy Technology Policy Division of the Agency. This paper reflects the views of the IEA Secretariat and may or may not reflect the views of the individual IEA member countries. For further information on this document, please contact the Renewable Energy Unit at: renewablesinfo@iea.org

INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty-six of the OECD's thirty member countries. The basic aims of the IEA are:

- To maintain and improve systems for coping with oil supply disruptions.
- To promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations.
- To operate a permanent information system on the international oil market.
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use.
- To assist in the integration of environmental and energy policies.

The IEA member countries are: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, the Republic of Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission takes part in the work of the IEA.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of thirty democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission takes part in the work of the OECD.

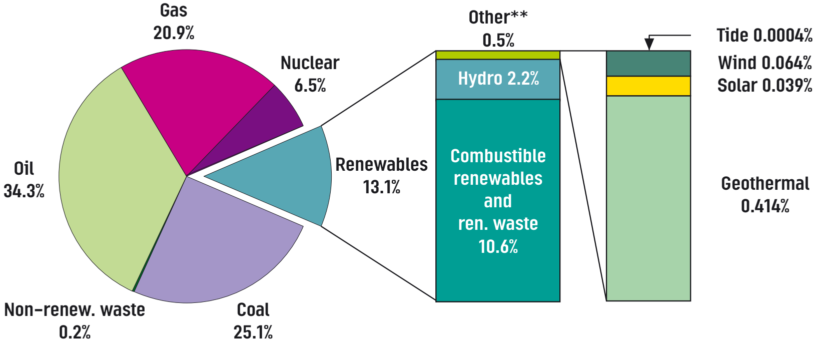
Part 1
RENEWABLES IN GLOBAL ENERGY SUPPLY 2004

Renewable energies are essential contributors to the energy supply portfolio as they contribute to world energy supply security, reducing dependency on fossil fuel resources, and provide opportunities for mitigating greenhouse gases. Differences in definition and lack of adequate data complicated the discussion between participants on these key issues. The International Energy Agency believes that this fact sheet can be of use to all to facilitate the debate on the past, current and future place and role of renewables in total energy supply.

Our goal is to present as objectively as possible the main elements of the current renewables energy situation. The definitions and coverage of national statistics vary between countries and organisations. In this fact sheet, the renewables definition includes combustible renewables and waste (CRW), hydro, geothermal, solar, wind, tide and wave energy (see definitions page 23).

Figure 1 represents the main fuels in the world total primary energy supply (TPES)*, with a disaggregation of the share of the main renewables categories. In 2004, renewables accounted for 13.1% of the 11 059 Mtoe of world total primary energy supply. Combustible renewables and waste (97% of which is biomass, both commercial and non-commercial) represented 79.4% of total renewables followed by hydro (16.7%).

Figure 1 • 2004 Fuel Shares of World Total Primary Energy Supply*



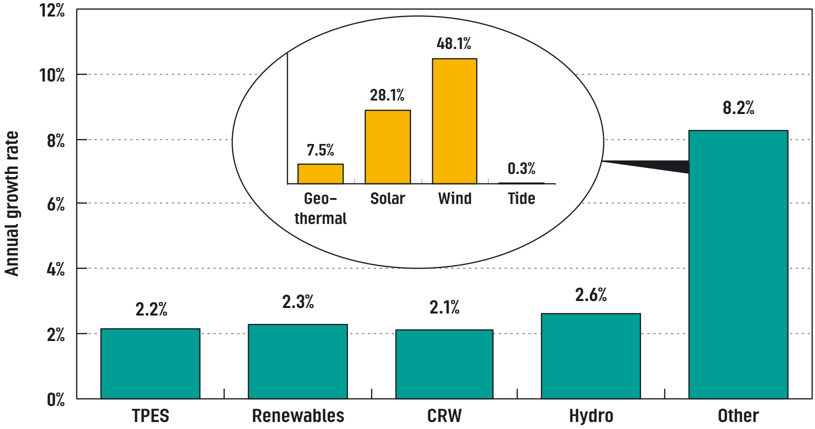
* TPES is calculated using the IEA conventions (physical energy content methodology). It includes international marine bunkers and excludes electricity/heat trade. The figures include both commercial and non-commercial energy.

** Geothermal, solar, wind, tide/wave/ocean.

Totals in graph might not add up due to rounding.

Source: IEA Energy Statistics

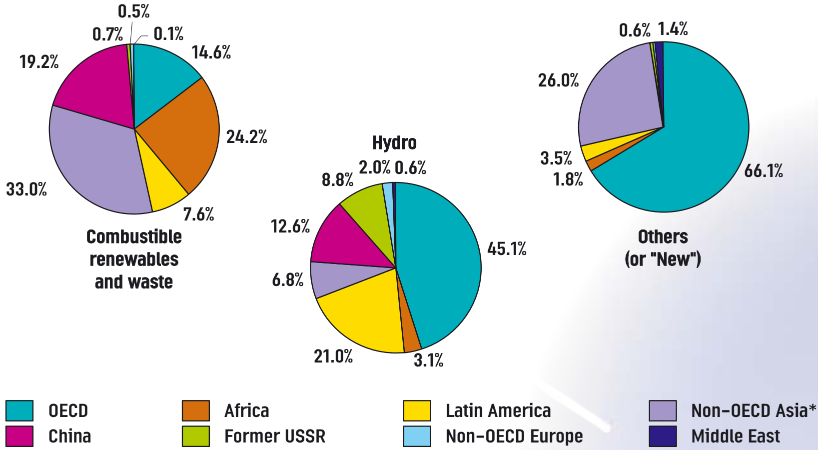
Figure 2 • Annual Growth of Renewables Supply from 1971 to 2004



Source: IEA Energy Statistics

Total renewables supply experienced an annual growth rate of 2.3% over the last 33 years, marginally higher than the annual growth of 2.2% in TPES. However, the "other" category in Figure 2 (also referred to as "new" renewables and including geothermal, solar, wind, etc.) recorded a much higher annual growth of 8.2%. Due to a very low base in 1971 and to recent fast-growing development, wind experienced the highest increase (+48% p.a.) followed by solar (+28% p.a.).

Figure 3 • 2004 Regional Shares in Renewables Supply

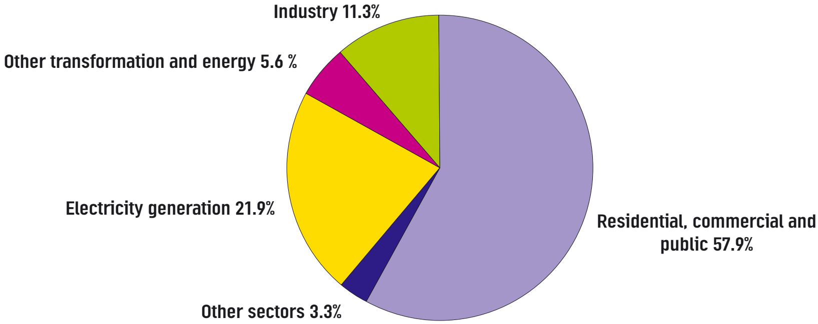


* Excluding China.

Source: IEA Energy Statistics

Due to the high share of biomass in total renewables, non-OECD regions like Asia, Africa and Latin America emerge as the main renewables users. The bulk of the consumption occurs in the residential sector for cooking and heating purposes. When looking at hydro and other (or "new") renewables (solar, wind, etc.), OECD accounts for most of the use with, respectively, 45% and 66% in 2004 (Figures 3 and 4).

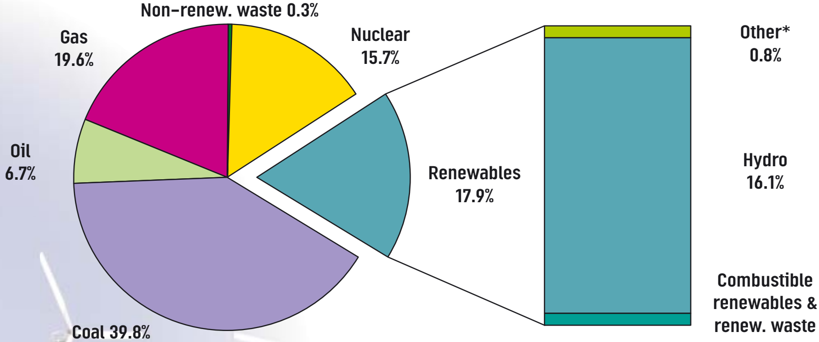
Figure 4 • 2004 Global Sectoral Consumption of Renewables



Source: IEA Energy Statistics

Renewables are the third largest contributor to global electricity production. They accounted for almost 18% of production in 2004, after coal (40%) and natural gas (close to 20%), but ahead of nuclear (16%), and oil (7%) and non-renewable waste. Almost 90% of electricity generated from renewables comes from hydropower plants while close to 6% comes from combustible renewables and waste. Geothermal, solar and wind have now reached 4.5% of renewable generation (Figure 5).

Figure 5 • 2004 Renewables in Electricity Production

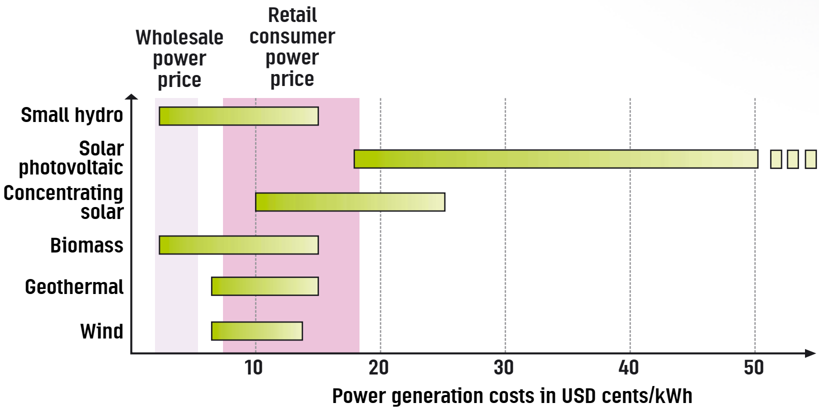


* Geothermal, solar, wind, tide/wave/ocean.
Source: IEA Energy Statistics

Impact of Past Market and Policy Trends on Renewable Energy

The principle constraint in advancing renewable energy over the last few decades has been cost-effectiveness. With the exception of large hydropower, combustible biomass (for heat) and larger geothermal projects (>30 MWe), the average costs of renewable energy are generally not competitive with wholesale electricity and fossil fuel prices (Figure 6). On the other hand, several renewable energy options for specific, small-scale applications can now compete in the marketplace, including hot water from solar collectors and electricity from small hydro and other technologies.

Figure 6 • Cost-competitiveness of Selected Renewable Power Technologies



Source: Renewable Energy: RD&D Priorities, OECD/IEA 2006.

The biggest challenge facing renewable energy technologies is to advance the state-of-the-art to the point where more renewable options can generate energy at costs that are competitive with conventional sources. With worldwide adoption of stricter environmental standards and guidelines for greenhouse gas emissions, it is becoming clear that renewable energy systems will be credited for their inherent advantage in lowering emissions. These environmental benefits will contribute towards making the delivered costs more palatable and are already the driving force behind policy initiatives in many IEA member countries. Nevertheless, achieving substantial technology breakthroughs to improve cost-competitiveness remains a priority.

In many IEA member countries, past policy initiatives to support renewable energy concentrated on research and innovation, market deployment and market-based energy. It is imperative to ensure that market-oriented policies complement technology initiatives. Based on experience to date, the following observations can be made regarding deployment:

- Significant market growth in renewable technologies results from a combination of policies that address specific barriers and/or complement existing policies. For example, in Japan, photovoltaic (PV) technology was supported by extensive RD&D investments to increase the competitiveness of the technology, through demonstration projects (to increase public awareness and acceptance), through financial incentives (to reduce the purchase price of PV systems) and by requiring utilities to accept, through net metering, excess power generated by PV systems at the retail price of electricity. In Spain, wind technology is supported by feed-in tariffs, low-interest loans, capital grants, and local support for manufacturing of turbines.
- Longevity and predictability of policy support are important to overall market success. In most cases, feed-in tariffs for renewable energy sources have an eight- to twenty-year time frame. The long-term support offered to biomass district heating plants in Austria provides an example. Conversely a 'stop–and-go' policy environment does not provide a sound basis to encourage the much-needed private sector involvement.
- With the trend towards market liberalisation, early support policies for emerging renewable energy technologies must be tailored carefully to insure against the impact of a significant drop in overall energy prices.

Maturity of Renewable Energy Technologies

Conceptually, one can define three generations of renewables technologies, reaching back more than 100 years (see page 24).

First-generation technologies emerged from the industrial revolution at the end of the 19th century and include hydropower, biomass combustion, and geothermal power and heat – some of which are still in widespread use.

Second-generation technologies include solar heating and cooling, wind power, modern forms of bioenergy, and solar photovoltaics. These are now entering markets as a result of RD&D investments by IEA member countries since the 1980s. The initial investment was prompted by energy security concerns linked to the oil price crises of that period but the enduring appeal of renewables is due, at least in part, to environmental benefits. Many of the technologies reflect revolutionary advancements in materials.

Third-generation technologies are still under development and include concentrating solar power, ocean energy, enhanced geothermal systems, and integrated bioenergy systems.

Conclusions

First-generation technologies are most competitive in locations with abundant resource endowment. Their future use depends on the exploration of the remaining resource potential, particularly in developing countries, and on overcoming challenges related to the environment and social acceptance.

Support for both RD&D and market deployment underpins the ongoing development of a second generation of renewable energy technologies. Some of these technologies are commercially available, albeit often with incentives to ensure cost reductions as a result of “market learning”. In principal, market learning provides complementary improvements, as manufacturers refine products and manufacturing processes. Renewable energy technologies exhibit similarities in learning effects or learning ratio (i.e., the per cent decrease in cost for each doubling of installed capacity) with other technologies. Markets for these technologies are strong and growing, but only in a few countries. The challenge is to broaden the market base to ensure continued rapid growth worldwide. Strategic deployment in one country not only reduces technology costs for users there, but also for those in other countries, contributing to overall cost reductions and performance improvement.

Third-generation technologies are not yet widely demonstrated or commercialised. They are on the horizon and may have potential comparable to other renewable energy technologies, but still depend on attracting sufficient attention and RD&D funding. These newest technologies include advanced biomass gasification, bio-refinery technologies, concentrating solar power, hot dry rock geothermal power, and ocean energy. Advances in nanotechnology also play a major role.

As first- and second-generation technologies have entered the markets, third-generation technologies, such as solar concentrating power, enhanced geothermal systems, ocean energy and advanced biomass heavily depend on long term RD&D commitments, where the public sector has a role to play.

Some of the second-generation renewables, such as wind, have high potential and have already realised relatively low production costs. However, issues of seasonal variability present a challenge to their grid integration. In such cases, first-generation technologies, such as hydropower, can serve to level out variable sources. Together with grid improvements and more advanced load and generation management, it is reasonable to assume that renewables will form part of a much more advanced electricity supply structure in the future.

Based on information collected from various sources worldwide, and noting the words of caution on page 11, the following tables give an idea of the contribution of renewables (with and without combustible renewables and waste) to total primary energy supply for over 140 countries (Table 1) and regions (Table 2).

Table 1 • Selected Renewables Indicators by Country for 2004

	TPES*	Share of Renewables in TPES	
		A	B
	Mtoe	**%**	**%**
Albania	2.4	26.3	20.0
Algeria	32.9	0.3	0.1
Angola	9.5	66.0	1.4
Argentina	63.7	7.5	4.1
Armenia	2.1	8.1	8.1
Australia	115.8	5.5	1.3
Austria	33.2	20.1	10.0
Azerbaijan	12.9	1.9	1.9
Bahrain	7.5	0.0	0.0
Bangladesh	22.8	36.2	0.5
Belarus	26.8	3.7	0.0
Belgium	57.7	1.5	0.1
Benin	2.5	65.6	0.0
Bolivia	5.0	18.4	3.8
Bosnia and Herzegovina	4.7	14.7	10.8
Botswana	1.9	24.5	0.0
Brazil	204.8	40.0	13.5
Brunei Darussalam	2.7	0.7	0.0
Bulgaria	18.9	5.2	1.4
Cameroon	6.9	82.7	4.9
Canada	269.0	15.4	10.9
Chile	27.9	22.7	7.3
People's Rep. of China	1609.3	15.6	1.9
Chinese Taipei	103.4	1.2	0.5
Colombia	27.7	27.4	12.5
Rep. of the Congo	1.1	64.9	3.2
Democratic Rep. of Congo	16.6	96.0	3.5
Costa Rica	3.7	46.9	38.7
Cote d'Ivoire	6.9	67.1	2.2
Croatia	8.8	11.1	6.8
Cuba	10.7	19.4	0.1
Cyprus	2.6	7.4	6.9
Czech Republic	45.5	3.3	0.4
Denmark	20.1	13.6	2.9
Dominican Republic	7.7	21.0	1.8
Ecuador	10.1	12.1	6.3
Egypt	56.9	4.5	2.0
El Salvador	4.5	54.6	22.0
Eritrea	0.7	64.4	0.0
Estonia	5.2	11.7	0.0
Ethiopia	21.2	91.5	1.0
Finland	38.1	23.0	3.4
France	275.2	5.9	2.0
Gabon	1.7	63.3	4.5
Georgia	2.8	41.6	18.7
Germany	348.0	3.8	1.3
Ghana	8.4	74.6	5.4
Gibraltar	0.1	0.0	0.0
Greece	30.5	5.1	2.0
Guatemala	7.6	55.7	2.8
Haiti	2.2	75.0	1.0
Honduras	3.9	45.3	5.2
Hong Kong (China)	17.1	0.3	0.0
Hungary	26.4	3.6	0.4
Iceland	3.5	72.0	72.0
India	572.9	38.8	1.3
Indonesia	174.0	30.8	3.8
Islamic Republic of Iran	145.8	1.2	0.6
Iraq	29.7	0.2	0.1
Ireland	15.2	2.1	0.7
Israel	20.7	3.5	3.5
Italy	184.5	6.1	4.6
Jamaica	4.1	12.0	0.3
Japan	533.2	3.2	2.2
Jordan	6.5	1.2	1.1
Kazakhstan	54.8	1.4	1.3
Kenya	16.9	80.8	6.7
Korea	213.0	0.5	0.2

A: Share of total renewables in TPES
B: Share of renewables **excluding combustible renewables and waste** in TPES
* Total primary energy supply calculated using the physical energy content methodology.

Table 1 • Selected Renewables Indicators by Country for 2004 (cont.)

	TPES*	Share of Renewables in TPES	
		A	B
	Mtoe	**%**	**%**
DPR of Korea	20.4	10.3	5.3
Kuwait	25.1	0.0	0.0
Kyrgyzstan	2.8	43.7	43.6
Latvia	4.6	35.9	5.9
Lebanon	5.4	4.3	1.9
Libya	18.2	0.8	0.0
Lithuania	9.2	8.0	0.4
Luxembourg	4.8	1.0	0.3
FYR of Macedonia	2.7	11.5	5.2
Malaysia	56.7	5.8	0.9
Malta	0.9	0.0	0.0
Mexico	165.5	9.8	4.8
Republic of Moldova	3.4	2.2	0.1
Morocco	11.5	5.3	1.4
Mozambique	8.6	95.8	11.7
Myanmar	14.1	74.9	1.4
Namibia	1.3	24.0	10.3
Nepal	9.1	89.0	2.2
Netherlands	82.1	2.0	0.2
Netherlands Antilles	1.7	0.0	0.0
New Zealand	17.6	29.8	24.9
Nicaragua	3.3	58.6	7.5
Nigeria	99.0	80.8	7.5
Norway	27.7	38.4	33.9
Oman	11.8	0.0	0.0
Pakistan	74.4	38.6	3.0
Panama	2.5	29.6	12.8
Paraguay	4.0	164.9	111.1
Peru	13.2	29.5	11.8
Philippines	44.3	45.6	21.6
Poland	91.7	4.7	0.2
Portugal	26.5	14.3	3.8
Qatar	18.1	0.0	0.0
Romania	38.6	12.0	3.9
Russia	641.5	2.9	2.4
Saudi Arabia	140.4	0.0	0.0
Senegal	2.8	39.8	0.9
Serbia and Montenegro	17.3	10.5	5.9

	TPES*	Share of Renewables in TPES	
		A	B
	Mtoe	**%**	**%**
Singapore	25.6	0.0	0.0
Slovak Republic	18.3	4.0	2.0
Slovenia	7.2	11.5	4.9
South Africa	131.1	10.2	0.2
Spain	142.2	6.2	2.9
Sri Lanka	9.4	54.7	2.7
Sudan	17.6	79.7	0.5
Sweden	53.9	25.7	9.7
Switzerland	27.1	15.1	11.2
Syria	18.4	2.0	2.0
Tajikistan	3.3	43.5	43.5
United Rep. of Tanzania	18.7	92.7	1.1
Thailand	97.1	16.9	0.5
Togo	2.7	71.1	0.5
Trinidad and Tobago	11.3	0.2	0.0
Tunisia	8.7	12.6	0.2
Turkey	81.9	13.2	6.4
Turkmenistan	15.6	0.0	0.0
Ukraine	140.3	0.9	0.7
United Arab Emirates	43.8	0.0	0.0
United Kingdom	233.7	1.5	0.3
United States	2325.9	4.2	1.5
Uruguay	2.9	29.7	14.4
Uzbekistan	54.0	1.0	1.0
Venezuela	56.2	11.7	10.7
Vietnam	50.2	50.2	3.0
Yemen	6.4	1.2	0.0
Zambia	6.9	89.6	10.5
Zimbabwe	9.3	68.9	5.1
Africa	**586.0**	**49.0**	**1.4**
Latin America	**485.5**	**28.9**	**10.9**
Asia	**1289.4**	**31.8**	**2.4**
China	**1626.5**	**15.4**	**1.9**
Non-OECD Europe	**104.3**	**10.6**	**4.8**
Former USSR	**979.3**	**3.0**	**2.2**
Middle East	**479.8**	**0.7**	**0.5**
OECD	**5507.9**	**5.7**	**2.7**
World	**11058.6**	**13.1**	**2.7**

A: Share of total renewables in TPES
B: Share of renewables **excluding combustible renewables and waste** in TPES
* Total primary energy supply calculated using the physical energy content methodology.

Table 2 • Key Regional Renewables Indicators for 2004

	TPES*	Of which Renew-ables	Share of Renewables in TPES	Share of the main fuel categories in total renewables		
				Hydro	Geothermal, Solar, Wind, etc.	Combustible Renewables and Waste
	Mtoe	**Mtoe**	**%**	**%**	**%**	**%**
Africa	586	287	49.0	2.6	0.4	97.1
Latin America	486	140	28.9	36.1	1.4	62.4
Asia**	1,289	411	31.8	4.0	3.6	92.4
China***	1,627	251	15.4	12.1	0	87.9
Non-OECD Europe	104	11	10.6	43.2	2.5	54.3
Former USSR	979	30	3.0	71.4	1.2	27.3
Middle East	480	3	0.7	43.4	24.4	32.2
OECD	5,508	315	5.7	34.6	12.0	53.4
World	**11,059**	**1,404**	**13.1**	**16.7**	**4.0**	**79.4**

* Total primary energy supply calculated using the physical energy content methodology.
** Asia excludes China.
*** China includes People's Republic of China and Hong Kong, China.

A Few Words of Caution on the Use of Data on Renewables

Definitions

Statistical information on renewables varies from country to country and from organisation to organisation. Time horizon, subsidies or taxation, sustainability and environment are some elements which might lead to differences in coverage for policy or practical reasons. For example, large hydro is sometimes excluded from renewables, while peat is sometimes included. The figures and data presented in this fact sheet are based on the coverage and definitions given on page 25.

Data Quality

Data on biomass, more specifically on "non-commercial" biomass, are often available only from secondary sources, due to the difficulty countries have in accurately monitoring the supply and consumption of biomass. As a consequence, the quality and reliability of the data may be limited, which makes comparison between countries difficult. The data on remote solar and wind installations are also difficult for national administrations to collect.

Part 2
SCENARIOS OF THE EVOLUTION OF RENEWABLES TO 2030[1]

The Alternative Policy Scenario

The Alternative Policy Scenario presented in this year's World Energy Outlook expands the analysis included in previous editions. It shows how the global energy market could evolve if countries around the world were to adopt a set of policies and measures that they are now considering and might be expected to implement over the projection period. Renewable energy contributes significantly towards achieving the objectives of this scenario: reductions in CO_2 emissions and improved security of supply. Table 3 summarises the main developments related to renewable energy in the Alternative Policy Scenario. In this scenario, the share of renewables in global energy consumption will remain largely unchanged at 14%. Traditional biomass currently accounts for 7% of world energy demand, but its share will fall as developing countries shift to modern forms of energy. World hydropower production will grow by 1.8% per year but its share will remain almost stable at around 2%. The shares of other renewables (including geothermal, solar and wind) will increase most rapidly at 6.2% per year but because they start from a very low base (0.5% share in 2003) they will still be the smallest component of renewable energy in 2030 with a share of only 1.7% of global energy demand.

Table 3 • Global Increase in Renewable Energy

	2004	2030	Approximate increase (times)
Electricity Generation (TWh)	**3 179**	**7 775**	**>2**
Hydropower	2810	4903	<2
Biomass	227	983	>4
Wind	82	1440	18
Solar	4	238	60
Geothermal	56	185	>3
Tide and Wave	<1	25	46
Biofuels (Mtoe)	**15**	**147**	**10**
Industry and Buildings (Mtoe)**	**272**	**539**	**2**
Commercial biomass	261	450	<2
Solar heat	6.6	64	10
Geothermal heat	4.4	25	6

* Excluding traditional biomass.
Source: World Energy Outlook 2006, OECD/IEA 2006.

1. Based on the *World Energy Outlook 2006*, OECD/IEA 2006.

Renewables in Electricity Generation

In the Alternative Policy Scenario, renewable energy plays a major role in the global electricity mix in 2030, supplying over a quarter of total electricity. This share was 18% in 2004. In absolute terms, electricity generation from renewable energy sources increases from 3 179 TWh to 7 775 TWh and renewable energy becomes the second largest source of electricity after coal.

The projected increase is the result of new policies currently under discussion - on the assumption that these policies will be implemented- as well as the result of the extension and strengthening of policies currently in place. Most OECD countries and an increasing number of countries outside the OECD are considering policies to increase the contribution of renewables. For the countries of the European Union, the Alternative Policy Scenario assumes that additional policies will be put in place to meet the target of the directive on the promotion of electricity from renewable energy sources.[2] There are no targets for renewables beyond 2010 at the EU level, although some countries have set national ones. The intention, however, is to continue the shift to renewables beyond this period. In the United States, about half of the states have plans to increase the share of renewables through renewables portfolio standards. China's Renewable Energy Law, which came into effect in January 2006, could have a large impact on electricity generation from renewable energy sources.

In the Alternative Policy Scenario, the share of renewables increases by ten percentage points above current levels in the OECD, by four points in developing countries, and by four points in the transition economies. In the OECD, the most dramatic increase is projected for OECD Europe, where 38% of electricity is based on renewables in 2030.

The share of hydropower in world electricity generation is 16% in 2030, the same as today. Most new hydropower plants are built in developing countries, where the unexploited potential is still large. In many of these countries, there is now renewed interest in hydropower (see Box on page 14). World hydropower capacity reaches 1 431 GW in 2030, compared with 851 GW now. Hydropower capacity in China increases from 105 GW in 2004 to 298 GW in 2030. In India, it increases from 31 GW to 105 GW.

Electricity generated from biomass, wind, solar, geothermal and tide and wave power reaches 2 872 TWh in 2030, almost eight times higher than now and their share in total generation grows from 2% now to 10% in 2030. The largest increase is in OECD Europe, where non-hydro renewables are projected to supply 22% of electricity needs by 2030 (Figure 7). Most of the growth is in wind power and biomass, the most competitive among the different renewable energy sources. These substantial increases reflect new policies aiming to support the development of renewables as well as cost reductions resulting from technological learning.

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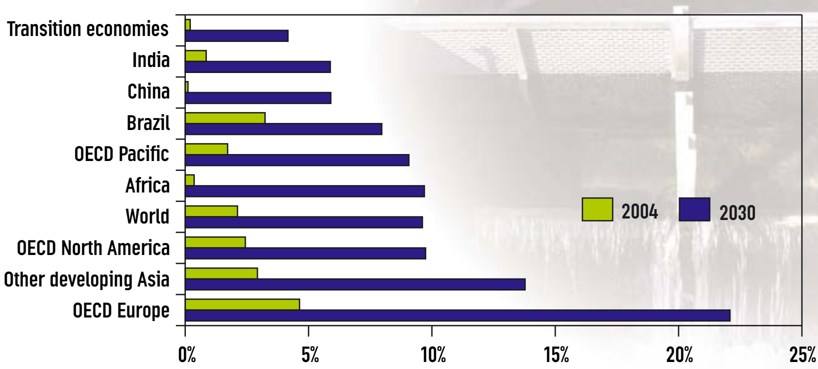
2. The directive, adopted in 2001, calls for an increase in the share of renewables in electricity generation from 13.9% in 1997 to 22.1% in 2010 in the 15 EU countries. The target was later extended to all 25 members, with the overall target share being somewhat lower.

Figure 7 • Shares of non-Hydro Renewable Energy in Electricity Generation by Region



Source: World Energy Outlook 2006, OECD/IEA 2006.

Prospects for Hydropower in Developing Countries

Over the past fifteen years, many large hydropower projects in developing countries have been adversely affected by concerns over the environmental and social effects of building large dams. Obtaining loans from international lending institutions and banks to finance such projects has become more difficult. Consequently, many projects have been delayed or cancelled. Five years ago, hydropower was the world's second-largest source of electricity; now it ranks fourth.

The remaining potential in developing countries is still very large. Several developing countries are focusing again on this domestic source of electricity, driven by a rapidly expanding demand for electricity, by the need to reduce poverty and to diversify the electricity mix. Support from international lenders and interest from the private sector is also growing.

There is a strong consensus now that countries should follow an integrated approach in managing their water resources, planning hydropower development in co-operation with other water-using sectors. There is significant scope for optimising the current infrastructure. The majority of reservoirs has been developed for water supply, primarily irrigation. Only about 25% of reservoirs worldwide have any associated hydropower facilities.

Properly managed, hydropower could help restrain the growth in emissions from burning fossil fuels. In Brazil, for example, where more than 80% of electricity is hydropower, the power sector accounts for just 10% of the country's total CO_2 emissions, four times less than the world average.

Biofuels

Globally, the share of biofuels in road transport increases from 1% today to 7% in 2030. Total biofuel consumption increases tenfold, from 15.5 Mtoe in 2004 to 146.7 Mtoe in 2030. The biggest increases in biofuels consumption occur in the United States - already the world's biggest biofuel consumer -, in Europe, in developing Asia and in Brazil. Biofuels-use outside these regions remains modest (Table 4). Ethanol is expected to account for most of the increase in biofuels use worldwide, as production costs are expected to fall faster than those of biodiesel – the other main biofuel. Trade grows, but its share of world supply remains small. Production is assumed to be based entirely on conventional crops and technology.

Table 4 • Biofuels Demand in Road Transport, by Region

	2004		2030	
	Demand (Mtoe)	% in Road Transport	Demand (Mtoe)	% in Road Transport
OECD	8.9	0.9%	84.2	7.2%
North America	7.0	1.1%	45.7	6.4%
United States	6.8	1.3%	42.9	7.3%
Europe	2.0	0.7%	35.6	11.8%
Pacific	0.0	0.0%	2.9	1.9%
Transition economies	0.0	0.0%	0.5	0.6%
Developing countries	6.5	1.5%	62.0	6.9%
China	0.0	0.0%	13.0	4.5%
India	0.0	0.0%	4.5	8.0%
Other developing Asia	0.1	0.0%	21.5	4.6%
Brazil	6.4	13.7%	23.0	30.2%
World	15.5	1.0%	146.7	6.8%
European Union	2.0	0.7%	35.6	11.8%

Source: World Energy Outlook 2006, OECD/IEA 2006.

About 14 million hectares of land are currently used for the production of biofuels – about 1% of the world's available arable land. This share rises to 3.5% in the Alternative Policy Scenario. Rising food demand, which will compete with biofuels for existing arable and pasture land, will constrain the potential for biofuels output, but this may be at least partially offset by higher agricultural yields.

Renewables for Heat Production

The industry and buildings sector consumed about 1 040 Mtoe of renewable energy in 2004. The bulk of it, some 770 Mtoe was traditional biomass in developing countries. Most of the remainder was commercial biomass used for heat production, in addition to 6.6 Mtoe of solar heat and 4.4 Mtoe of geothermal energy. Commercial biomass use is projected to increase from 261 Mtoe in 2004 to 450 Mtoe in 2030. Solar heat (solar water heaters) is projected to reach 64 Mtoe and geothermal heat 25 Mtoe. Most of the increase will be in the OECD.

Beyond the Alternative Policy Scenario

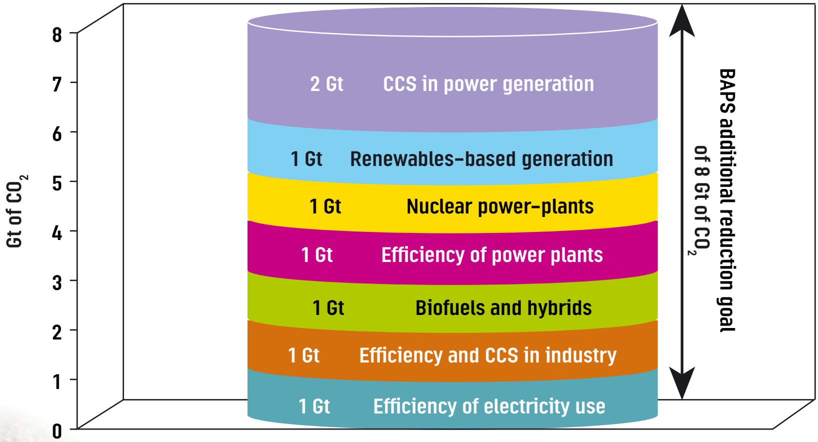
Although the policies and measures in the Alternative Policy Scenario would substantially improve energy security and reduce energy-related CO_2 emissions fossil fuels would still account for 77% of primary energy demand. Global CO_2 emissions would still be 8 Gt higher in 2030 than they are today. A Beyond the Alternative Policy Scenario (BAPS) Case responds to requests by policy-makers to illustrate the potential for achieving still more ambitious emissions reductions through stronger policies and more favourable technological development, and to analyse the obstacles and the implications for energy security.

The goal adopted in this Case, as a proxy for more diverse energy objectives, is to ensure that global energy-related CO_2 emissions in 2030 are no higher than the 2004 level of 26.1 Gt. This means reducing emissions in 2030 by 8 Gt more than in the Alternative Policy Scenario, which would require major changes in energy supply and use. Achieving the BAPS goal will almost certainly call for new technologies as well as improvements to those that exist. Of the existing technologies that are currently under development but not yet commercially available, carbon capture and storage (CCS) and second-generation biofuels seem the most promising.

To illustrate the potential of additional emissions reductions, six different initiatives are identified, each of which can yield a saving of 1 Gt of CO_2 emissions, and then add a seventh, CO_2 capture and storage in power generation, which could save 2 Gt, in order to arrive at cumulative savings of 8 Gt beyond those made in the Alternative Policy Scenario in 2030. The mix of options is presented in Figure 8. It is not necessarily the cheapest, nor the easiest strategy to implement politically or technically. But it is consistent with even more ambitious emissions reductions beyond 2030.

Renewable energy plays a greater role in BAPS. An additional 550 TWh of hydropower and 550 TWh of other renewables-based generation would need to be commissioned, each saving 0.5 Gt of CO_2 emissions. With such additions, renewables-based generation represents a 32% share of electricity generated in 2030, as compared with 26% in the Alternative Policy Scenario. Policies could include research and development to bring down costs, renewable portfolio standards or feed-in tariffs, and loan guarantees to reduce the cost of capital. Biofuels consumption rises to 295 Mtoe in 2030, double the level projected in the Alternative Policy Scenario. Given the constraints on land and biomass availability, this higher level of penetration of biofuels could only be achieved through the large-scale introduction of second-generation biofuels based on lingo-cellulosic feedstock. Policies to encourage this could include increased research and development, incentives for construction and operation of biorefineries and minimum requirements for biofuels in conventional fuel blends.

Figure 8 • Reduction in Energy-related CO_2 Emissions in the BAPS Case Compared with the Alternative Policy Scenario by Option



Source: World Energy Outlook 2006, OECD/IEA 2006.

Part 3
SCENARIOS AND STRATEGIES OF RENEWABLES TECHNOLOGY TO 2050[3]

The IEA Accelerated Technology (ACT) scenarios investigate the potential of energy technologies and best practices aimed at reducing energy demand and emissions, and diversifying energy sources. The scenarios focus on technologies which exist today or which are likely to become commercially available in the next two decades. The results of the ACT scenarios illustrate the impact of a wide range of policies and measures that overcome barriers to the adoption of these technologies. In addition to the ACT scenarios, a scenario with more optimistic assumptions about the rate at which certain technological barriers are overcome, the TECH Plus scenario, is considered.

In the ACT scenarios, policies and measures are assumed to be put in place that would lead to the adoption of low-carbon technologies with a cost of up to USD 25 per tonne of CO_2. The ACT scenarios are based on the incentives being in place from 2030 in all countries, including developing countries. The incentives could take many forms – such as regulation, pricing, tax breaks, voluntary programmes, subsidies or trading schemes.

The five ACT scenarios, each of which assumes the same set of core efforts and policies described above, vary only in that they assume different rates of progress in overcoming technological barriers, achieving cost reductions and winning public acceptance for a technology. The technology areas where different assumptions are made are: (1) the progress in cost reductions for renewable power generation technologies; (2) constraints on the development of nuclear power plants; (3) the risk that CO_2 capture and storage (CCS) technologies will not be commercialised by 2050; and (4) the effectiveness of policies to increase the adoption of energy efficient end-use technologies (Table 5).

Table 5 • Overview of Scenario Assumptions for ACT and TECH Plus Scenarios

	Renewables	Nuclear	CCS	H_2 Fuel Cells	Advanced Biofuels	End-use Efficiency
Scenario						
Map						
Low Renewables	Pessimistic					
Low Nuclear		Pessimistic				
No CCS			No CCS			
Low Efficiency						Pessimistic
TECH Plus	Optimistic	Optimistic	Optimistic	Optimistic	Optimistic	

Source: Energy Technology Perspectives 2006, OECD/IEA 2006.

3. Based on the *Energy Technology Perspectives - Scenarios and Strategies to 2050*, OECD/IEA 2006

In the Baseline Scenario, total primary energy supply (TPES) grows 110% between 2003 and 2050. In the Map scenario, primary energy use in 2050 is only 58% higher than in 2003, at 16 762 Mtoe. This is 24% lower than that in the Baseline Scenario in 2050. Primary energy use varies little among the ACT scenarios, except in the Low Efficiency scenario where it is 14.6% higher. Hydro energy use doubles compared to 2003 levels. Most of this growth is already included in the Baseline scenario. Other renewables increase by 71 to 137%, compared to the Baseline (Table 6).

Table 6 • Changes in Primary Energy Supply by Fuel in the Map, No CCS[4]

	Map Scenario		No CCS		TECH Plus	
	(difference from Baseline Scenario in 2050)					
	(%)	(Mtoe)	(%)	(Mtoe)	(%)	(Mtoe)
Coal	-61	-4 620	-72	-5 421	-65	-4 878
Oil	-20	-1 209	-21	-1 237	-36	-2 165
Gas	-30	-1 602	-25	-1 360	-31	-1 651
Nuclear	72	585	85	687	156	1 264
Hydro	11	41	9	36	14	51
Renewables	71	1 455	78	1 599	137	2 822
Total	**-24**	**-5 350**	**-26**	**-5 696**	**-21**	**-4 556**

Source: Energy Technology Perspectives 2006, OECD/IEA 2006.

In the Baseline Scenario, the growth in CO_2 emissions continues through to 2050, reaching 58 Gt. CO_2 emissions in 2050 - an unsustainable 137% higher than in 2003. Significant CO_2 emissions reductions are achieved in all of the ACT scenarios. In the Map scenario, emissions almost return to the 2006 level by 2050, or 6% higher than in 2003.[5] In the four remaining ACT scenarios – Low Nuclear, Low Renewables, No CCS and Low Efficiency – CO_2 emissions are higher than in the Map scenario, ranging between 9% and 27% above the 2003 level.

Only in the TECH Plus scenario are CO_2 emissions lower in 2050 than in 2003. In this scenario, more optimistic assumptions about reductions in the cost of nuclear, renewables, hydrogen fuel cells and the production of ethanol from cellulosic feedstocks lead to greater use of these technologies and fuels. It is also the only scenario where there is significant penetration of hydrogen. CO_2 emissions in this scenario are 21% below the Map scenario and 16% below 2003 levels by 2050.

4. Oil refers to primary oil supply and therefore excludes the synfuel produced from coal-to-liquids and gas-to-liquids. The primary energy consumption from producing these fuels is reported under coal and gas.

5. 2003 is the latest year for which the IEA had detailed statistics on CO_2 emissions from energy use at the time *Energy Technology Perspectives 2006* went to press.

Increased use of renewables in power generation contributes 9% of the emissions reduction in the Map scenario and 16% in the No CCS scenario. Assuming more modest cost declines for renewables, as in the Low Renewables scenario, means the share of reductions from renewable generation technologies falls to 5%.

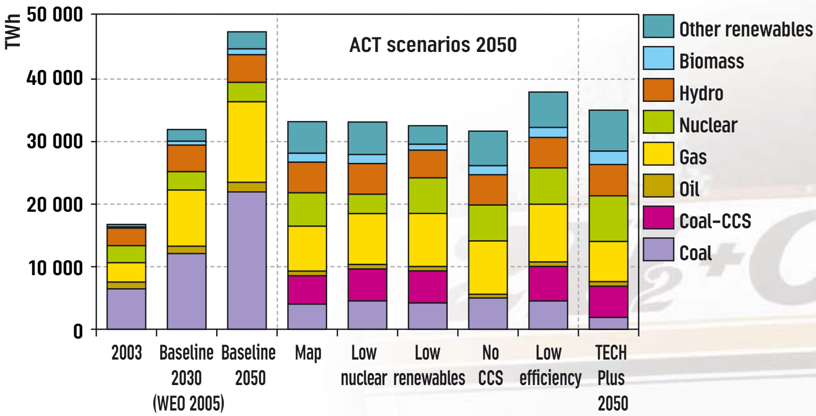
In 2050, the share of renewables in industry increases from 8% in the Baseline Scenario to 12% in the Map scenario. In the buildings sector, the increase in the renewables share is from 15% to 18%. Most of the increase in the buildings sector is due to the increased use of solar hot water heating systems. The greater efficiency of biomass use, particularly in developing countries, in the ACT scenarios allows greater energy service demands to be met from an equivalent quantity of biomass.

In the transport sector, biofuels and fuel cells using hydrogen offer two of the few opportunities to reduce the carbon intensity of the sector. The contribution to CO_2 emissions reductions from the increased use of biofuels in transport is around 6% in all the ACT scenarios. In the TECH Plus scenario, biofuels' share of CO_2 emissions savings is 0.6 percentage points higher, saving 500 Mt of CO_2 more than in the Map scenario.

Electricity production from biomass and other combustible renewables increases significantly from current levels both in the Baseline Scenario and in the ACT scenarios. By 2050, the biomass share of electricity output is 2% in the Baseline Scenario, 3% in the Low Renewables scenario and around 4.5% in all other ACT scenarios. In the TECH Plus scenario, the share of biomass reaches 5.1% in 2050.

Other renewables, which includes wind, solar, geothermal, tidal and wave, are the area of electricity production that grows the fastest, although they start from a very low base. By 2050, electricity production from other renewables

Figure 9 • Global Electricity Production by Fuel and Scenario, 2003, 2030 and 2050



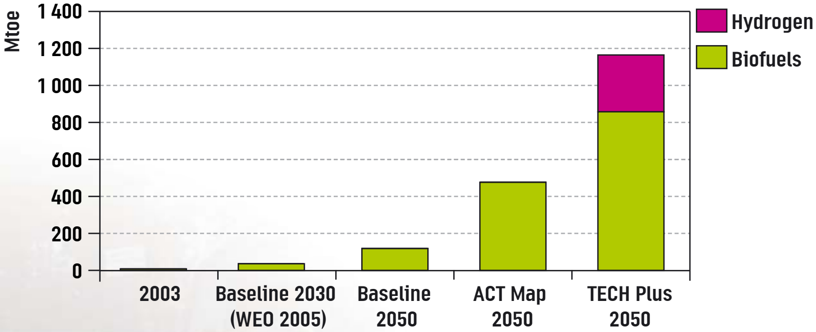
Source: Energy Technology Perspectives 2006, OECD/IEA 2006.

in the Baseline Scenario reaches 1 800 TWh, up from 113 TWh in 2003. In the Map scenario, the production from these renewable sources is twice that of the Baseline level in 2050 and even higher in the other ACT scenarios. One exception is the Low Renewables scenario, where more pessimistic assumptions on future cost reductions for this category of renewables leads to production being just 10% higher than the Baseline level in 2050. Wind is by far the most important generation source in this category. In the Map scenario, wind accounts for about two-thirds of the 3 620 TWh generation from other renewables. The remaining share is split almost equally between solar and geothermal, with a very minor contribution from tidal and wave power.

In the TECH Plus scenario, the more optimistic assumptions for cost improvements, particularly for wind and solar, cause electricity generation from other renewable sources to grow at 8% per year on average between 2003 and 2050 to reach 4 869 TWh in 2050, or 15% of total electricity generation.

In the Map scenario, total transport energy demand in 2050 is 17% or 767 Mtoe below the Baseline scenario, while in the TECH Plus scenario, fuel savings reach 1 011 Mtoe in 2050, or a 23% reduction from the Baseline level. Biofuel production grows significantly in the ACT scenarios. Biofuels' share of transport demand increases to 13% in 2050 in the Map scenario and to almost 25% in the more optimistic TECH Plus scenario (Figure 10).

Figure 10 • Global Use of Hydrogen and Biofuels, by Scenario 2003 – 2050



Source: Energy Technology Perspectives 2006, OECD/IEA 2006.

The increase in renewables use in the ACT scenarios is affordable. For example in the power sector the additional investment costs for renewable, nuclear and CCS plants are to a large extent offset by avoided investment in fossil-fuel generation capacity. These avoided investments depend on two factors: first, significant demand-side savings reduce the need to build new capacity; second, some of the fossil-fuel-based capacity built in the Baseline is replaced by other capacity in the Map scenario. Additional investments in renewables technologies amount to

USD 7.4 trillion but the total additional power generation investment cost compared to Baseline amounts only to USD 3.6 trillion over the period 2005 to 2050, or about USD 80 billion per year. If energy efficiency did not reduce electricity demand below the Baseline Scenario, then the additional cumulative investment needs would be about USD 4.1 trillion higher.

In the Map scenario, the total deployment costs or "learning investments" for renewables amount to USD 720 billion over the period 2005-2050, or about USD 16 billion per year. This is less than 10% of the USD 9.8 trillion additional investment costs in renewables, nuclear and CCS technologies. However, most of the deployment support will be needed over the next two to three decades and would thus represent a significant investment which would have to be borne, at least to some degree, by governments.

With a 3% discount rate, the net costs for the electricity sector in the Map scenario would be around the same level as in the Baseline, while the net cost would be about USD 5 trillion higher with a 10% discount rate. This illustrates, to a large extent, that the additional investment costs in the ACT scenarios can be regarded as transitional, leading to significant economic as well as environmental and security benefits in the longer term.

Annex I
DEFINITIONS

Renewables include the following categories:

Combustible Renewables and Waste (CRW)[6]:

Solid Biomass: Covers organic, non-fossil material of biological origin which may be used as fuel for heat production or electricity generation.

Wood, Wood Waste, Other Solid Waste: Covers purpose-grown energy crops (poplar, willow etc.), a multitude of woody materials generated by an industrial process (wood/paper industry in particular) or provided directly by forestry and agriculture (firewood, wood chips, bark, sawdust, shavings, chips, black liquor etc.) as well as wastes such as straw, rice husks, nut shells, poultry litter, crushed grape dregs etc.

Charcoal: Covers the solid residue of the destructive distillation and pyrolysis of wood and other vegetal material.

Biogas: Gases composed principally of methane and carbon dioxide produced by anaerobic digestion of biomass and combusted to produce heat and/or power.

Liquid Biofuels: Bio-based liquid fuel from biomass transformation, mainly used in transportation applications.

Municipal Waste (renewables)[6]: Municipal waste energy comprises wastes produced by the residential, commercial and public services sectors and incinerated in specific installations to produce heat and/or power. The renewable energy portion is defined by the energy value of combusted biodegradable material.

Hydropower: Potential and kinetic energy of water converted into electricity in hydroelectric plants. It includes large as well as small hydro, regardless of the size of the plants.

Geothermal Energy: Energy available as heat emitted from within the earth's crust, usually in the form of hot water or steam. It is exploited at suitable sites for electricity generation after transformation, or directly as heat for district heating, agriculture, etc.

Solar Energy: Solar radiation exploited for hot water production and electricity generation. Does not account for passive solar energy for direct heating, cooling and lighting of dwellings or other.

Wind Energy: Kinetic energy of wind exploited for electricity generation in wind turbines.

Tide/Wave/Ocean Energy: Mechanical energy derived from tidal movement, wave motion or ocean current, and exploited for electricity generation.

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6. Some of the waste (the non-biodegradable part of the waste) is not considered renewables as such. However, proper breakdown between renewables and non-renewables is not always available.

Annex II
RENEWABLES TECHNOLOGY DEVELOPMENT

First-generation Technologies

Hydropower

Hydropower is an extremely flexible technology from the perspective of power grid operation. Large hydropower provides one of the lowest cost options in today's energy market, primarily because most plants were built many years ago and their facility costs have been fully amortised.

Capital costs for new large plants in IEA member countries are about USD 2 400/MW, with generating costs in the range of USD 0.03/kWh to USD 0.04/kWh. The technical potential of small hydropower capacity worldwide is estimated at 150 GW to 200 GW. Small hydropower costs are in the range of USD 0.02/kWh to USD 0.06/kWh; the lowest costs occur in good resource areas. Once the high up-front capital costs are written off, plants can provide power at even lower cost levels, as such systems commonly operate without major replacement costs for 50 years or more. At present, only 5% of the global hydropower potential has been exploited through small-scale sites. The principal barriers to exploiting more fully small hydro capacity worldwide, are access to transmission systems and environmental and social concerns.

Biomass Combustion

Biomass combustion for heat and power is a fully mature technology. It offers both an economic fuel option and a ready disposal mechanism of municipal, agricultural and industrial organic wastes. However, the industry has remained relatively stagnant over the last decade, even though demand for biomass (mostly wood) continues to grow in many developing countries. One of the problems of biomass is that material directly combusted in cook stoves produces pollutants, leading to severe health and environmental consequences; although improved cook stove programmes are alleviating some of these effects. A second issue is that burning biomass emits CO_2, even though biomass combustion is generally considered to be "carbon-neutral" because carbon is absorbed by plant material during its growth, thus creating a carbon cycle. First-generation biomass technologies can be economically competitive, but may still require deployment support to overcome public acceptance and small-scale issues.

Geothermal Power and Heat

Geothermal power plants can operate 24 hours per day, providing base-load capacity. In fact, world potential capacity for geothermal power generation is estimated at 85 GW over the next 30 years. The costs of geothermal energy have dropped substantially from the systems built in the 1970s. Generation costs at current plants in the United States are as low as USD 0.015/kWh to USD 0.025/kWh. New construction can deliver power at USD 0.05/kWh to USD 0.08/kWh, depending on the quality of the resource.

However, geothermal power is accessible only in limited areas of the world, the largest being the United States, Central America, Indonesia, East Africa and the Philippines. Challenges to expanding geothermal energy include very long project development times, and the risk and cost of exploratory drilling. Geothermal heat generation can be competitive in many countries producing geothermal electricity, or in other regions where the resource is of a lower temperature.

Second-generation Technologies

Solar Heating and Cooling

Solar thermal collectors are already widely used in certain countries, primarily for hot water production. Various technologies are becoming more widely used, such as unglazed, glazed and evacuated tube water collectors, which have market shares of 30%, 50% and 20%, respectively. In principle, larger systems can be used for residential space heating and – in combination with absorption heat pumps – for cooling. However significant cost reductions are needed before the latter application will become cost-effective.

Wind Energy

Wind technology has become very reliable, operating with availabilities of more than 98% and having a design life of 20 years or more. Moreover, as the costs of wind turbines have steadily declined, technical reliability has increased. The factors that currently limit wind energy's market penetration include variability, public acceptance and grid reliability. However, recent developments in electricity market reform, which promote better grid integration and improved management of natural cycles of renewables, diminish the technological barriers that have constrained market penetration.

In the area of wind energy, continued RD&D is essential to provide the necessary reductions in cost and uncertainty to realise the anticipated level of deployment. Other RD&D priorities include increasing the value of forecasting power performance, reducing uncertainties related to engineering integrity, improvement and validation of standards, reducing the cost of storage techniques, enabling large-scale use, and minimising environmental impacts. Further expansion of wind power will promote significant reductions in greenhouse gases. With further deployment support, wind power may become generally competitive with conventional technologies by 2015-20; off-shore wind will likely become competitive to a degree after that.

Solar Photovoltaics

The photovoltaic (PV) market has grown extensively since 1992. RD&D efforts, together with market deployment policies, have effectively produced impressive cost reductions: every doubling of the volume produced prompted a cost decrease of about 20%. But market deployment is concentrated: Japan, Germany and the United States account for over 85% of total installed capacity. PV still requires substantial RD&D investments, as well as deployment supports, to gain market learning. In the near term, RD&D efforts will focus on improving the balance-of-system components for both grid connected and stand-alone applications. Even with these supports, PV is not expected to be generally competitive until after 2020 – although it will continue to compete well in a growing range of market niches in which the cost of deployment supports is moderate.

Modern Forms of Bioenergy

More modern forms of bioenergy include biomass-based power and heat generation, co-firing, biofuels for transport and short rotation crops for energy feedstocks. These are more advanced and each has its own unique benefits. Biomass is attractive for use either as a stand-alone fuel or in fuel blends, such as co-firing wood with coal, or mixing ethanol or biodiesel with conventional petroleum-based fuels. Anaerobic digestion has strong potential in countries with ample resources. Electricity generated from biomass is based on steam turbine technology. Many regions of the world still have large untapped supplies of biomass residues, which could be converted into competitively priced electricity using steam turbine power plants.

Co-firing is a low-cost and low-risk way of adding biomass capacity. Co-firing systems that use low-cost biomass supply can have payback periods as short as two years. In addition, biomass can substitute up to 15% of the total energy input in a power plant, often with few modifications other than the burner and feed intake systems. Co-firing is of particular interest in developing countries, because it improves the economic and ecological quality of many older, coal-fired power plants.

Biofuels from agricultural biomass production is another well-developed conversion technology. Biomass grown as dedicated energy crops can provide new economic opportunities for farmers and forest owners. The primary barriers to increased use of biomass on a larger scale are the cost of systems required for dedicated feedstock production, harvesting, and transportation, as well as the fuel conversion technologies. With further RD&D and deployment support in 2020-30, these technologies could achieve commercialisation.

Third-generation Technologies

Concentrating Solar Power

Three types of concentrating solar power (CSP) technologies support electricity production based on thermodynamic processes: parabolic troughs, parabolic dishes and solar central receivers. The cost of power generated with these up-to-date technologies is between USD 0.10/kWh and USD 0.15/kWh. Current RD&D efforts concentrate on parabolic trough technology. To achieve progress, much larger resources are needed than what is currently offered in public programmes. Optimal conditions for CSP are an arid or semi-arid climate, limiting its usefulness to southern Europe, north and southern Africa, the Middle East, western India, western Australia, the Andean Plateau, north-eastern Brazil, northern Mexico and the US Southwest.

Ocean Energy

Over the last 20 years, ocean energy technology received relatively little RD&D funding. However, there is renewed interest in the technology, and several concepts now envisage full-scale demonstration prototypes around the British coast. But ocean energy technologies must still solve two major problems concurrently: proving the energy conversion potential and overcoming a very high technical risk from a harsh environment. Other non-technical barriers include resource assessment, energy production forecasting and design tools, test and measurement standards, environmental impacts, arrays of farms of ocean energy systems, and dual-purpose plants that combine energy and other structures.

Enhanced Geothermal Systems

Enhanced geothermal systems, known as hot dry rock, utilise new techniques to exploit resources that would have been uneconomical in the past. These systems are still in the research phase, and require additional RD&D for new approaches and to improve conventional approaches, as well as to develop smaller modular units that will allow economies of scale on the manufacturing level. Several technical issues need further government-funded research and close collaboration with industry in order to make exploitation of geothermal resources more economically attractive for investors. These are mainly related to exploration of reservoirs, drilling and power generation technology, particularly for the exploitation of low-temperature cycles.

Integrated Bioenergy Systems

The biomass integrated gasifier/gas turbine (BIG/GT) is not yet commercially employed, but substantial demonstration and commercialisation efforts are ongoing worldwide, and global interest is likely to lead to market deployment within a few years. Overall economics of biomass-based power generation should improve considerably with BIG/GT systems as opposed to steam turbine systems.

The biorefinery concept for biomass feedstocks also has potential to meet a large proportion of future energy demand, particularly once dedicated crops tailored to biorefinery requirements are developed. Current RD&D efforts focus on reducing the costs of dedicated plantations, mitigating potential environmental impacts of bio-refineries and creating an integrated bioenergy industry that links bioenergy resources with the production of a variety of other energy and material products.

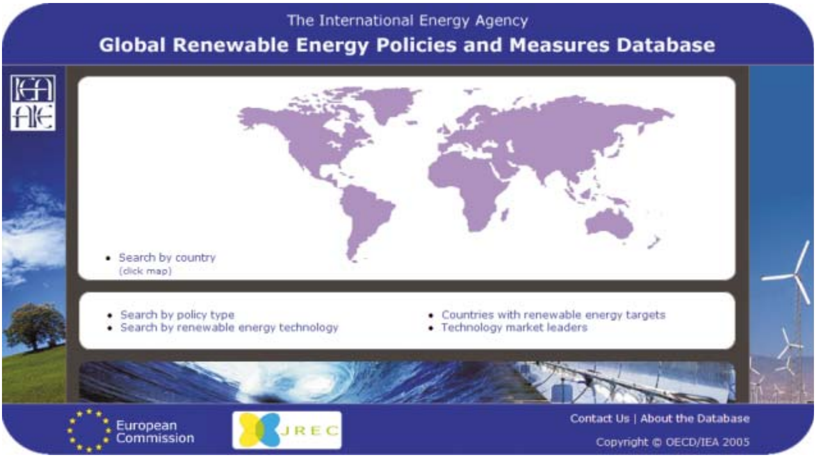
RENEWABLE ENERGY POLICIES AND MEASURES ON A GLOBAL SCALE

The Global Renewable Energy Policies and Measures Database is an initiative led by the International Energy Agency, and is being implemented in collaboration with the European Commission and the Johannesburg Renewable Energy Coalition.

The Database features over 100 countries and offers renewable energy market and policy information in one format in one location for countries that together represent almost total global renewables supply.

The Database is freely accessible online via the IEA website. Visitors can search for information according to country, policy instrument, renewable energy technology, renewable energy target and other criteria.

This online searchable database is part of a continued effort by the International Energy Agency to contribute to the international dialogue on renewable energy by providing unbiased information and analysis for the use by decision-makers, policy experts, researchers and industry, as well the broader public.

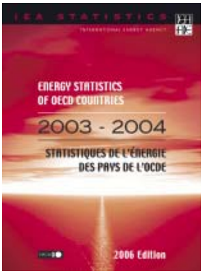


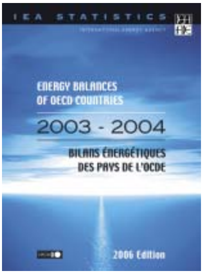
http://renewables.iea.org

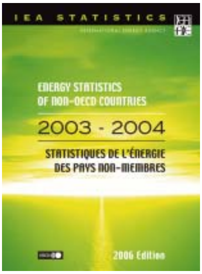
The International Energy Agency supports the development of renewable technologies through its Renewable Energy Working Party (REWP) and nine international Implementing Agreements (IAs). Details and contacts for these agreements can be found on:
http://www.iea.org/Textbase/techno/technologies/renew.asp

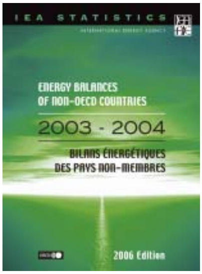
INTERNATIONAL ENERGY AGENCY

Detailed historical data on renewables and other energy fuels are published in several annual IEA statistics books:

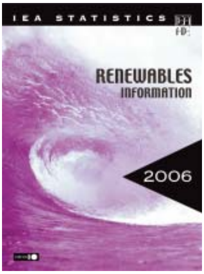








The IEA also publishes books on coal, electricity, gas and oil as well as on CO_2 Emissions from Fuel Combustion and on Energy Prices and Taxes. The full time series are available on CD Roms as well as on the internet.



Renewables Information 2006 presents a detailed and comprehensive picture of developments for renewable and waste energy sources for each of the 30 OECD Member countries, encompassing energy indicators, generating capacity and heat production from renewable and waste sources, as well as production and consumption of renewable and waste products. It also includes a selection of indicators for over 100 non-OECD countries and regions.

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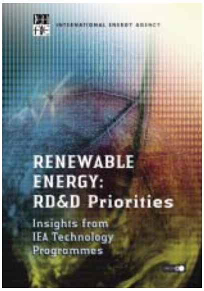

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