



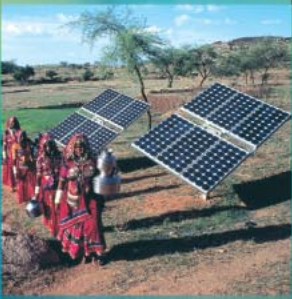
EREC

European Renewable Energy Council



RENEWABLE ENERGY SCENARIO TO 2040

HALF OF THE GLOBAL
ENERGY SUPPLY
FROM RENEWABLES
IN 2040



RENEWABLE ENERGY SCENARIO TO 2040

This briefing shows that renewable energy sources will be able to play a significant role in future energy supply worldwide.

In the long term, renewable energies will dominate the world's energy supply system. The reason is at the same time very simple and imperative: there is no alternative. Mankind cannot indefinitely continue to base its activities on the consumption of finite energy resources.

Renewable sources of energy are in line with an overall strategy of sustainable development. They help reduce dependence on energy imports, or do not create a dependence on energy imports in countries that will have increased energy needs in the future, thereby ensuring a sustainable security of supply. Furthermore, renewable energy sources can help improve the competitiveness of industries and have a positive impact on regional development and employment. Renewable energy technologies are suitable for off-grid services, serving those in remote areas of the world without having to build or extend expensive and complicated grid infrastructure.

Combined with the improvement of energy efficiency and the rational use of energy, renewable energy can provide everything fossil fuels currently offer in terms of energy services:

- **Heating and cooling** - solar domestic water heating, solar passive, biomass and solar space heating for buildings, geothermal heat and geothermal heat pumps are entering the market as mainstream technologies. Solar cooling for buildings and industry has been installed in a number of demonstration projects.
- **Electricity** - Electricity from wind power, small-scale hydro and biomass are market reality. Geothermal electricity has existed for decades and supplies electricity for 30 million people worldwide. Photovoltaics are already cost-effective in niche markets world-wide, while tidal and wave power as well as concentrated solar power will need further research and development before they can be commercialized.

- **Transport fuels** - liquid biofuels like bioethanol and biodiesel produced from agricultural crops, will require better recognition of their low-carbon benefits and their rate of progress will be influenced by decisions taken in other areas of policy such as taxation policy and agricultural policy.

Though humans have been tapping into most renewable energy sources (wood, solar, wind, geothermal and water) for thousands of years, so far only a tiny fraction of the technical¹ and economic potential of renewable energy has been captured and exploited. Yet, with existing and proven technologies, renewable energy offers safe, reliable, clean, local and increasingly cost-effective alternatives for all our energy needs.

The question is: How fast can the transformation into a carbon free energy supply system based on renewable energy sources happen?

Some existing projections neglect the possibilities of renewable energy technologies to be available worldwide quickly and easily. In most cases renewables are more cost effective than traditional centralized energy structures, predominantly where no infrastructure is built yet.

50 % by 2040 is feasible

Assumptions made by EREC- the European Renewable Energy Council- together with its member associations (EPIA, ESHA, ESTIF, EUBIA, EUREC Agency, EWEA, AEBIOM and EGEC) based on experiences and cumulative knowledge lead to assumptions on expected annual installations growth rates for different technologies and show that by 2040, a share of renewable energy up to 50% worldwide is possible. To reach such a share, advanced, intelligent and reliable policy measures have to be implemented at least in the majority of countries worldwide.

1. A study shows that the total available global wind resource technically recoverable is more than twice as large as the projection for the world's entire electricity demand in 2020. Similarly, theoretical solar energy potential corresponds to almost 90,000,000 Mtoe per year, which is almost 10,000 times the World Total Primary Energy Supply (IEA 2003).

2. Dynamic current policies scenario (DCP)

Dynamic current policies does not mean “business as usual”. Assuming that a “business as usual” is seen as impossible for a sustainable future by a lot of decision makers, the model is based on less international cooperation as the AIP-scenario in the field of RES, but expects ambitious policy measures on national level at least in the industrialised part of the world. The assumptions are based on policy measures that are similar to what already happens in some countries of the world. During the last years some regions have given increased attention to the promotion of renewable energy sources, some have given less. It is assumed that the commitment to renewables development in the very proactive countries, such as Germany, continues to strengthen and will be adopted also by others at least in the industrialized part of the world as national policies, and additionally that especially in the least developed countries and areas without existing networks for electricity renewables will be a competitive alternative to conventional sources in the near future, even without special promotion.

The figures for total energy consumption in the DCP are also taken from a scenario from IIASA, but it assumes a higher total consumption. This was used, because EREC considers it is more appropriate to predict a higher total consumption if no major international action is taken. It is a single “middle-course” scenario for the total consumption. It incorporates more modest estimates of economic growth and technological development, and the demise of trade barriers and expansion of new arrangements facilitating international exchange.

Sources of information

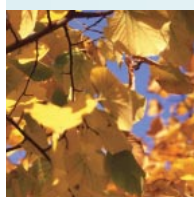
For this briefing, different sources have been used. For the total energy consumption during 2001 and 2040 the briefing is based on the IIASA scenarios. For electricity the figures are based on the International Energy Outlook from the IEA. EREC did not make any assumption on the remaining part of energy supply that will not be covered by renewable energy sources. This means that the conventional energy supply that is needed in addition to renewable energy supply is not analysed in its mix. The following sources are used in one way or another in the calculations:

- **United Nations Development Programme, World Energy Council:** World Energy Assessment (WEA) - 2000, used for electricity
- **Thomas B. Johansson and others, The Potentials of Renewable Energy, TBP, 2004**
- **G8:** Renewable Energy Development that lasts - G8, Renewable Energy Task Force - 2001
- **International Energy Agency:** World Energy Outlook 2002 - IEA
- **Wind Force 12:** EWEA, Greenpeace - 2004 (for advanced international policies scenario)
- **SG:** Solar Generation - EPIA, Greenpeace - 2002 (for advanced international policies scenario)
- **EREC:** Renewable Energy Target for Europe - 20% by 2020 - 2004 - World Electricity Consumption Annual Growth Rate (AGR) - IEA

2001 - 2010	2,8%
2011 - 2020	2,6%
2021 - 2029	2,0%
2030 - 2040	1,5%
- **Scientific co-ordination of EREC scenario:** Prof. Arthouros Zervos

The Advanced International Policies Scenario (AIP)

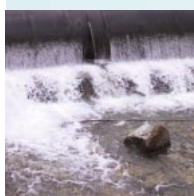
For the advanced international policies scenario different assumptions for different technologies are made. The assumptions take into account the different scenarios of the sources mentioned at the beginning of this briefing. The cumulative annual growth rates vary significantly between the technologies.



For **Biomass** - the most used renewable energy source now and in future - the growth rates are relatively low during the whole projection, mainly because of its comparatively high starting point, but due to its variable use -heating, electricity and fuels - the overall contribution of biomass to the energy supply will be the most important renewable energy source also in future. It is assumed that a large deployment of small decentralised systems is taking place after 2010.

	2001-2010	2010-2020	2020-2030	2030-2040
AIP	2,2 %	3,1 %	3,3 %	2,8 %

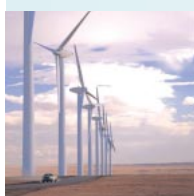
Expected annual growth rates for Biomass



The potential of sustainable **large hydro** is quite limited to some regions in the world. The sources to be used in a sustainable way will be exploited during the next 20 years, thereafter no potential is left and therefore no significant growth will be registered after that time. Hitherto the potential for **small hydro** (< 10 MW) power is still significant. The exploitation of new potential will reach a peak during the next decade between 2010 and 2020, substantial growth will still be registered thereafter.

		2001-2010	2010-2020	2020-2030	2030-2040
AIP	Small Hydro	8,0 %	10,0 %	8,0 %	6 %
AIP	Large Hydro	2 %	1,5 %	1 %	0,5 %

Expected annual growth rates for Hydro Power



Wind Power, a technology with annual growth rates of more than 30% during the last years, will face a reduction in annual growth rates as the initial period of exponential growth reduces the pace. This is the same pattern of development as large-scale hydro and nuclear energy have followed historically. After 2020, the growth rates are mainly based on replacements of existing installations. After 2040 zero cumulative growth is expected.

	2001-2010	2010-2020	2020-2030	2030-2040
AIP	28 %	20 %	7 %	2 %

Expected annual growth rates for Wind Power



Photovoltaics already had impressive annual growth rates of more than 30 % during the last years. Due to its enormous potential and the possibilities for flexible off-grid as well as on-grid connections it is seen as the future renewable energy source with the highest and steadiest growth rates of all. Of course PV starts on a relatively low production level, but expected cost reduction and the flexibility of PV systems can make it the second largest contributor within the overall share of renewables in 2040. The use of solar energy to generate power or heat is the only energy source for which, in relation to all projections of human energy requirements, no limitation, according to present knowledge, is foreseen. The sustainable potential of solar energy is thus virtually unlimited in relation to human energy requirements.

	2001-2010	2010-2020	2020-2030	2030-2040
AIP	28%	30%	25%	13,5%

Expected annual growth rates for PV



The **solar thermal** heating and cooling sector today is experiencing steady growth in industrialised countries with mainly small scale applications. There is nearly no geographical limit for solar thermal uses. In future the extension to large scale applications for heating and cooling is expected and this thereby helps to increase the share rapidly. After 2030 a peak of growth will have been reached due to a reduced need for heating and cooling installations. The reduction is based on the assumption that by that time a greater level of energy efficiency performance in buildings will limit the growth thereafter. That means, that if energy systems are restructured with efficiency improvements as a guiding principle, then within a few decades the demand for thermal energy in the buildings sector will no longer grow substantially. This particularly limits the demand for thermal energy from solar sources and from biomass as well as geothermal sources for heating demand over the medium term.

	2001-2010	2010-2020	2020-2030	2030-2040
AIP	16%	16%	14%	7%

Expected annual growth rates for solar thermal



Geothermal electricity as well as heat is limited to the characteristics of local resources and reservoirs. Its substantial potential is limited to some parts of the world, whereas potential for small scale applications (heat pumps) is given broadly. Technical exploitable potential will increase during the next years due to innovation, whereas the limitation of the potential will then lead to a steady reduction of growth rates.

	2001-2010	2010-2020	2020-2030	2030-2040
AIP	8%	8%	6%	4%

Expected annual growth rates for geothermal energy



“Cumulative annual growth rates vary significantly between the technologies”



The **solar thermal electricity** sector is at the moment still in a state of immaturity and its applications are limited to some technical test installations. But the technical and economical potential is to be expected to be very high. It is estimated that the market exploitation of solar thermal electricity follows the wind energy development with twenty years delay.

	2001-2010	2010-2020	2020-2030	2030-2040
AIP	16%	22%	18%	15%

Expected annual growth rates for solar thermal electricity



Marine energy (tidal/wave/ocean) is assumed to have a significant contribution after 2020. Growth rates similar to wind and solar thermal electricity are used with corresponding time delays of 30 and 10 years accordingly.

	2001-2010	2010-2020	2020-2030	2030-2040
AIP	8%	15%	22%	21%

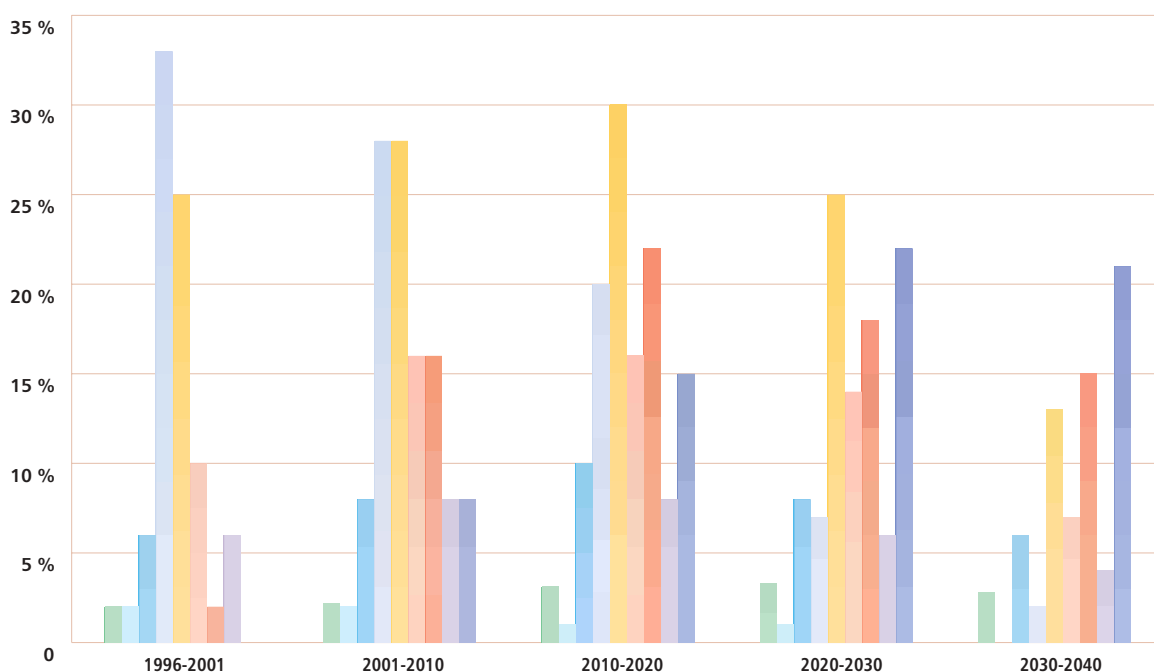
Expected annual growth rates for marine energy

The assumption for all renewable energy sources technologies :

	1996-2001	2001-2010	2010-2020	2020-2030	2030-2040
Biomass	2%	2.2%	3.1%	3.3%	2.8%
Large hydro	2%	2%	1%	1%	0%
Small hydro	6%	8%	10%	8%	6%
Wind	33%	28%	20%	7%	2%
PV	25%	28%	30%	25%	13%
Solar thermal	10%	16%	16%	14%	7%
Solar thermal electricity	2%	16%	22%	18%	15%
Geothermal	6%	8%	8%	6%	4%
Marine (tidal/wave/ocean)	-	8%	15%	22%	21%

In the graphical view one can see the different growth scenarios for the different technologies during the decades up to 2040. It also shows the complementarities of the different renewable energy sources. Some renewable energy technologies will grow more quickly during the next 20 years than others, but will then face a significant reduction in terms of market growth. Others still need some years to reach the break-through, but will then mainly due to cost reductions or technical innovations grow quickly and steadily.

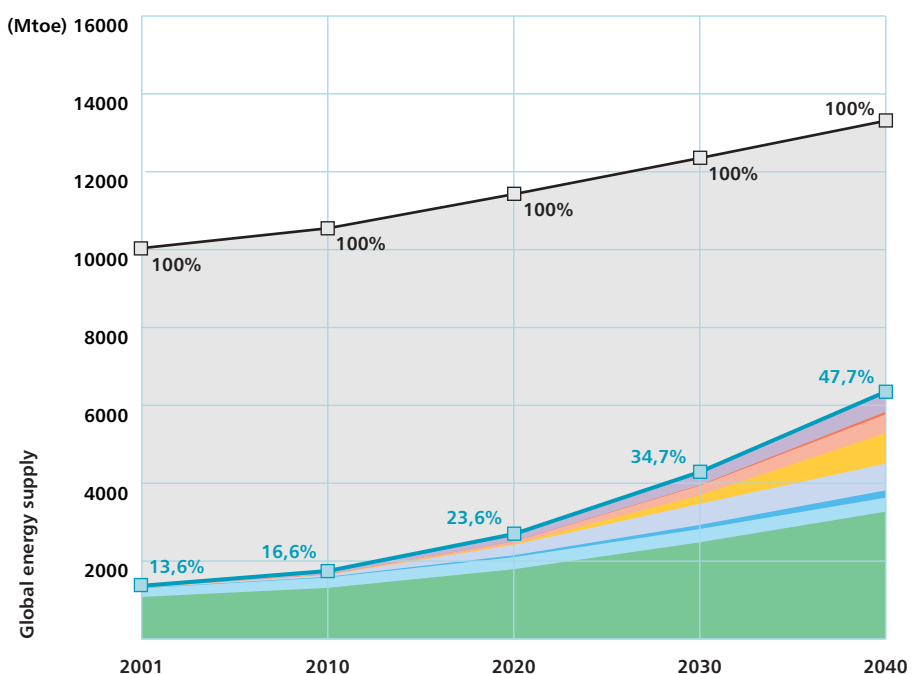
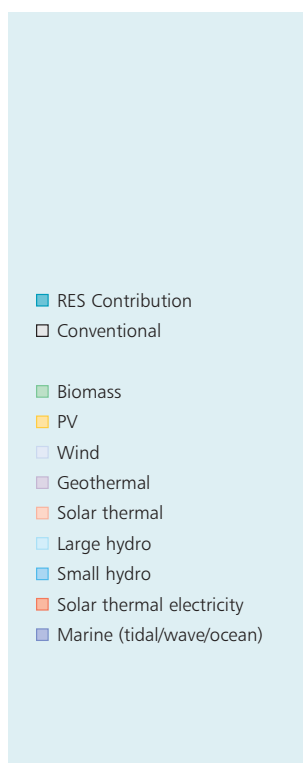
Also in terms of technical restraints these different growth rates show the complementarity of all renewable energy sources. Intermittency of wind power or PV will not cause any problems to electricity supply until a significant share is reached. But by that time other renewable energy sources such as small hydro or marine technologies will complement the system and by that cover the necessary base-load.



The contribution of Renewable Energy Sources to the world energy supply in 2040 - Projections in Mtoe - Advanced International Policy Scenario

	2001	2010	2020	2030	2040
Total Consumption in Mtoe (IIASA)	10038,3	10549	11425	12352	13310
Biomass	1080	1313	1791	2483	3271
Large hydro	222,7	266	309	341	358
Small hydro	9,5	19	49	106	189
Wind	4,7	44	266	542	688
PV	0,2	2	24	221	784
Solar thermal	4,1	15	66	244	480
Solar thermal electricity	0,1	0,4	3	16	68
Geothermal	43,2	86	186	333	493
Marine (tidal/wave/ocean)	0,05	0,1	0,4	3	20
Total RES	1364,5	1745,5	2694,4	4289	6351
RES Contribution	13,6%	16,6%	23,6%	34,7%	47,7%

If the advanced cumulative growth rates as outlined in this briefing are reached, renewable energy sources will have a contribution to total primary energy consumption of nearly 50 % by 2040.



Exemplary detailed scenario for electricity - advanced international policies scenario

If only electricity supply is assumed for the years up to 2040 the contribution of renewable energies in this field is much higher compared to total energy supply in 2040. The higher penetration of renew-

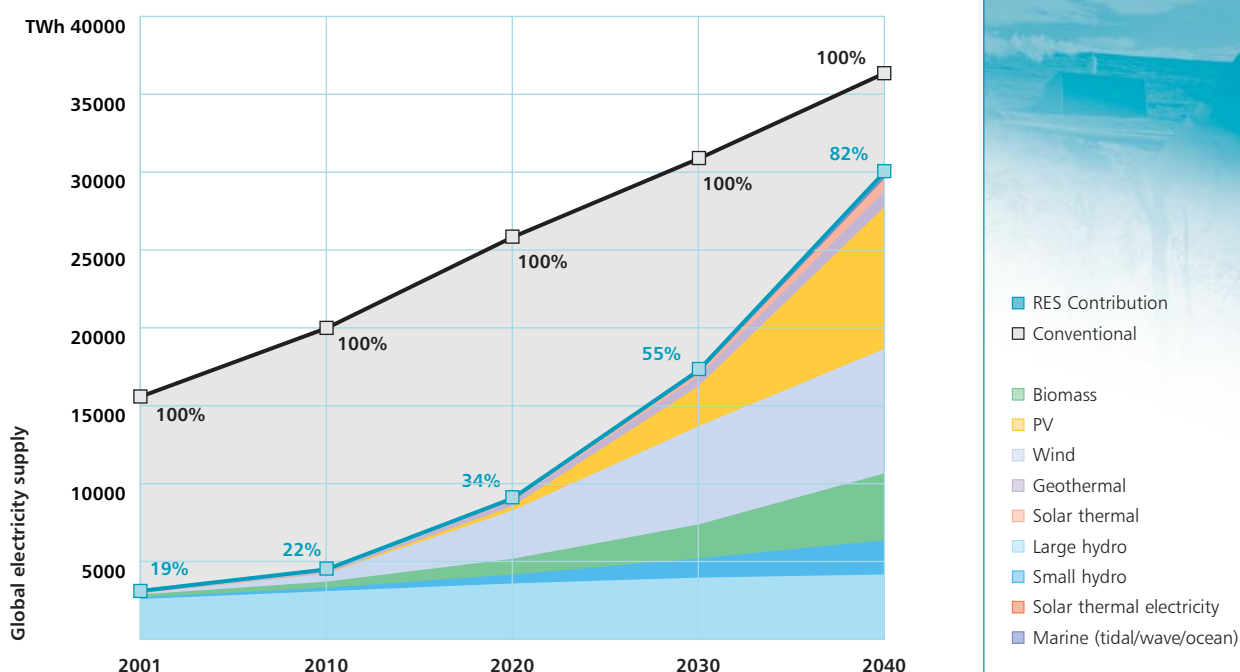
ables in electricity supply has different factors. On the one hand, some renewable techniques for electricity supply are already more mature now compared to, for example, the conversion of renewables into fuels for transport. On the other hand, there are limiting factors for heating and cooling applications such as missing policy instruments that are more difficult to overcome.

	2001	2010	2020	2030	2040
Total Consumption in TWh (IEA)	15578	19973	25818	30855	36346
Biomass	180	390	1010	2180	4290
Large Hydro	2590	3095	3590	3965	4165
Small Hydro	110	220	570	1230	2200
Wind	54,5	512	3093	6307	8000
PV	2,2	20	276	2570	9113
Solar Thermal	1	5	40	195	790
Geothermal	50	134	318	625	1020
Marine	0,5	1	4	37	230
Total RES	2988,2	4377	8901	17109	29808
RES Contribution	19,2%	21,9%	34,5%	55,4%	82,0%

Advanced International Policies Scenario Share of Renewables in World Total Electricity Consumption

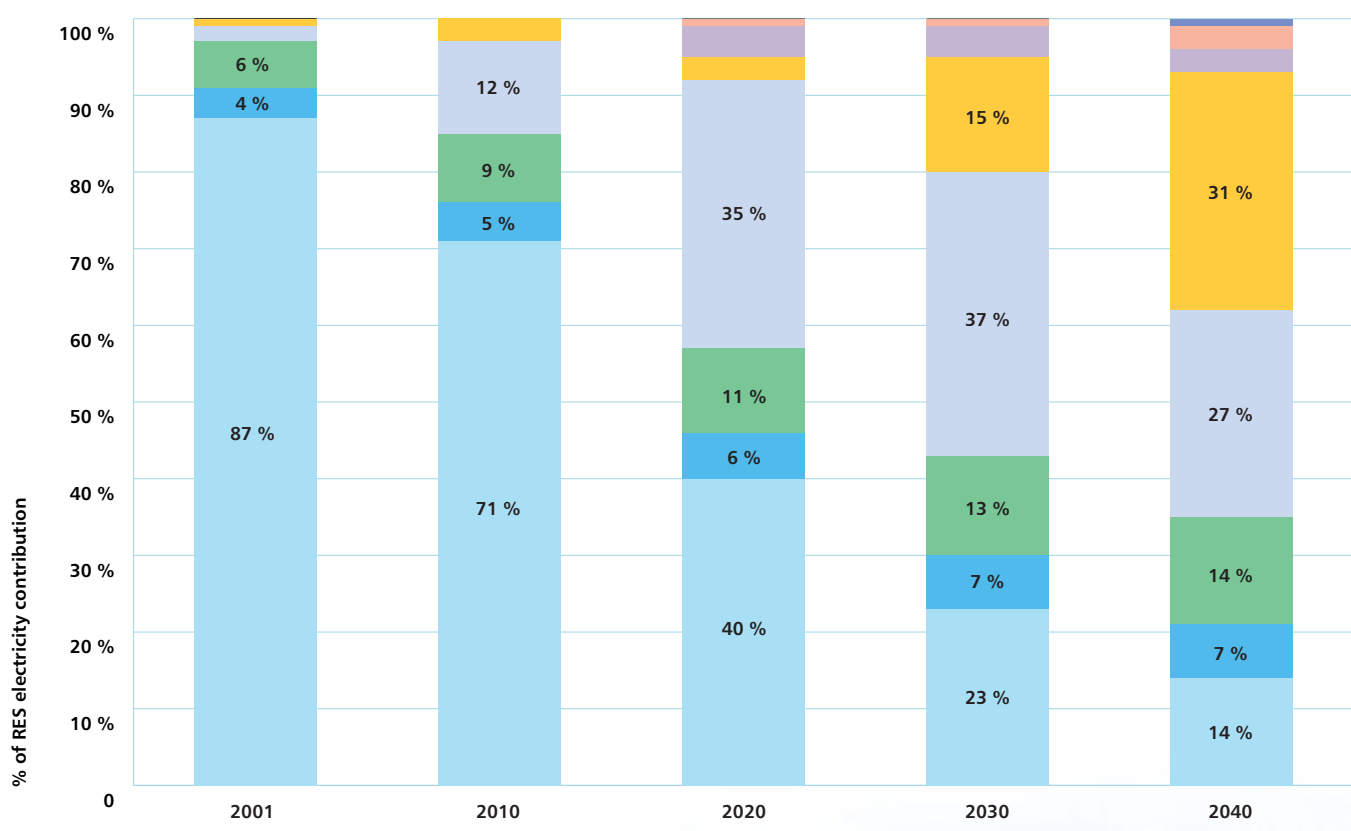
Therefore the assumptions for electricity supply of renewables by 2040 are that renewables will

contribute more than 80 % to the total global electricity supply in 2040.



In the electricity supply, the share of large hydro in terms of percentage will significantly decrease, because there is no major growth expected. From its current status as the number one renewable electricity supply,

it will only be in fourth place in 2040. Conversely, PV will then be the largest renewable electricity source with a production of more than 9000 TWh, followed by wind and biomass.



- RES Contribution
- Conventional
- Biomass
- PV
- Wind
- Geothermal
- Solar thermal
- Large hydro
- Small hydro
- Solar thermal electricity
- Marine (tidal/wave/ocean)

This graph shows that the mix of renewable energy sources is changing during the years in terms of percentage. In total numbers, all renewable energy sources will have a greater contribution to electricity supply than now. It is important to note, that a well-balanced mix of the different renewable energy sources will be the key solution for a carbon-free energy supply.

Necessary Policy Measures

To make this scenario - an ambitious, but feasible projection - become reality advanced policy measures have to be adopted globally. Governments from all over the world need to implement necessary minimum policy measures to guarantee the further deployment of renewable energy technologies and additional commitments on the international level have to be made.

Minimum requirements are as follows :

Establishment of legally binding RES targets

The states that are currently actively promoting renewable energy sources should set up legally binding targets for renewable energy sources in their governing areas. The mandatory targets can also be complemented by financial incentives in the respective countries. This too, would be an effective policy to address security of supply, technology development, employment and climate objectives.

Awareness of RES

Many decision-makers and politicians are not aware of the many results that can be derived from renewables. Therefore, information campaigns are necessary as a tool to provide first-hand information and increase awareness towards the advantages of RES in the climate change debate. Additionally, governments should be informed how RES projects can help them to reach their binding targets of CO₂ reductions under Kyoto.

More emphasis on RES projects in development policy

In the current development policy, the developing countries' governments put little emphasis on RES. One of the main aims should be to create sustainable development in developing countries: access to energy in order to fight the vicious circle of poverty, which 2 billion people are still in at the

moment, and to foster economic development without this putting pressure on the environmental equilibrium. The target can only be achieved with the use of renewable energy sources.

Support from International Financial Institutions

A special focus needs to be set on financial institutions, such as the World Bank. Financial resources should be mobilised to help developing countries carry out their obligations in the field of sustainable development. Funds (small- and medium-sized funds) should be provided for projects in the field of renewable energy sources. A significant part of financial institutions' resources should go to the funding of RES projects for climate change purposes.

Change of subsidies-policy

The social and environmental costs of polluting energy are not internalised in current prices of conventional energy. A lot of countries worldwide pay (direct or indirect) subsidies to conventional energy. If this kind of policy is changed, renewable energy sources will be even more competitive.

Research and Development

The direct public spending on research and development in the energy sector in the industrialized countries should be increased significantly. A shift for energy research and development priorities should be reached rapidly away from fossil energy and energy from nuclear fission towards renewables and energy efficiency.

Ratification of Kyoto-Protocol

All efforts should be made to ratify the Kyoto-Protocol and set targets for the period after 2012. After having the Kyoto protocol in place, additional measures and targets for reducing greenhouse gases need to be set. Renewable energy should be set as a priority for all CDM projects.

“Necessary
Policy
Measures”

The dynamic current policies scenario (DCP)

If the necessary policy measures to make the advanced international policies scenario become feasible are not going to be adopted on the international level and the current policies are continuing as described in the CIP outline (page 4), the assumptions for future renewable energy supply are significantly different.

For all technologies the overall growth rates will be lower than in the advanced policies scenario and the total consumption will be higher. For some technologies such as wind and PV, the growth rates in the first two decades especially are lower, after that time the growth could be even higher than in the advanced international policies scenario, but then starting from a lower point.

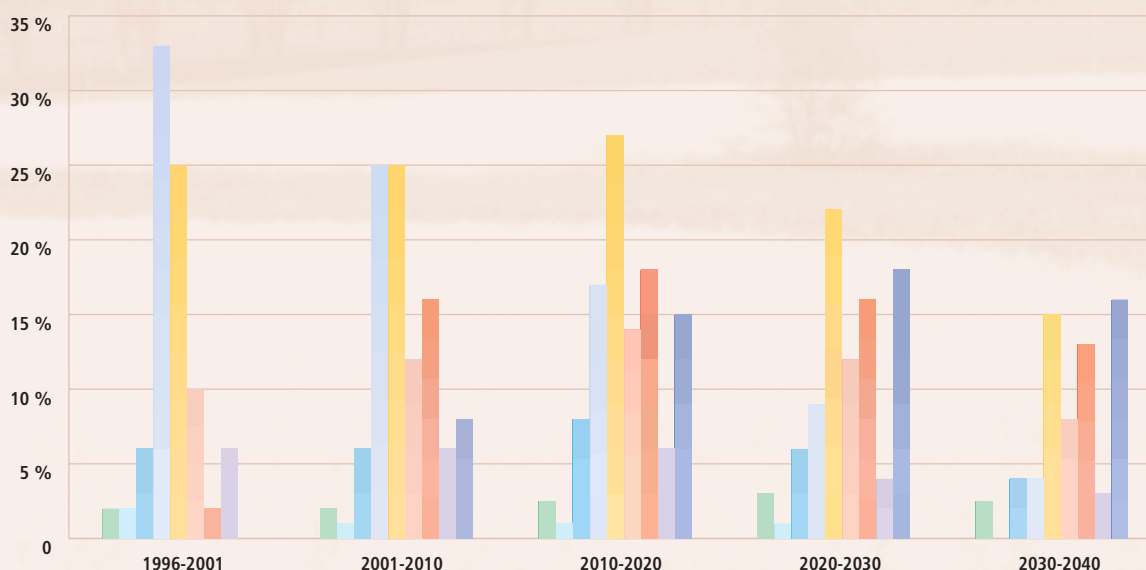
The assumptions for the different technologies are as follows :

	1996-2001	2001-2010	2010-2020	2020-2030	2030-2040
Biomass	2%	2%	2.5%	3%	2.5%
Large hydro	2%	1%	1%	1%	0%
Small hydro	6%	6%	8%	6%	4%
Wind	33%	25%	17%	9%	4%
PV	25%	25%	27%	22%	15%
Solar thermal	10%	12%	14%	12%	8%
Solar thermal electricity	2%	16%	18%	16%	13%
Geothermal	6%	6%	6%	4%	3%
Marine (tidal/wave/ocean)	-	8%	15%	18%	16%

Growth rates for the different technologies after the current international policies scenario

Graphical overview of the expected growth rates in the dynamic current policies scenario compared to the advanced international policies scenario :

Dynamic current policies scenario



Growth rates for the different technologies after the dynamic current policies scenario

The contribution of Renewable Energy Sources to the world energy supply in 2040 - Projections in Mtoe - Dynamic Current Policy scenario

If no further significant international policy measures for the promotion of renewables and tackling climate change and poverty alleviation via renew-

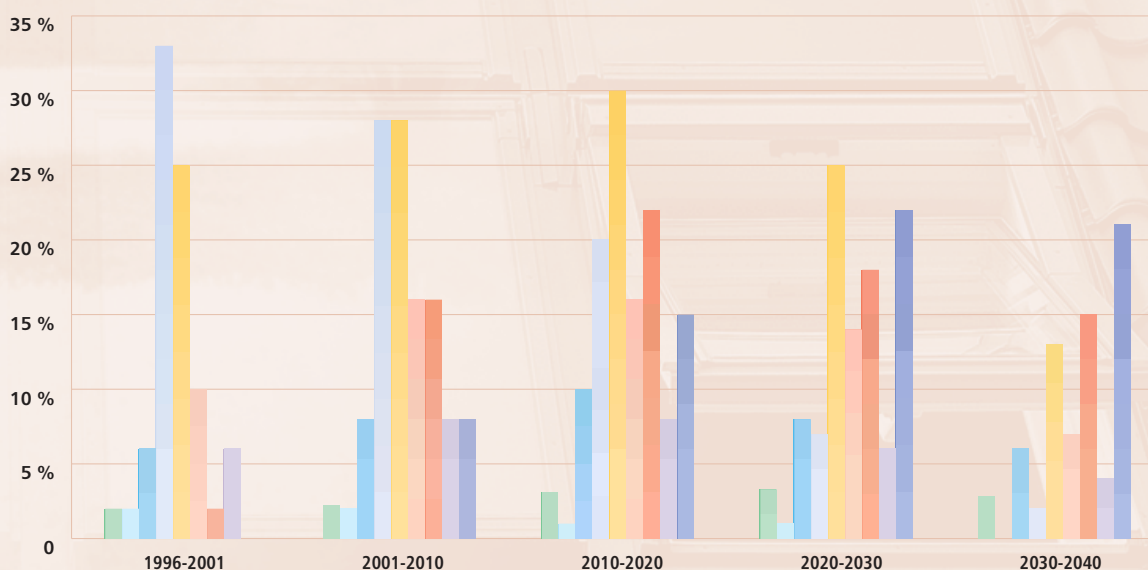
ables are taken, the assumptions are, that by 2040 around 27 % of global energy consumption will be supplied by renewable energy sources.

	2001	2010	2020	2030	2040
World Primary Energy Consumption (Mtoe)	10038,3	11752	13553	15547	17690
Biomass	1080	1291	1653	2221	2843
Large Hydro	222,7	255	281	296	308
Small Hydro	9,5	16	34	62	91
Wind	4,7	35	167	395	584
PV	0,2	1	15	110	445
Solar Thermal	4,1	11	41	127	274
Solar Thermal Power	0,1	0,4	2	9	29
Geothermal	43,2	73	131	194	261
Marine (tidal/wave/ocean)	0,05	0,1	0,4	2	9
TOTAL RES	1364,5	1682,5	2324,4	3416	4844
RES Contribution	13,6%	14,3%	17,1%	22,0%	27,4%

As explained, there are serious and significant reasons to shift to RES as soon as possible. To

make the advance scenario come true, with all its benefits - global effort should be taken.

Advanced international policies scenario



Growth rates for the different technologies after the advanced international policies scenario.





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EREC - European Renewable Energy Council

EREC - the European Renewable Energy Council - is the umbrella association of the leading European renewable energy industry, trade and research associations active in the field of photovoltaics, small hydropower, solar thermal, biomass, wind and geothermal energy.

EREC's members

- EPIA** - European Photovoltaic Industry Association
- ESHA** - European Small Hydropower Association
- ESTIF** - European Solar Thermal Industry Federation
- EUBIA** - European Biomass Industry Association
- EWEA** - European Wind Energy Association
- EUREC Agency** - European Renewable Energy Research Centres

And associate members

- AEBIOM** - European Biomass Association
- EGEC** - European Geothermal Energy Council

The Renewable Energy House

EREC shares its office with several of its members associations in the Renewable Energy House, the central meeting point for renewable energy actors in the political heart of Europe.



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RESCENARIO TO 2040