ENERGYWATCHGROUP

Supported by Ludwig Bölkow Stiftung

Renewable Energy Outlook 2030

Energy Watch Group Global Renewable Energy Scenarios

Short Version – The Global Picture

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About Energy Watch Group

Energy policy needs objective information.

The Energy Watch Group is an international network of scientists and parliamentarians. The supporting organization is the Ludwig-Bölkow-Foundation. In this project scientists are working on studies independently of government and company interests concerning

- the shortage of fossil and nuclear energy resources,
- development scenarios for regenerative energy sources

as well as

- strategic deriving from these for a long-term secure energy supply at affordable prices.

The scientists are therefore collecting and analysing not only ecological but above all economical and technological connections. The results of these studies are to be presented not only to experts but also to the politically interested public.

Objective information needs independent financing.

A bigger part of the work in the network is done unsalaried. Furthermore the Energy Watch Group is financed by donations, which go to the Ludwig-Boelkow-Foundation for this purpose.

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Content

Executive Summary

The objective of this study is to present an alternative and - from our point of view - more realistic view of the chances of the future uses of renewable energies in the global energy supply. The scenarios in this study are based on the analysis of the development and market penetration of renewable energy technologies in different regions in the last few decades. The scenarios address the question of how fast renewable technologies might be implemented on a worldwide scale and project the costs this would incur. Many factors, such as technology costs and cost-reduction ratios, investments and varying economic conditions in the world's regions, available potentials, and characteristics of growth have been incorporated in order to fulfil this task.

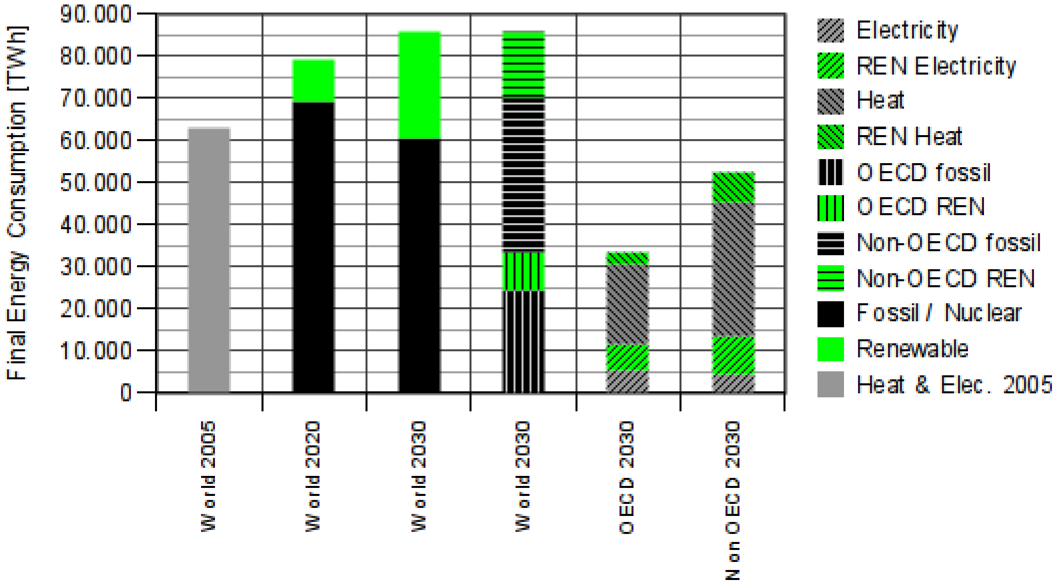
The scenarios describe only two possible developments among a range of prospects, but they represent realistic possibilities that give reason for optimism. The results of both scenarios show that – until 2030 – renewable capacities can be extended by a far greater amount and that it is actually much cheaper than most scientist and laypeople think. The scenarios do explicitly not describe a maximum possible development from the technological perspective but show that much can be achieved with even moderate investments. The scenarios do not pay attention to the further development of Hydropower, except for incorporating the extensions that are planned actually. This is not done to express our disbelief in the existence of additional potentials or to ignore Hydropower, but due to the fact that reliable data about sustainable Hydropower potentials were not available. Consequently, the figures in this study show how much can be achieved, even if Hydropower remains on today's levels more or less. Higher investments into single technologies,e.g. Hydropower or Biomass, or in general than assumed in the "REO 2030" scenarios will result in higher generating capacities by 2030.

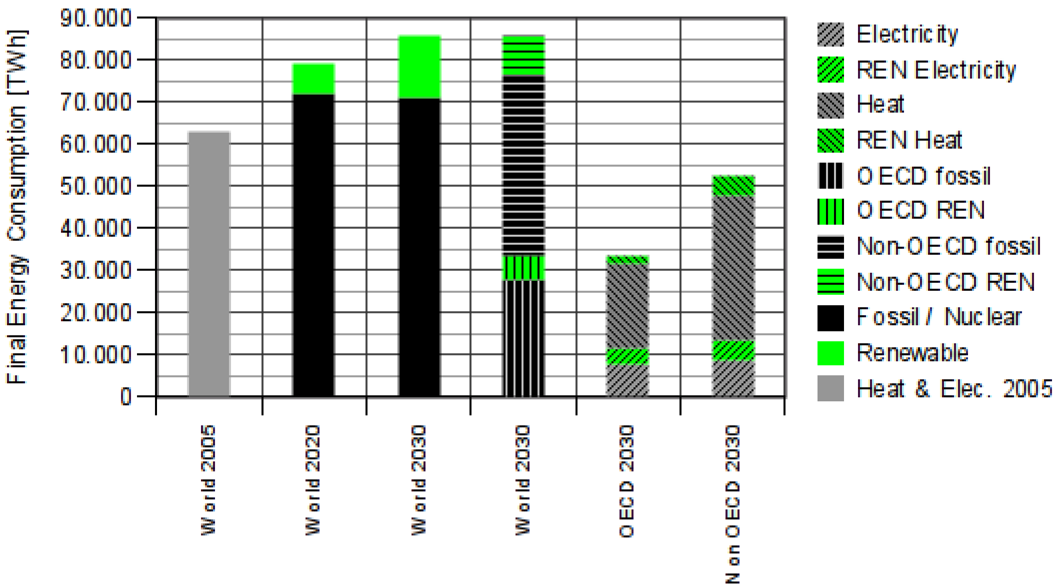
On the global scale, scenario results for 2030 show a 29% renewable supply of the heat and electricity (final energy demand) in the "High Variant". According to the "Low Variant", over 17% of the final electricity and heat demand can be covered by renewable energy technologies.

Presuming strong political support and a barrier-free market entrance, the dominating stimulus for extending the generation capacities of renewable technologies is the amount of money invested. Within the REO scenarios we assume a growing *"willingness to pay"* for a clean, secure, and sustainable energy supply starting with a low amount in 2010. This willingness to pay is expressed as a target level for annual investments per inhabitant (capita) that will be reached by the year 2030. The targeted amounts differ for the various regions of the world (see Table 1). On a global average 124 $€_{2006}$ are to be spent in 2030 per capita in the "High Variant". In the "Low Variant" the target for 2030 is half that amount (62 $€_{2006}$ per capita and year).

This scenario approach requires considering the reduction of technology costs due to the growing market and the capability of industry to learn. To achieve this, cost-progression ratios for each technology, calculated from the total amount of investments into a specific technology and the resulting development of production volumes, are considered in the scenarios.

The scenarios primarily address the development of the electricity capacities, heat supplied by renewable energies is only partially analysed. Fuels are not part of the study.





The first bar shows the final energy demand in 2005 (grey), without breakdown to fossil or renewable sources. Bars 2 an d 3 show the development of final energy demand up to 2030, the renewables contribution (always green) according to the scenarios and the fossil & nuclear contribution (always black or grey). The remaining bars provide more details on the figure for 2030. Bar 4 shows the values for OECD (vertically hatched, black is fossil, green is renewable) and non-OECD (horizontally hatched). Bars 5 and 6 show details for OECD (bar 5) and non-OECD (bar 6), broken down to electricity (hatched lower left to upper right) and heat (hatched upper left to lower right). Again renewewables are green but fossils are grey this time.

Figure 1: Final electricity and heat demand and renewable shares in 2030 in the "High Variant" (upper figure) and the "Low Variant" scenario (lower figure) [EWG; 2008]. Final Energy Demand: [IEA; 2006]

The future energy demand is taken from the “Alternative Policy Scenario” of the IEA's Study ”World Energy Outlook 2006” (WEO 2006).[1]

The OECD region will be able to cover more than 54% of its electricity and more than 13% of heat requirements from renewables in 2030, totalling a final energy share of 27% (low variant: almost 17%). In the non-OECD region, the share of renewables rises to 30% in the “High Variant” (“Low Variant” 18%). Increases due to renewables account for almost 68% in regard to electricity, while renewable heat contributes about 17% of final heat demand (“Low variant”: 36% of electricity and 11% of heat).

The scenarios show that renewable energy technologies have huge potential to help in solving the climate change problem, lowering dependence on fossil fuels, and making it possible to phase out nuclear energies. In both scenarios, the contribution of fossil and nuclear technologies increases until 2020. By that time, energy production by fossil and nuclear fuels exceeds the total final energy demand that existed in 2005. In the “Low-variant scenario”, this figure is only somewhat lower again in 2030. Looking at the “High-variant scenario”, the drop after 2020 is remarkable: in 2030 fossil and nuclear technologies have to contribute less to energy supply than the total level of energy demand in 2005.

World Region	Investment per capita per year in 2030 [€2006/cap*a]		Total investment budgets in 2030 [billion €2006]	
	Low Variant	High Variant	Low Variant	High Variant
OECD Europe	111	223	60	121
OECD North America	110	220	59	118
OECD Pacific	112	224	22	44
Transition Economies	91	180	31	60
China	102	204	149	299
East Asia	41	81	33	66
South Asia	35	71	73	147
Latin America	46	91	26	52
Africa	20	41	30	59
Middle East	101	202	28	55
Global Scale	**62**	**124**	**510**	**1021**

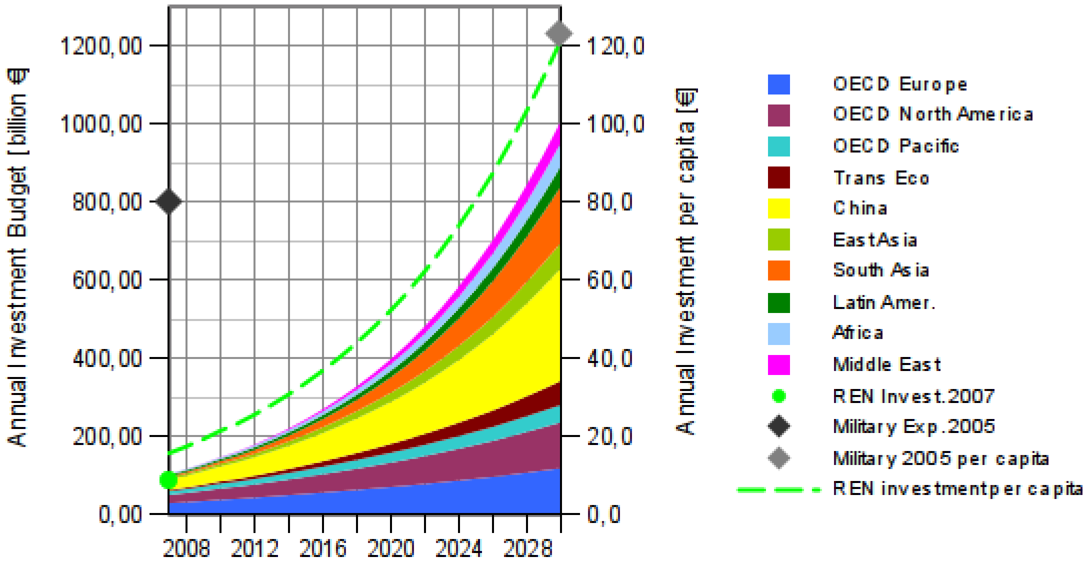
Table 1: Target investment 2030 per capita per year in various regions considered in the scenarios. All regions start with a low amount in 2010. [EWG; 2008]

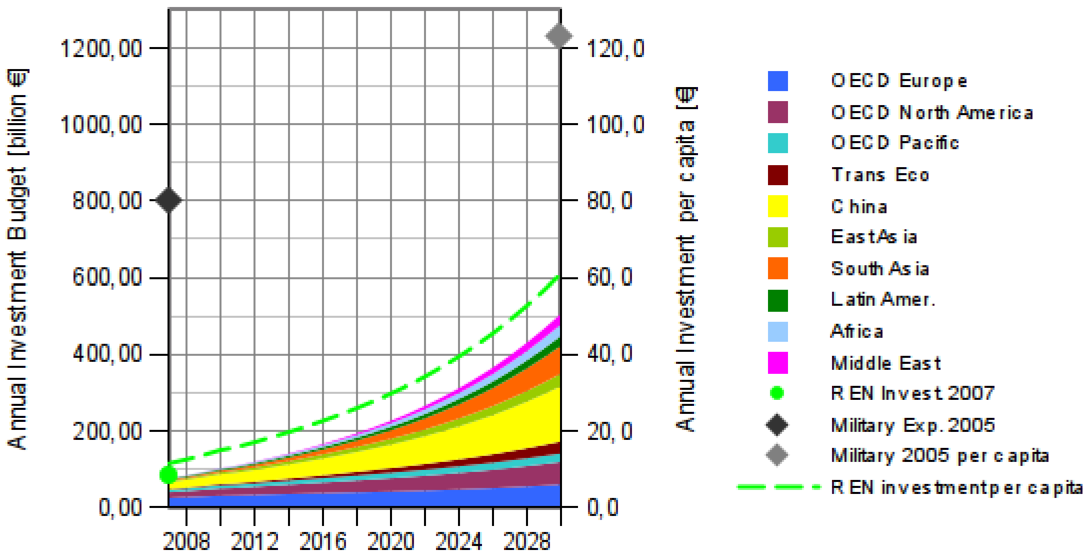
Absolute investments in 2030 are approximately 510 billion $€_{2006}$ in the ”Low Variant Scenario” and about 1,021 billion $€_{2006}$ in the ”High Variant”. The biggest single investor in both scenarios is China, followed by South Asia – both regions having a high percentage of the world population – and OECD Europe, which is less populated but shows considerably higher

1 Although an updated WEO appeared in 2007, the team continued to refer to the WEO 2006 data because differences in the development of energy demand portrayed in the two publications are only marginal. Global primary energy supply (PES) projections in the “Alternative Policy Scenario” differ by about 1.6% when comparing WEO 2006 and WEO 2007.

spendings per inhabitant in 2030. OECD Pacific has the lowest investment figure, behind Africa, the Middle East, and Latin America.

Investment sums of the dimension given here tend to be somewhat abstract and quickly appear to present an insurmountable barrier. To provide a better feeling for what such investment figures really mean with regard to today's real world, Figure 2 compares the renewable investments of this study to the global military expenditures in 2005 [SIPRI; 2006]. Only the ”High Variant” shows renewable per capita investments coming close to the military expenditures of 2005. Another illustrative comparison is the amount of money spent by each German in 2005 for culture-related activities - on the magnitude of 100€ annually [DESTATIS; 2008].





Coloured areas and markers on the left ordinate (Y-axis) show the absolute annual investments, while the dotted line and markers on the right ordinate show annual investments per capita as global average.

Figure 2: Development of investment budgets in the world regions in the "High Variant" (upper figure) and "Low Variant Scenario" (lower figure) [EWG; 2008]. Data on military expenditures: [SIPRI; 2006]. Data on REN investment 2007 [UPI; 2008].

According to an article published by United Press International in February 2008, the global investments in the renewable energy sector in 2007 (green dot in Figure 2) were about 117 billion US$, or 84 billion €; a figure closely approximates the investments in the "Low Variant Scenario".

The difference in the development of installed renewable generating capacities in both scenarios is even greater than the difference in investment budgets. With about 4,450 GW of "new" renewable electricity generating capacity in 2030, the "High Variant Scenario" is much more than double the capacity reached in the "Low Variant Scenario" (1,840 GW)[2].

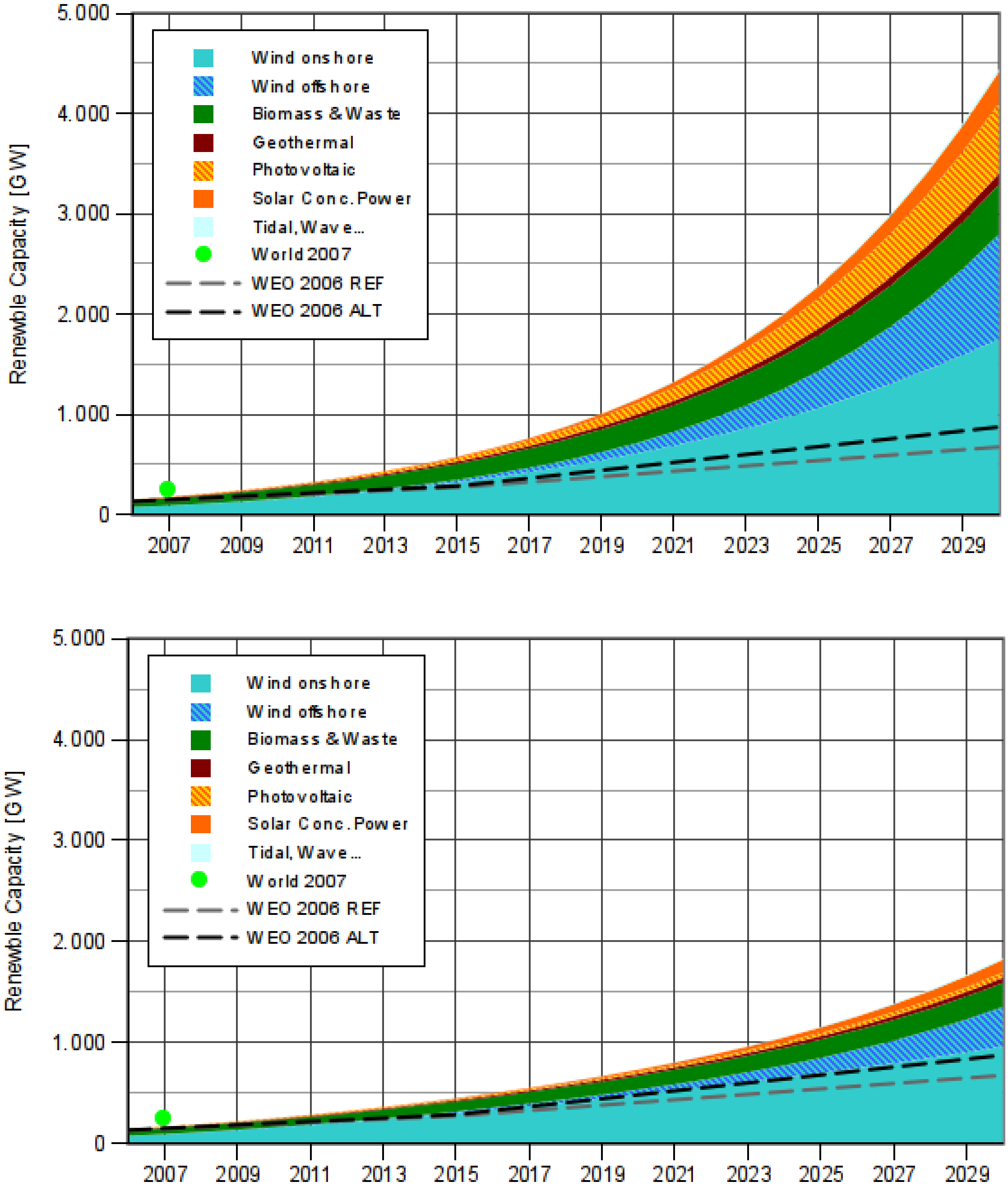


Figure 3: Development of "new" renewable electricity generating capacities in the world regions in the "High Variant" (upper figure) and "Low Variant Scenario" (lower figure) [EWG; 2008].Data on renewable capacity 2007: [REN 21; 2007].

2 Hydropower is not part of capacity extensions in the scenarios as there is no clear figure of the sustainable potential for the further increase in hydropower capacities.

The vast majority of the generating capacity in 2030 in both scenarios is onshore and offshore Wind Energy. Technologies in general develop much better in the ”High Variant Scenario”, but Photovoltaic can be seen as the big winner when the two scenarios are compared. PV, in fourth place in the ”Low Variant”, is the second-biggest contributor in the ”High Variant” (2030). Biomass & Waste follows in third place (second in the ”Low Variant”). Minor contributions come from Geothermal Power and Tidal, Wave and other Maritimes (“Tidal, Wave...” in Figure 3).

The scenarios deal with the extension of “new” renewables, i.e. hydropower is not part of the investment-budgets in the scenarios, but planned extensions of hydropower capacities (from about 762 GW today to about 856 GW in 2030) are considered because hydropower is the most important component of renewable electricity supply today and will still be important in 2030. Be that as it may, Hydropower loses its predominant role in both scenarios.

Electricity generation from “new” renewables increases with growing capacities. Starting with about 3,300 TWh in 2005, electricity generation increases to about 8,600 TWh in the “Low” and to about 15,200 TWh in the ”High Variant Scenario” (see bars in Figure 4).

Most of the “new” renewables production comes from Wind Energy, but the production share is not as high as the share in capacities[3]. Nevertheless, in 2030 electricity production from Wind Energy comes close to Hydropower in the ”Low Variant”. In the ”High Variant” Wind Energy outpaces Hydropower by about 2,000 TWh. The second-biggest source among the “new” renewables is Biomass & Waste, followed by Geothermal and Solar Concentrating Power.

For a better comparison of what the scenarios mean with regard to the WEO 2006 “Alternative Energy Scenario”, the development of renewables in this scenario is represented by marked lines and transparent areas. It is easy to see that the WEO 2006 assumes a far greater extension of Hydropower capacities (purple markers and area in Figure 4), but the development of “new” renewables (green markers and area stacked onto Hydropower) definitely even falls behind the development in the “Low Variant Scenario”.

3 This was to be expected, as wind energy (and also PV) depends on climate conditions and potentially is not as productive as Biomass or Geothermal power.

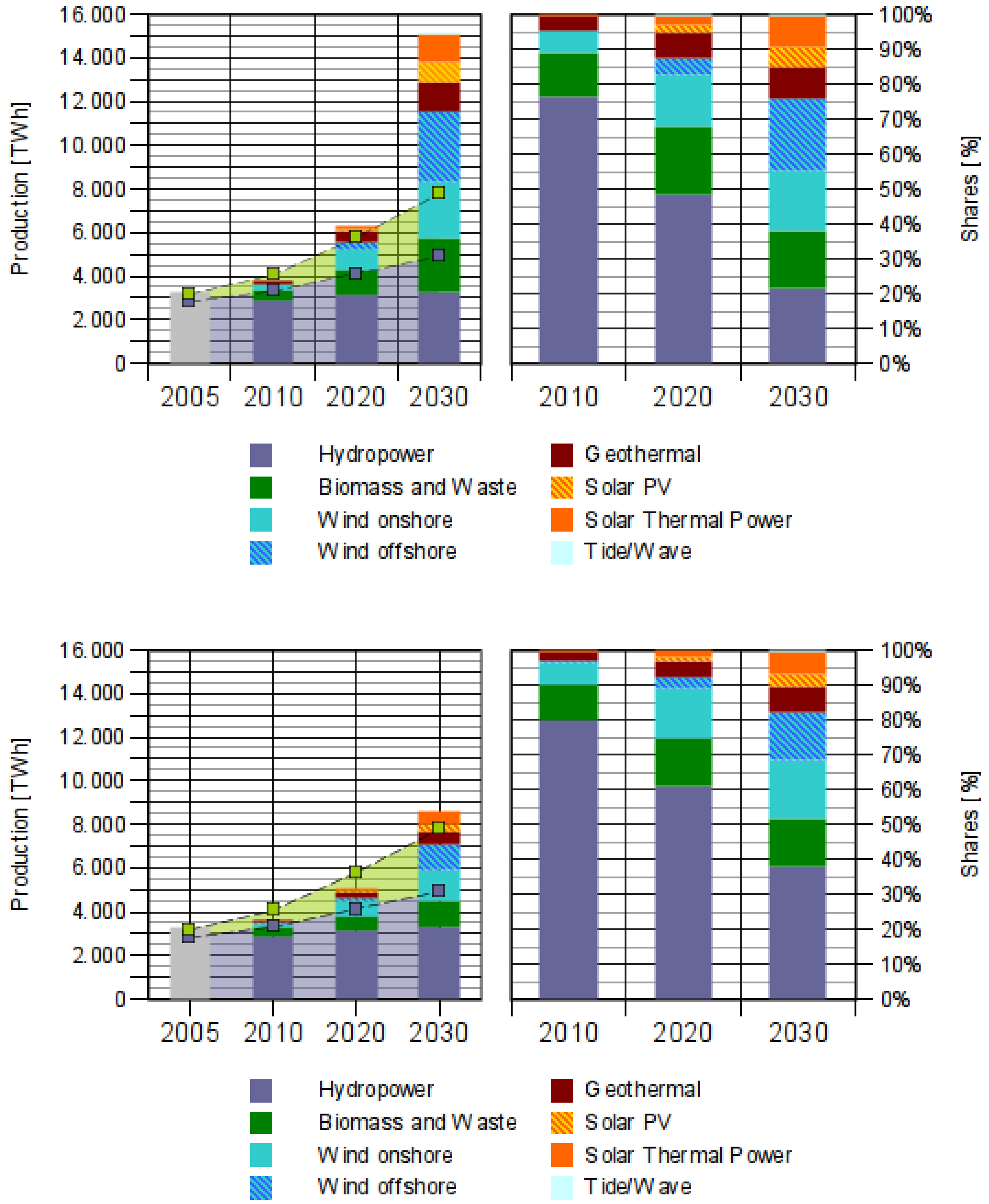


Figure 4: Development of electricity production from renewables in the "High Variant" (upper figure) and the "Low Variant Scenario" (lower figure), 2010 to 2030 [EWG; 2007]. Data 2005: [IEA; 2007b]

So far, only the electricity sector has been described, but heat supply also forms part of the scenarios. On one side, heat comes from cogeneration. Half of the Biomass & Waste and half of the Geothermal plants in the scenarios are cogeneration plants, producing heat and electricity simultaneously. Another heat producer in the scenarios is the solar thermal collectors, which account for a considerable percentage of investments in both scenarios. In fact, there is a bigger focus on solar thermal collectors in the ”Low Variant” than in the ”High Variant”. The reason for this is that solar thermal collectors are comparably cheap, and the ”Low Variant” has to get by with substantially lower investments.

The capacity of solar thermal collectors increases from 137 GW (2006) to almost 2,900 GW (2030) in the ”Low Variant”. The ”High Variant” shows an increase to about 3,800 GW. The difference between Biomass & Waste and Geothermal heat capacities in the two scenarios is proportional to the differences in electricity capacities, thus both are far lower in the ”Low Variant”.

Coming to final energy supply, about 30% of the final electricity and heat stem from renewable sources in the ”High Variant”. Consequently the percentage of renewables in the ”Low Variant” is less (more than 17 %).

Generally, renewables' share in electricity is considerably higher than in heat. Comparing the figures for 2030, renewable energy technologies contribute about 62% to final electricity and about 16% to final heat in the ”High Variant”. The related figures in the ”Low Variant” scenario are 35% of final electricity and 10 % of final heat originating from renewables.

Coming to a conclusion, both scenarios show an extension of renewable generating capacities that is far greater than the picture drawn even in the IEA's WEO 2006 “Alternative Policy Scenario”[4]. Necessary investments into renewable generating capacities – often seen as the predominant problem – are relatively low, not only in the face of ongoing and accelerating climate change, but also in comparison to today's investment figures in other sectors. To achieve a level of development as described in the “High Variant Scenario”, it would be sufficient to raise investments in renewable generating capacities to 124€$_{2006}$ per capita of the world's population until 2030; a per-capita investment the world has already seen for military expenditures in 2005. Half of this investment target would be sufficient for a development like in the “Low Variant Scenario”.

It took a long time to get scientific research focused on renewables and even more time was spent before renewable technologies could successfully be introduced into markets (e.g. in Europe). Once this happened and effective support mechanisms were implemented, such as the German EEG (Renewable Energy Law) with the feed-in tariff structure, renewables – and

4 From the pure technological perspective (technological development, possible increase in production capacities) a much higher growth could have been justified.

initially Wind Energy in particular – displayed dynamic development and increasingly became a “normal” part of thinking when dealing with the future energy supply.

A great deal of time was lost struggling over the reasons for climate change and the question of whether fossil energy resources would become scarce - and if so, when - before we recognised that the time to change our use patterns and supply of energy is **now**, is a task of **today's** generation. Starting sooner would of course have been more favourable. However, considering the relatively low investment figure and an almost 30% share of final energy demand, and that 62% of global electricity can be supplied by renewable technologies by 2030, there is reason for being optimistic that hummankind can come to grips with the problems of climate change and the reality of steadily depleting fossil energy sources.

Following a path of development as described in the “High Variant Scenario” would offer a substantial opportunity to reduce fossil and nuclear capacities in the global energy supply. Although the energy supply will require a striking amount of oil to fulfil energy demand until at least 2030, the problem of being strictly dependent on oil can be partially solved by a massive extension of renewables.

It is our strong conviction that nuclear power will not be needed if we undertake the types of development as proposed here. Furhtermore, we contend that there is no necessity to build new nuclear power plants, as proposed by the IEA, or to prolong the lifetime of existing ones. Using nuclear power, with all the associated problems (proliferation-prone nuclear material, final disposal of nuclear waste, severe accidents in nuclear power plants) can be discontinued - and this must take place as soon as possible. Instead of financing new nuclear plants, which definitely cannot provide a sustainable solution to our energy problems, this money should be invested in renewable technologies, which offer the only known sustainable solution to the world's energy-supply problems.

Although the scenarios demonstrate how renewable shares in energy supply can be increased significantly, they should also turn our attention to energy demand and its future development. In this study, we have referred strictly to the energy demand figures given in the IEA's World Energy Outlook 2006 “Alternative Policy Scenario”. As a result, even in the “High Variant Scenario”, the contribution of non-renewable sources to final energy supply in 2030 is almost as high as the total final energy demand was in 2005. This demonstrates impressively that we will also have to tackle energy consumption with the same level of effort we spend on the supply side. It might be questioned whether the IEA's demand projections are encouraging enough to deliver a perspective for solving the energy problems with which we will be confronted in the future. It is quite clear that there are huge potentials for energy savings, especially in the field of heat consumption, and that we will have to tap these potentials. This, however, is an issue to be addressed in future work.

Introduction

The objective of developing the scenarios of this study is to present an alternative to the prevailing thinking - which we find flawed - and a more realistic view of the role energies can play in a future global energy supply. Some of the latest global and regional scenarios do not really show the potentials renewable energy technologies have in the near future. The scenarios in this study are based on the analysis of the development and market penetration renewables have showed in different regions in recent decades. The scenarios illustrate that renewable energy technologies have huge potential to help to solve the climate change problem and to lower the dependence on fossil and nuclear energies.

With the release of the recent IPCC climate study at the very latest, there can no longer be any legitimate doubt that human activity is having a decisive influence on the changes in climate currently being observed worldwide. The possible magnitude of these climate changes appear set to reach levels that threaten our economies, the stability of ecosystems and, hence, sustainable development. Recently, Nicholas Stern, former chief economist of the World Bank, has drawn attention to the economic aspects of climate change, many of which have generally gone unnoticed though, in fact, they have already been commented upon in publications. According to Stern's analysis, climate change could cause a decrease in global GDP by at least 10%, and - in the worst case - even by 20%.

To avoid an increase in the average global temperature that exceeds a tolerable limit of 1.5 to 2°C, the atmospheric concentration of greenhouse gases (GHG) must be stabilised at a level of about 420 ppm (parts per million) of CO2 equivalents in this century.

This stabilisation can only be achieved if global greenhouse gas (GHG) emissions are reduced to less than half of current levels by the middle of this century. As today's developed countries are the predominant contributors to global GHG emissions, they have to commit themselves to making the first moves toward a clean energy supply and concurrently to reducing their GHG emission by 80% within the same time frame. Developed countries, among them the Member States of the European Union, must provide intermediate targets to keep this process revisable, transparent, and convincing to others, and will have to assist less-developed countries in ensuring a clean and secure energy supply.

The serious consequences of using fossil fuels, the risks of nuclear energy, and the foreseeable end of cheap fossil and nuclear fuels[5] show us that the use of these technologies must be discontinued. With regard to nuclear fusion, this technology has so far not functioned, and even if it did, it would involve the production of radioactive waste.

5 Additional EWG Publications on these issue can be found at: www.energywatchgroup.org/Studien.24+M5d637b1e38d.0.html

Over the medium and long terms, a sustainable energy system can only be supplied by renewable sources. Although the amount of energy offered by renewable sources exceeds the global energy demand by far, the expense to install the technical equipment in order to utilise these renewable sources should be kept at a minimum. This entails energy having to be used as efficiently as possible, i.e. renewable supply and energy-efficient technologies have to be combined.

One of the most common questions regarding the establishment of a renewable energy supply is related to the time necessary to realise such a system. Some scenarios have already addressed this question on a regional level[6]. The scenarios in this study deal with the questions of how fast renewable technologies might be implemented on a worldwide scale and the level of costs this magnitude of development would result in.

Addressing these questions cannot be separated from the questions of how, how fast, and to what extent greenhouse gas emissions can be reduced. Although it is quite clear that renewable technologies and energy efficiency will be the major keys in reducing greenhouse-gas emissions, clarifying the required time and costs makes the effort humanity has to make more apparent and more transparent. Last but not least, the outcome of the scenarios will also help in defining goals for the reduction of greenhouse-gas emissions.

6 e.g. German Parliaments Enquete Commission on sustainable energy supply [Enquete-Kommission; 2002], Solar Catalonia - A Pathway to a 100% Renewable Energy System for Catalonia [Peter et al.; 2006], Study on fossil plant substitution by renewables [Peter/Lehmann; 2005], Long Term Integration of Renewable Energy Sources into the European Energy System [LTI; 1998], Long Term Scenarios for the Sustainable Use of Energy in Germany[DLR/WI; 2002]

Methodology

We were asked to calculate the possible increase in renewable energy capacities assuming a hindrance-free development. This means that the “Renewable Energy Outlook 2030” (REO 2030) scenarios presume a strong support framework for renewables (political, financial, and administrative) to avoid further delays in market introduction and penetration.

The REO scenarios consider ten world regions, which are the same as in IEA's “World Energy Outlook 2006” (WEO 2006). This was not done arbitrarily: this approach helps in that it enables the comparison of the results of these scenarios with the “World Energy Outlook” scenarios and other scenarios.

Assuming strong political support and barrier-free market entrance, the dominating stimulus for extending the generation capacities of renewable technologies is the amount of money invested. Within the REO scenarios, we assume a *willingness to pay* for a clean, secure, and sustainable energy supply. This assumed willingness to pay is expressed as a target level for annual payments per capita that - after a period of continuously growing investments in renewable energies - will be reached by the year 2030. As incorporating estimations regarding inflation was viewed as adding unnecessary uncertainty to our results, all prices in this report are expressed on the basis of figures for the year 2006.

Because all investments in energy supply will have to be paid by the energy consumers in the end, the extension of renewable energies will impose a financial burden on societies[7]. Although a growing acceptance of and support for a clean energy supply by societies is assumed in this work, the Energy Watch Group respects the fact that that overextending financial burdens might negatively impact societies’ attitude towards renewable energy support. This would be likely to have knock-on negative effects on the investors’ trust in the continuity of political support for renewable energy, *ceteris paribus*.

The annual payments, starting in 2010 with a low amount of capital and reaching a defined amount of investment in 2030, are divided into two fractions called “basic investment” and “advancement investment”. “Basic investment” ensures the necessary technological diversification of renewable energy technologies; “advancement investment” makes it possible to adapt development to existing potentials within the regions.

In this study, we calculate two “REO 2030” scenarios, which differ in terms of their assumed acceptance, thus reflecting a low societal acceptance on one side and a high one on the other. Consequently, there is a “low variant” scenario, assuming lower investment budgets, and a “high variant” scenario with substantially higher expected investments in renewable technologies.

7 This is also true for conventional power supply, e.g. costs for erecting conventional power plants, maintenance, or the renewal of the power plant pool.

General Calculation Approach

In both scenarios, the total quantity of installed renewable energy technologies depends on the development of specific technology costs and total investment budgets (increasing towards 2030). There is a close relation between specific technology costs and the development of installed capacities. While specific technology costs determine the capacity that can be purchased for a specific amount of money, there is a strong interrelation between market development and specific costs, as product prices decrease with increasing production rates. To solve this problem, we selected an iterative process to calculate the interacting curves of future cost development and installed generating capacities.

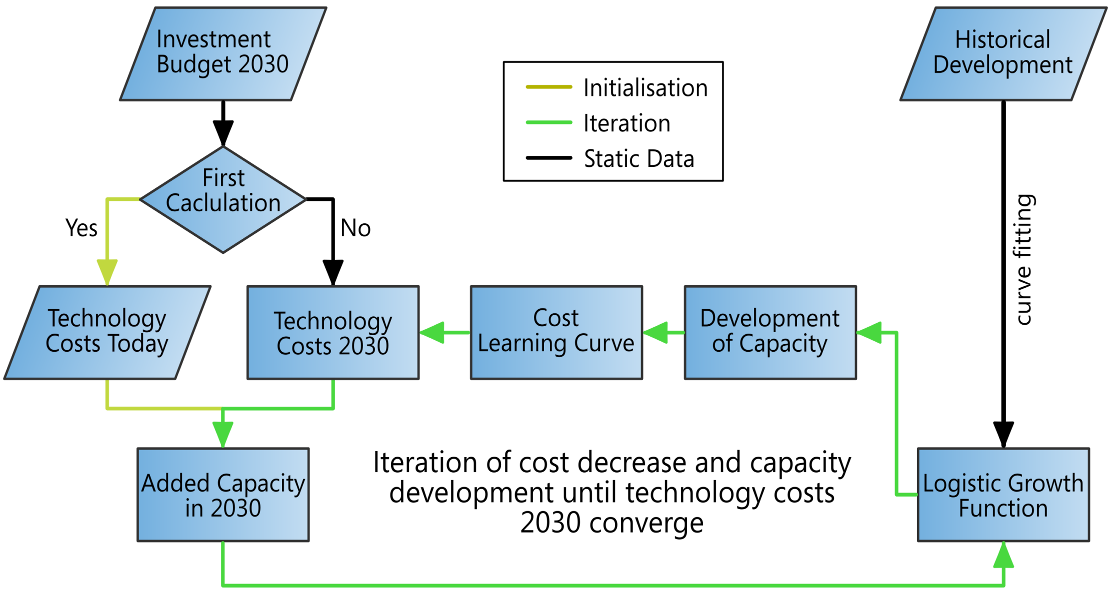


Figure 5: Flow chart of the scenario development process with iteration of technology costs and added capacities in 2030. [S. Peter, H. Lehmann; 2007]

In the scenarios, both investment budgets and specific technology costs determine the generating capacities that can be added annually up to 2030, thus providing a target mark for the development of installed capacities until that year. This is, in a first run, done using today's technology costs for the whole period up to 2030. The resulting development of the total capacities installed worldwide afterwards is used to generate technology-specific "learning-curves" for cost digression. The next run uses these decreased technology costs to recalculate installed generating capacities – with the corrected capacities-technology costs recalculated, and so forth. The execution of this calculation loop stops if technology costs for 2030 converge. The picture above (Figure 5) gives an overview of the scenario-development process.[8]

8 For more details see "Details on mapping technological and cost development" in the Annex

In the strict sense, this makes the scenario development a mixture of financial and technologically driven factors, as the fixed investment budgets in 2030 determine the preceding development in terms of installed capacities and thus the decrease of specific technology costs.

The scenarios do explicitly not describe a maximum possible development, neither from a technological nor from a financial perspective. The scenarios show what could be achieved with only moderate investments. Off course higher investments than assumed in the "REO 2030" scenarios, whether this might be for single technologies or in general, can and – likely - will allow for a much more dynamic growth and higher renewable generating capacities in 2030. There is no indication that technological aspects, such as expanding production capacities, could be a bottleneck for a faster increase of renewables.

Interaction of Investment Budget and the Decreased Cost of Technologies

The Renewable Energy Budget determines the renewable generating capacity that can be added in the course of 2030. For this purpose, the purchasable generating capacity in 2030 is calculated by dividing the investment budget by specific technology costs in 2030, which are calculated within an iteration loop (see also Figure 5 and Figure 6). On this note, in 2030 the investment budget and added capacity are equivalent by the factor of specific technology costs in that year. The decrease in specific technology costs is calculated using what are called "learning curves". Learning curves consist of a progression ratio that determines by how much costs will decrease if production doubles. For example, with a progression ratio of 0.9, costs will decrease by 10 percent for any doubling of production.

To calculate the cost decrease for each of the technologies, the following progression ratios are used:

Technology	Progress ratio
Wind Energy, onshore	0.85 up to 200 GW and 0.9 up to 2,000 GW
Wind Energy, offshore	Same as onshore but calculated as difference costs compared to onshore Wind Energy
Biomass & Waste	0.9 up to 2010, 0.93 up to 2020 and 0.95 up to 2030
Geothermal	0.95
Photovoltaic	0.8 up to 200 GW and 0.9 up to 2,000 GW
Solar Concentrating Power	0.93 up to 2020, and 0.95 up to 2030
Tidal, Wave & other Maritimes	prototype phase up to 2010, then 0.9
Solar Thermal Collectors	0.9

Table 2: Progress ratios for the technologies considered in the scenarios. [EWG; 2007]

Although there is a fixed target for the amounts that will be spent in 2030, the investment budgets in the REO scenarios are explicitly not static over the period of time considered. Annual renewable energy investments for the preceding years are a result of a technological development up to 2030, which has to fulfil the prerequisite that the overall costs of new capacities added in 2030 meet that year's investment target.

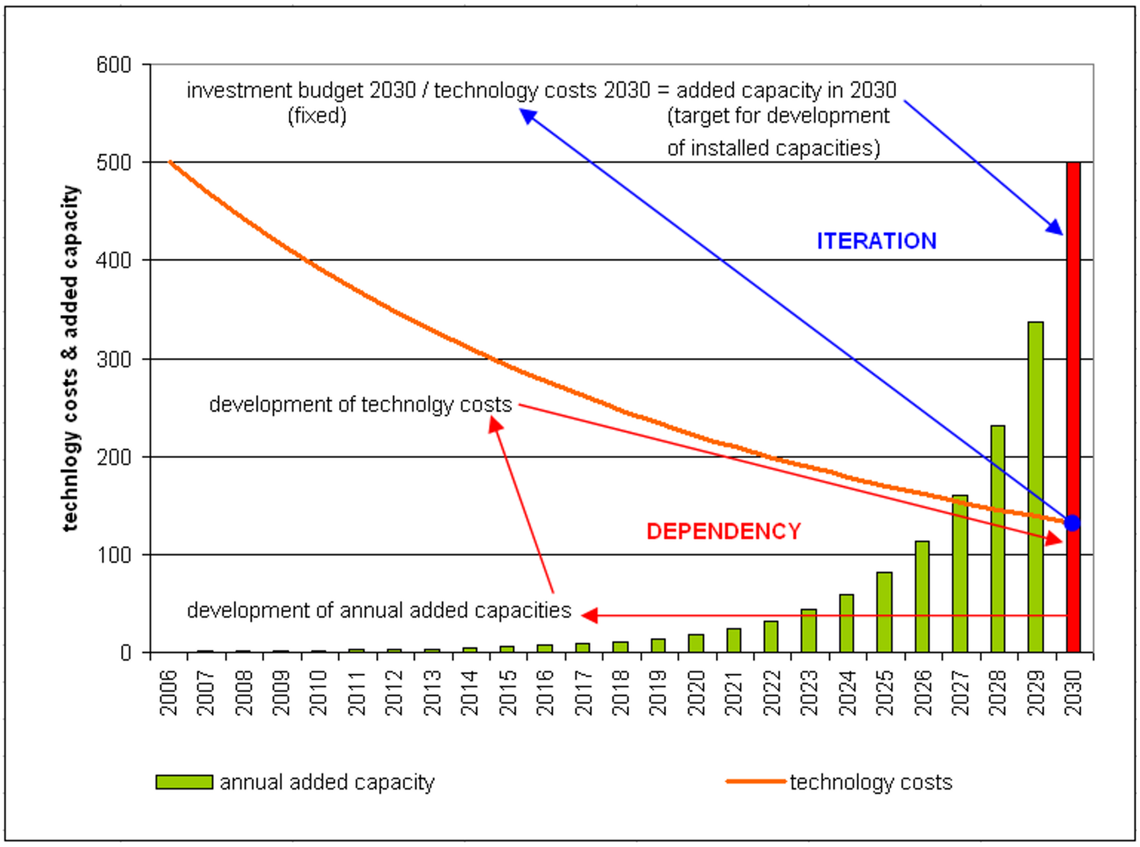


Figure 6: Example of translating the 2030 investment budget into new added capacities in 2030 with regard to degression of specific technology costs (see also Figure 5 on page 17 for more information on iterative technology cost calculation). [S. Peter, H. Lehmann; 2007]

General Growth Assumption

The general approach of mapping the development of individual renewable technologies to the time line within the various regions uses what are termed “logistic growth functions”, which show a typically s-shaped curve for growth with saturation effects in the later stage of development. This reflects the underlying assumption that growth cannot be unlimited if any of the resources that growth depends on is limited. In general, logistic growth starts with an exponential development that, in the course of time, becomes increasingly dampened by saturation effects. The last phase of development shows a slow (asymptotic) approach towards a maximum value. The curve of a logistic growth function does not show the development of growth itself, but rather shows the development of inventory (growth rates follow a bell-shaped curve).

Translated, e.g. to growth of a technology, logistic growth consists of a phase of market introduction that is followed by a dynamic market growth which later declines due to market constraints. These can include, e.g., high market penetration, which makes it increasingly difficult to find new customers (e.g. in case of a product) or an increasing scarceness of available or suitable sites for installation (e.g. for Wind Energy or PV).

Generally logistic growth (or so-to-say logistic inventory development) is an idealised process of limited growth. In reality, growth might be influenced by various factors, e.g. by changes in legislation and/or financial support in the case of renewable energies.

Another issue that can be well explained by means of a logistic growth function is the advantage of starting development sooner. In the example below, the dark red curve shows the development from the start; the lighter curves started ten and twenty years earlier respectively. After twenty years of development, the curve called "logistic growth" shows a value of 10%, the curve starting ten years earlier a value of almost 30%, and the curve starting twenty years earlier a value of more than 50%. This 20% advantage per decade in the example is still present one decade later for both of the other curves (the 30th year of development for the "logistic growth" curve). Afterwards, the gap begins to close, but this happens quicker for the development starting twenty years earlier than for the one that starts ten years earlier (still almost a 20% advantage for the "ten-years-earlier" curve but "only" 35% for the "twenty- years-earlier" curve when compared to the "logistic growth" curve).

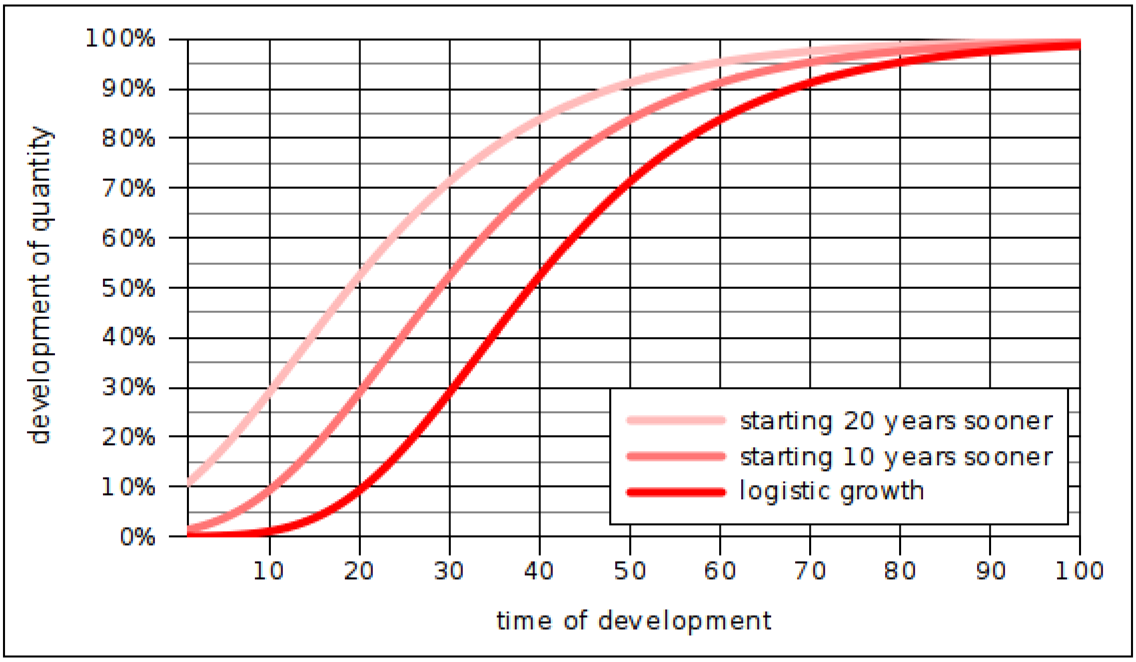


Figure 7: Example for logistic growth and the advantage of starting sooner [EWG; 2008].

One important question is whether a logistic growth function can reflect the growth characteristics of renewable energies in a way that can be seen as a valid approximation of reality (This does not mean that the logistic growth function will deliver "the right" projection for future development, but that historical development and logistic growth are sufficiently similar). Therefore, the logistic growth function used in the "REO 2030" scenarios has been applied to the German Wind Energy development (Figure 8). The result shows a good approximation of the logistic growth to historical development, which means that growth of Wind Energy in Germany has experienced logistic growth so far.

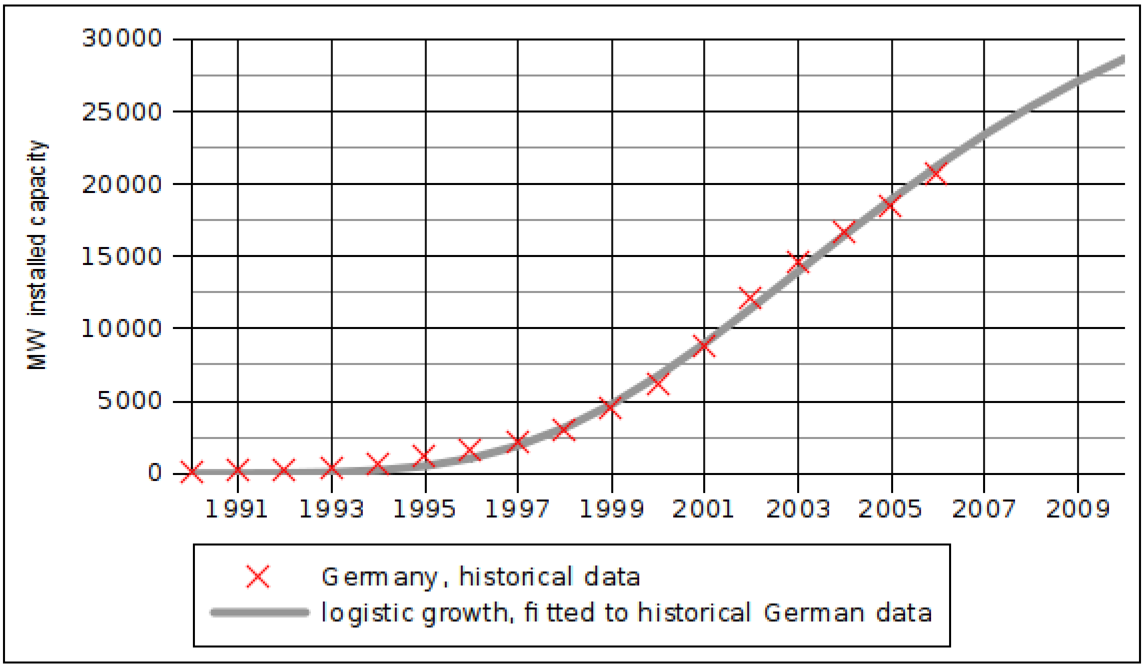


Figure 8: Example of fitting the logistic growth function used in the "REO 2030" scenarios to historical data of Wind Energy development in Germany.

Investment Budgets for Renewable Energy Technologies

Assuming strong political support and a barrier-free market entrance, the dominating stimulus for extending the generation capacities of renewable technologies is the amount of money invested. In the "REO 2030" scenarios, we assume a growing *"willingness to pay"* for a clean, secure and sustainable energy supply starting with a low amount in 2010. This willingness to pay gets expressed as a target level for annual investments per inhabitant (per capita) that will be reached by the year 2030, after a period of continuous growing investments in renewable energies.

As mentioned above, incorporating estimations regarding inflation was viewed as adding unnecessary uncertainty to the results of this report. Therefore, all prices are expressed on the basis of figures for the year 2006.

The annual payments are divided into two fractions called "basic investment" and "advancement investment", with one proportion (basic investment) being equally distributed to all the renewable energy technologies considered[9] to ensure the necessary technological diversification. The remaining budget (advancement investment) is distributed in relation to the regional potentials of the different technologies. This is done to adapt the introduction of renewable energy technologies to the existing potentials in the related regions.

The "Renewable Energy Investment Budget", i.e. the amount of money invested in renewable generating capacities, respects expectations regarding the future economic development of the different regions. Therefore, investment budgets are adapted to the economic situation of any of the regions, which results in stronger economies having higher investment targets for 2030 than weaker ones. Furthermore, rapidly developing economies are assumed to spend more money than slower ones, as they will have to improve their energy supply in any case.

This, however, is not the only criterion for the setup of the investment budgets. From the very beginning, there was some discussion about reasonable amounts per capita for the different regions. During the initial effort, investment budgets were decisively higher and showed less differentiation between the regions. As this resulted in renewable electricity shares that the working team judged as unreasonably high, investment targets were lowered region by region in order to achieve a more moderate scenario approach. The working team is aware that even higher installed capacities could have been justified from the perspective of possible technological growth, but it was decided to favour relatively low investments.

Some regions, in particular those that are currently viewed as relatively underdeveloped, will have to make stronger efforts in terms of the percentage of their Gross Domestic Product that will have to be spent to achieve the goals described in the scenarios. In the long term, the likelihood must be considered that many of the non-OECD countries will experience

9 Exceptions were made to tidal, wave and other maritime energies and solar thermal collectors.

substantially higher economic growth than most OECD countries. Some of them will even be confronted with the task of developing an energy supply that is both adequate and reliable enough to maintain the pace of their economic growth. This implies that many of the less-developed non-OECD countries will have to make massive infrastructure investments - including their energy supply - if they are to be able to participate in global economic development. This does not necessarily mean that these countries will have to bear all the related costs by themselves, as richer countries should contribute to this development, e.g. via the Clean Development Mechanism (CDM) or Joint Implementation (JI).

Investment Budgets in the REO 2030 Scenarios

In the “High Variant Scenario” (HV), per capita investments in 2030 grow to 124 € per capita per aear in global average. Investment targets differ from region to region: in 2030 220 € per capita and year (€/cap*a) are spent in the OECD regions, 200 €/cap*a in China and the Middle East; decreasing further for the Transition Economies (180 €/cap*a) and the remaining regions (all with less than 100 €/cap*a and down to about 41 €/cap*a in Africa). As the scenario is based on an iterative calculation, the estimated values do not exactly match these target values. The regions are very different in terms of population, and therefore total investment sums do not show the same distribution as the investments per capita. China and South Asia, for example, both regions with far more than one billion inhabitants, have the biggest total investments by 2030 (see Table 3 on page 24 for details).

The “Low Variant” (LV) of the “REO 2030" scenarios assumes half the investment budget of the "High Variant" (62 € per capita and year on global average in 2030), but in both the relation of investments in the various regions is the same; with the highest per-capita spendings in the OECD countries and lowest investment figures for Africa (see Table 3 for details).

Looking at the figures for 2010, investment starts with about 21 €/cap in that year in the “High Variant Scenario” (about 15 €/cap*a in the “Low Variant”). Already in 2010 the OECD regions spend most: about 60 € in OECD Pacific (“Low Variant”: 38 €/cap*a) to 70 € in OECD Europe (“Low Variant”: 56 €/cap*a) per inhabitant per year. In Africa, having the lowest investments, this figure is about 3½ € per capita.

Until 2020 investments in the “High Variant” increase to about 53 € per inhabitant per year on the global scale (about 30 €/cap*a in the “Low Variant”). By that time investments in the OECD are about 125 € to 131 € per capita (70 to 76 €/cap*a in the “Low Variant”). In China, the figure is more than half of this, while in the Transition Economies and the Middle East, it is about the half. Lowest per-capita investments fall upon East Asia, Latin America (approx. 33 €/cap*a in the “High Variant” and about 20 €/cap*a in the “Low Variant”) and, finally, South Asia (HV: 22 €/cap*a, LV: 12 €/cap*a) and Africa, with 14 (HV) and. 8 € per capita (LV) respectively.

Due to the widely differing populations of the various regions, China is already on par with OECD Europe in terms of total investments by 2010 and surpasses all other regions during the further development. By 2030, China's total investment in renewable capacities (299 billion €2006) is more than double the amount spent in South Asia (147 billion €2006, second place). OECD Europe and OECD North America are in third and fourth place, both spending about 30 billion € less than South Asia. In all other regions, total investment is lower than 70 billion euros (see Table 3 for more details).

Region	Investment budgets (€2006)					
	Per Capita			Total [bill. $€_{2006}$]		
	2010	2020	2030	2010	2020	2030
"High variant" scenario						
OECD Europe	69.2	130.9	222.8	37.0	71.1	120.9
OECD North America	62.7	126.2	220.0	28.6	62.8	118.4
OECD Pacific	59.1	124.7	223.9	11.9	25.0	43.6
Transition Economies	16.2	65.5	180.0	5.6	22.3	60.3
China	28.2	76.3	203.8	38.3	109.7	299.3
East Asia	10.3	32.2	81.3	6.8	23.9	65.6
South Asia	4.1	21.8	71.1	6.5	39.8	146.7
Latin America	12.0	32.7	91.4	5.6	17.1	51.5
Africa	3.5	14.2	40.8	3.5	17.3	59.4
Middle East	4.8	56.2	202.2	1.0	13.3	55.1
WORLD	**21.3**	**53.2**	**123.9**	**144.8**	**402.4**	**1020.8**
"Low variant" scenario						
OECD Europe	55.7	76.1	111.3	29.8	41.4	60.4
OECD North America	40.8	70.4	110.0	18.6	35.0	59.2
OECD Pacific	38.2	70.2	111.8	7.7	14.1	21.8
Transition Economies	8.9	35.0	91.1	3.0	11.9	30.5
China	18.8	43.4	101.7	25.5	62.3	149.4
East Asia	7.4	20.5	40.5	5.0	15.2	32.7
South Asia	3.0	12.2	35.4	4.7	22.2	73.1
Latin America	7.4	18.2	45.6	3.5	9.5	25.7
Africa	2.1	7.7	20.3	2.1	9.3	29.5
Middle East	2.9	26.5	101.1	0.6	6.3	27.5
WORLD	**14.8**	**30.1**	**61.9**	**100.4**	**227.3**	**509.8**
"Low variant" as percentage of "High variant"						
OECD Europe	80%	58%	50%			
OECD North America	65%	56%	50%			
OECD Pacific	65%	56%	50%			
Transition Economies	55%	53%	51%			
China	67%	57%	50%			
East Asia	72%	64%	50%			
South Asia	73%	56%	50%			
Latin America	62%	56%	50%			
Africa	60%	54%	50%			
Middle East	60%	47%	50%			
WORLD	**69%**	**57%**	**50%**			

Table 3: Development of investment per capita and total investments from 2010 to 2030 [EWG; 2008].

The development of investment budgets does not show a great difference between the "High Variant" and the "Low Variant" by 2010. On a global average, the 2010 budget in the "Low

Variant" scenario is about 70% of the “High Variant” budget. This difference grows during the further development to 57 % of the “High Variant” budget by 2020 and 50% by 2030 (see Table 4 for details).

Distribution of Investments in Various Technologies

The distribution of investments is divided into a basic investment, which is equally distributed among all technologies considered (making up half of the investment budget). The second fraction, named “advancement”, is generally oriented toward the varying potentials of the individual technologies, with some additional adjustments to add further support to specific technologies; e.g. Solar Concentrating Power in sunny regions and OECD Europe, and a general stronger support for Solar Collectors.

There is no “extra” investment in heat generation from Biomass & Waste or Geothermal Energy, which does not mean, however, that these technologies aren't used for heat supply. The scenarios assume a certain fraction of Biomass & Waste and Geothermal plants to be cogeneration facilities, producing electricity and heat simultaneously.

Distribution of investments to technologies									
Region / Technology	**Wind onshore**	**Wind offshore**	**Wind total**	**Biomass**	**Geothermal**	**PV**	**Solar Concentrating Power**	**Tide & Wave**	**Solar Collectors**
"High variant" scenario									
OECD Europe	10.5%	24.3%	34.8%	10.6%	9.2%	14.5%	11.0%	3.7%	16.2%
OECD North America	15.6%	20.1%	35.7%	13.3%	8.6%	11.0%	11.7%	3.4%	16.4%
OECD Pacific	16.7%	19.8%	36.4%	10.5%	8.6%	8.6%	16.5%	3.2%	16.1%
Transition Economies	21.3%	13.5%	34.8%	17.4%	11.4%	10.7%	0.0%	1.7%	23.9%
China	11.8%	16.3%	28.1%	11.0%	7.9%	17.1%	13.9%	2.8%	19.2%
East Asia	8.6%	21.4%	30.0%	9.8%	7.1%	13.6%	13.2%	1.4%	24.9%
South Asia	6.7%	9.4%	16.1%	8.0%	6.1%	24.1%	10.6%	1.3%	33.8%
Latin America	14.5%	20.5%	35.0%	12.4%	9.9%	10.0%	13.2%	1.6%	18.0%
Africa	12.2%	11.7%	23.9%	11.2%	6.6%	10.6%	16.0%	1.3%	30.4%
Middle East	14.3%	20.1%	34.4%	0.0%	9.5%	13.7%	21.0%	1.8%	19.6%
WORLD	**12.2%**	**17.2%**	**29.4%**	**10.6%**	**8.2%**	**15.2%**	**12.5%**	**2.4%**	**21.7%**
"Low variant" scenario									
OECD Europe	9.5%	21.9%	31.3%	9.5%	8.3%	13.1%	10.0%	3.3%	24.5%
OECD North America	14.1%	18.1%	32.1%	11.9%	7.8%	9.9%	10.5%	3.0%	24.8%
OECD Pacific	15.0%	17.8%	32.8%	9.4%	7.8%	7.7%	15.0%	2.9%	24.4%
Transition Economies	17.0%	10.8%	27.8%	14.0%	9.3%	8.7%	0.0%	1.4%	38.9%
China	10.1%	14.0%	24.1%	9.4%	6.8%	14.7%	12.0%	2.4%	30.5%
East Asia	6.6%	16.5%	23.2%	7.6%	5.5%	10.5%	10.2%	1.1%	42.0%
South Asia	5.4%	7.6%	12.9%	6.4%	4.9%	19.4%	8.5%	1.0%	46.9%
Latin America	12.7%	17.9%	30.7%	10.9%	8.6%	8.8%	11.6%	1.4%	28.1%
Africa	8.2%	7.8%	16.1%	7.5%	4.4%	7.1%	10.7%	0.9%	53.3%
Middle East	12.2%	17.2%	29.5%	0.0%	8.2%	11.7%	18.2%	1.5%	30.9%
WORLD	**10.3%**	**14.6%**	**25.0%**	**8.9%**	**6.9%**	**12.8%**	**10.6%**	**2.1%**	**33.7%**
Changes in Distribution, "Low variant" compared to "High variant"									
OECD Europe	-1,0%	-2,4%	-3,5%	-1,1%	-0,9%	-1,4%	-1,0%	-0,4%	8,3%
OECD North America	-1,5%	-2,0%	-3,6%	-1,4%	-0,8%	-1,1%	-1,2%	-0,4%	8,4%
OECD Pacific	-1,7%	-2,0%	-3,6%	-1,1%	-0,8%	-0,9%	-1,5%	-0,3%	8,3%
Transition Economies	-4,3%	-2,7%	-7,0%	-3,4%	-2,1%	-2,0%	0,0%	-0,3%	15,0%
China	-1,7%	-2,3%	-4,0%	-1,6%	-1,1%	-2,4%	-1,9%	-0,4%	11,3%
East Asia	-2,0%	-4,9%	-6,8%	-2,2%	-1,6%	-3,1%	-3,0%	-0,3%	17,1%
South Asia	-1,3%	-1,8%	-3,2%	-1,6%	-1,2%	-4,7%	-2,1%	-0,3%	13,1%
Latin America	-1,8%	-2,6%	-4,3%	-1,5%	-1,3%	-1,2%	-1,6%	-0,2%	10,1%
Africa	-4,0%	-3,9%	-7,8%	-3,7%	-2,2%	-3,5%	-5,3%	-0,4%	22,9%
Middle East	-2,1%	-2,9%	-4,9%	0,0%	-1,3%	-2,0%	-2,8%	-0,3%	11,3%
WORLD	**-1,9%**	**-2,6%**	**-4,4%**	**-1,7%**	**-1,3%**	**-2,4%**	**-1,9%**	**-0,3%**	**12,0%**

Table 4: Distribution of investments to the different technologies and differences between "Low variant" and "High variant" [EWG; 2008]

The resulting distribution favours Wind Energy, which receives about one third of all investments in all regions but South Asia and Africa. In case of Wind Energy, it has to be considered that this is the only technology that can be utilized on land and on sea, resulting in massive potentials all over the world. Almost 22% ("High Variant") or 34% ("Low Variant") of the total investments on the global level go to solar collectors, as this technology is considered a must for heat supply and should be implemented on every building possible (not only for heat, but also for cooling). Photovoltaic holds third place in the investment ranking (15% on average), followed by biomass (11%) and geothermal energy (8%). Tidal & Wave and other maritime sources receive the least support, as these technologies are seen as having a relatively long and slow evolution from the prototype stage to field testing and on to becoming mature technologies in the coming years or decades.

The "High Variant" and "Low Variant" scenarios manifest differences in their respective comparisons of the distribution of investment budgets among the technologies. In general, all electricity-generating technologies show lower budget shares than in the "High Variant", while Solar Thermal Collectors show a remarkable plus in investment shares. As investments in the "Low Variant" are substantially lower than in the "High Variant", the working team decided to favour more support to the relatively cheap Solar Thermal Collector technology.

Development of Technology Costs

Technology costs in the scenarios are calculated using progress ratios for the cost decrease. These progress ratios describe the relation between cost reduction and production capacity in such a way that the progression ratio represents the cost reduction if production capacity doubles; e.g. a progress ratio of 0.9 expresses a cost reduction of 10 % for any doubling of production capacity. Figure 9 shows an example of this relation (see also progression ratios used in Table 6 on p. 29).

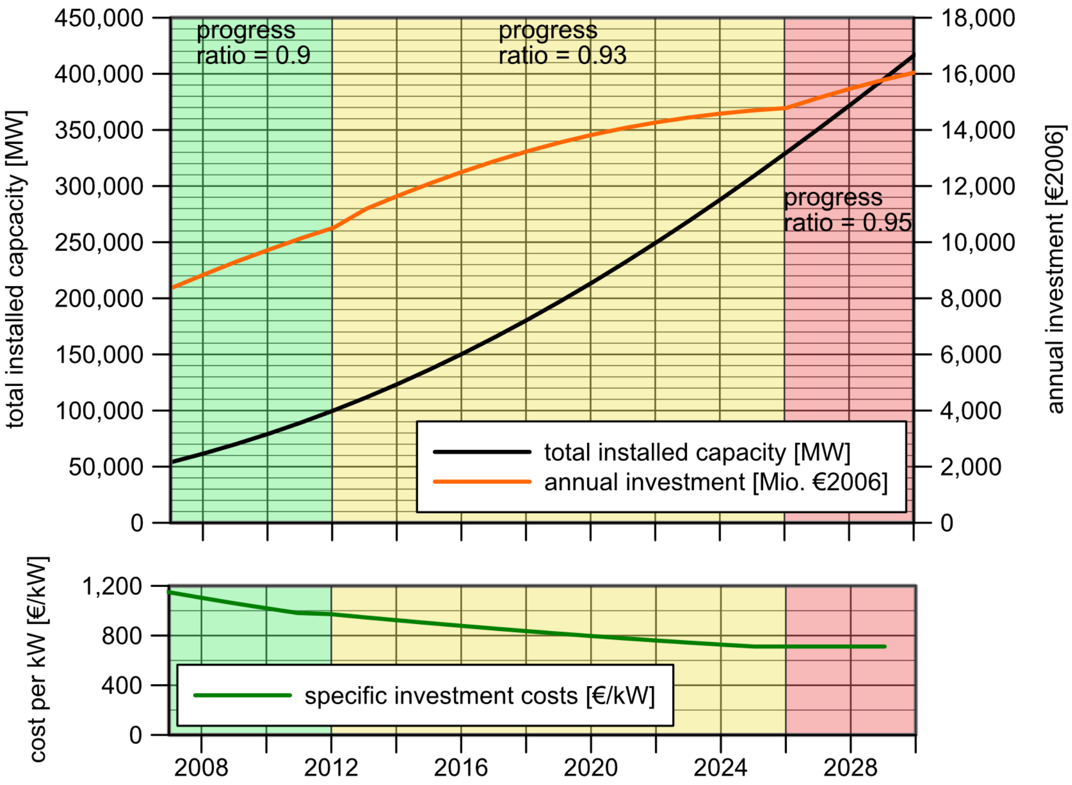


Figure 9: Example for calculating technology cost decrease by progress ratio. [EWG; 2008]

The starting point for technology costs is the same in both scenarios. Initially, the most expensive among the established technologies (which include everything but Tidal, Wave & other Maritimes) is Photovoltaic, followed by Geothermal, Biomass & Waste, Solar Concentrating Power and – substantial less costly than those technologies – offshore and onshore Wind Energy. At the very bottom, Solar Thermal Collectors are the cheapest technology (see Table 5 below for the initial technology costs).

Technology	Initial Costs [€2006/ kW]	Remarks
Wind Energy, onshore	1,200	
Wind Energy, offshore	650	Additional costs compared to onshore Wind, resulting to initial cost of 1,850 €/kW
Biomass & Waste	4,400	
Geothermal	4,750	average value for ORC/KALINA and conventional plants, cost reduction only assumed for ORC/KALINA
Photovoltaic	5,000	
Solar Concentrating Power	4,000	
Tidal, Wave & other Maritimes	6,662	starting with prototype cost of 9,500 €/kW, which decreases down to 7,200 €/kW until 2015. Normal calculation with progress ratio (0.9) afterwards.
Solar Thermal Collectors	1,000	

Table 5: Initial technology costs used in the scenarios. [EWG; 2008]

Both scenarios also use the same assumptions regarding cost-progression ratios for the different technologies. To calculate the cost decrease for each of the technologies, the following progression ratios are used[10]:

Technology	Progress ratio
Wind Energy, onshore	0.85 up to 200 GW and 0.9 up to 2,000 GW
Wind Energy, offshore	Same as onshore, but calculated as different costs compared to onshore Wind Energy
Biomass & Waste	0.9 until 2010, 0.93 until 2020 and 0.95 until 2030
Geothermal	0.95
Photovoltaic	0.8 up to 200 GW and 0.9 up to 2,000 GW
Solar Concentrating Power	0.93 until 2020, and 0.95 until 2030
Tidal, Wave & other Maritimes	prototype phase until 2010, then 0.9
Solar Thermal Collectors	0.9

Table 6: Progress ratios for the technologies considered in the scenarios. [EWG; 2008]

Due to the varying development in the “High Variant” and “Low Variant” scenarios, the decrease of technology costs is different, too. Table 7 below gives an overview of the cost development per installed kW of capacity for the technologies used in the scenarios.

Although all technologies see a remarkable decrease in costs, the ranking does not change a lot. Only Photovoltaic, which shows the biggest decrease in costs, catches up some places in the ranking. Already by about 2010, PV is cheaper than Geothermal and Biomass & Waste and falls below the cost of Solar Concentrating Power in 2014. Finally, PV is the fourth-cheapest technology, with below 2,000 € per kW installed capacity.

10 The progression ratio represents a factor for cost decrease if production quantity doubles; e.g. with a progress ratio of 0.9 technology costs decrease by 10 % for any doubling of the produced quantity.

In the ”Low Variant Scenario”, technologies can be categorized into three cost classes in 2030: about 4,000 to 5,000 €/kW (Tidal and Wave, Geothermal and Biomass & Waste, about 2,000 to 2,500 €/kW (SCP and PV), and about 1,000 €/KW (Wind Energy and Solar Thermal Collectors).

Technology cost in the scenarios [€2006/kW]								
Scenario	Wind onshore	Wind offshore	Biomass & Waste	Geothermal	Photo-voltaic	Solar Con. Power	Tidal & Wave[1)]	Solar Collectors
Initial technology costs	1,200.0	1,850.0	4,400.0	4,750.0	5,000.0	4,000.0	6,662.0	1,000.0
Low variant scenario								
Low variant 2010	1,108.5	1,642.4	4,323.6	4,674.0	4,164.4	3,700.7	9,527.0	939.9
Low variant 2020	989.2	1,291.9	3,995.3	4,422.5	2,285.0	2,939.9	5,914.2	797.1
Low variant 2030	916.9	1,138.4	3,748.4	4,197.6	1,752.8	2,480.9	4,655.1	714.6
High variant scenario								
High variant 2010	1,082.8	1,588.9	4,270.9	4,648.6	3,975.5	3,634.2	9,527.0	933.1
High variant 2020	878.5	1,134.8	3,849.2	4,347.2	1,975.3	2,769.8	5,761.0	786.0
High variant 2030	778.9	961.7	3,594.6	4,123.5	1,504.3	2,314.8	4,351.9	710.1
Reduction high scenario against low scenario								
Cost reduction high 2010	**25.7**	**53.5**	**52.6**	**25.4**	**188.9**	**66.5**	**0.0**	**6.7**
as percentage	*2.3%*	*3.3%*	*1.2%*	*0.5%*	*4.5%*	*1.8%*	*0.0%*	*0.7%*
Cost reduction high 2020	**110.6**	**157.1**	**146.1**	**75.3**	**309.7**	**170.2**	**153.2**	**11.1**
as percentage	*11.2%*	*12.2%*	*3.7%*	*1.7%*	*13.6%*	*5.8%*	*2.6%*	*1.4%*
Cost reduction high 2030	**138.0**	**176.7**	**153.8**	**74.1**	**248.5**	**166.1**	**303.2**	**4.5**
as percentage	*15.1%*	*15.5%*	*4.1%*	*1.8%*	*14.2%*	*6.7%*	*6.5%*	*0.6%*
Reduction against initial technology costs in 2030								
Low variant scenario	**283.1**	**711.6**	**651.6**	**552.4**	**3,247.2**	**1,519.1**	**2,006.9**	**285.4**
as percentage	*23.6%*	*38.5%*	*14.8%*	*11.6%*	*64.9%*	*38.0%*	*30.1%*	*28.5%*
High variant scenario	**421.1**	**888.3**	**805.4**	**626.5**	**3,495.7**	**1,685.2**	**2,310.1**	**289.9**
as percentage	35.1%	48.0%	18.3%	13.2%	69.9%	42.1%	34.7%	29.0%

Table 7: Technology costs in 2030 in the High and Low Variant Scenarios compared. [EWG; 2008]

There are substantially greater decreases in costs in the ”High Variant Scenario”, but not to the same extent for all technologies. While Tidal & Wave, Geothermal, Biomass, Solar Concentrating Power and Solar Thermal Collectors only show a minor decrease in specific costs, Photovoltaic and Wind Energy benefit more from the higher investments in the ”High Variant Scenario”.

Both types of Wind Energy (onshore and offshore) fall below 1,000 €/kW until 2030 in the ”High Variant Scenario” (offshore Wind stays above 1,000 €/kW in the ”Low Variant”). Photovoltaic costs (about 1,750 €/kW in the ”Low Variant”) reduce further to about 1,500 €/kW. The lowest additional decrease in technology cost can be found for Geothermal Energy and Solar Thermal Collectors.

An overview of the development of technology costs in both scenarios is given in Figure 10 below.

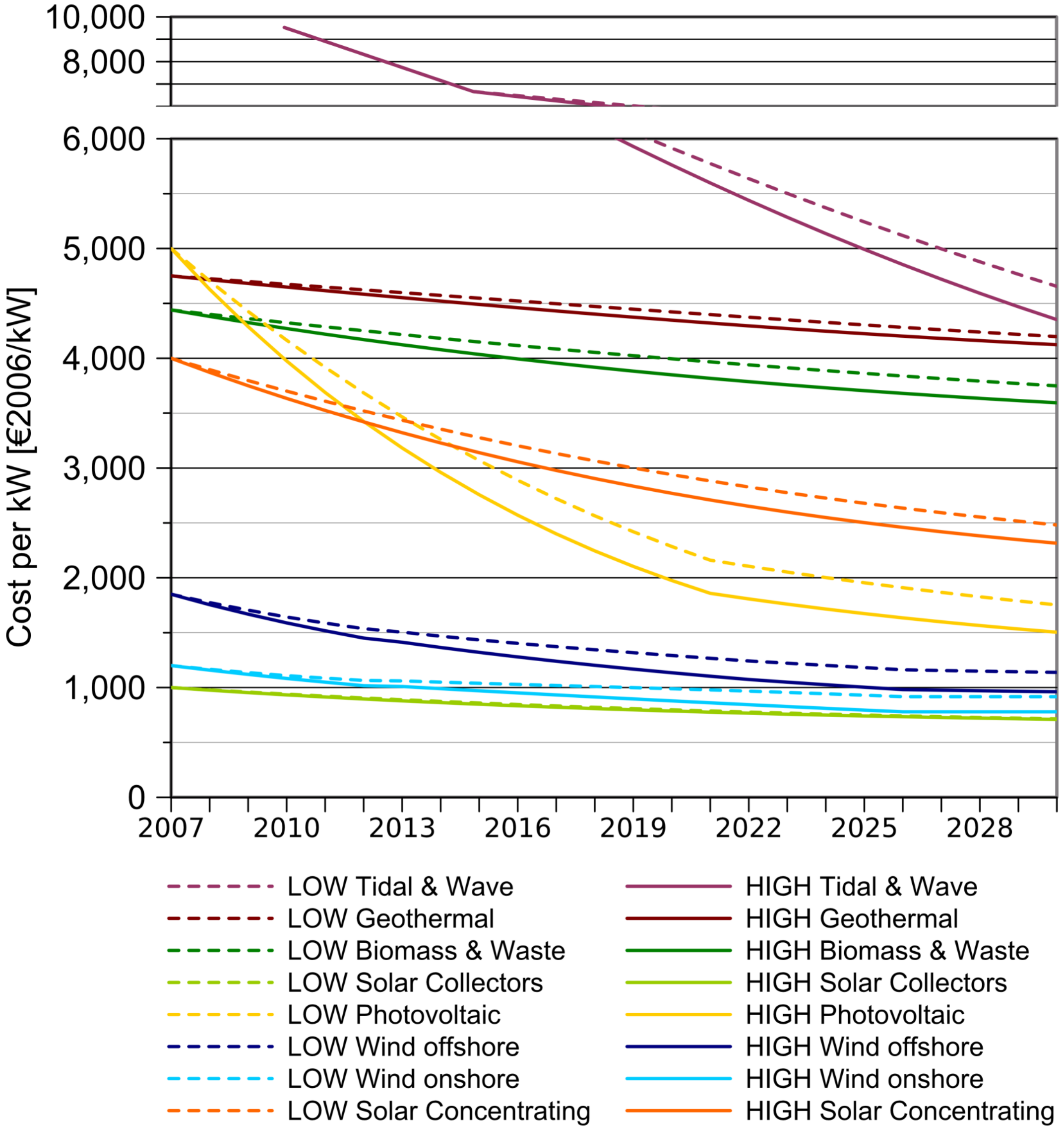


Figure 10: Development of technology costs in the scenarios. [EWG; 2008]

Development of Investment Budgets in the Scenarios

As the scenarios develop towards an investment target that was set for the year 2030, investments increase from year to year with increasing additions of renewable generating capacities.

The absolute global investment figure for 2010 in the "Low Variant Scenario" is approx. 100 billion €$_{2006}$, about 225 billion €$_{2006}$ in 2020, and finally, slightly more than 500 billion €$_{2006}$ in 2030 (Figure 11).

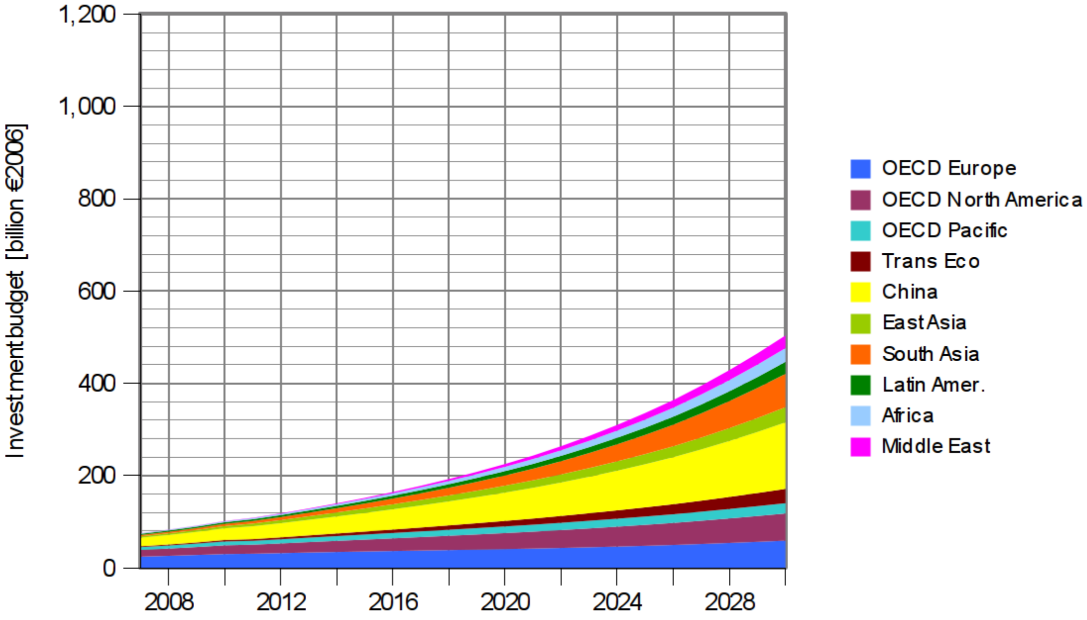


Figure 11: Development of investment budget in the "Low Variant Scenario" [EWG; 2008]

The investment budget in the "High Variant "reaches a level of double the amount than the "Low Variant" in 2030 (1,000 billion €$_{2006}$). As both scenarios share the same starting point, the differences between the "Low Variant" and the "High Variant" grow considerably during the progress of capacity extension. In 2010, investments in the "High Variant Scenario" are already about one-and-a-half times the investment figures in the "Low Variant" (100 billion €$_{2006}$ in low and almost 146 billion €$_{2006}$ in the "High Variant"). This gap increases further to more than 170 billion €$_{2006}$ in 2020 (397 billion €$_{2006}$ total budget in the "High Variant").

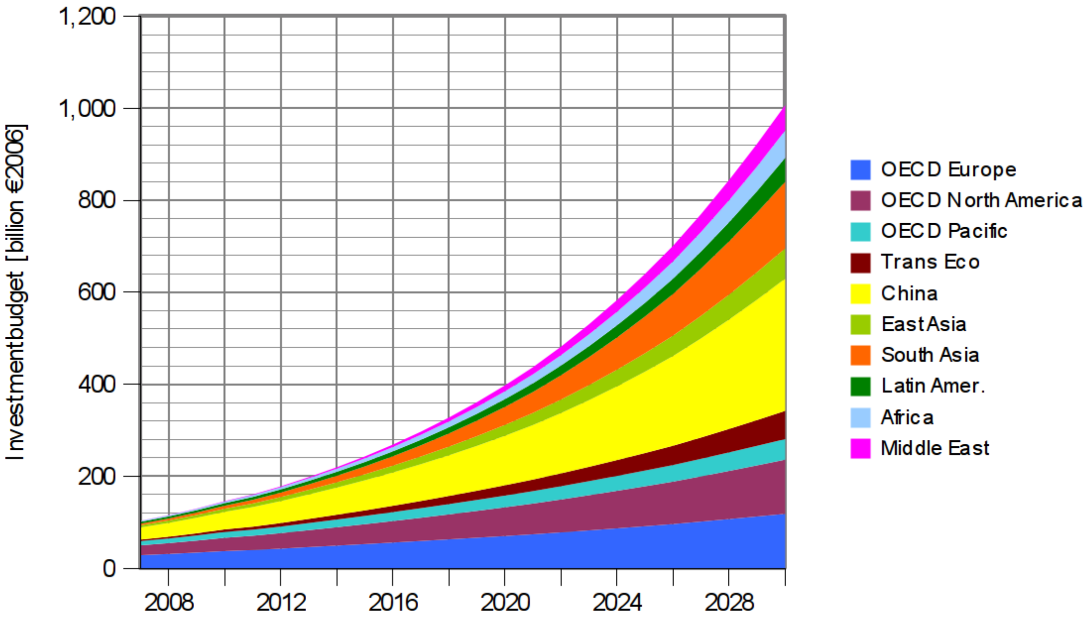


Figure 12: Development of investment budget in the "High Variant ScenarioV [EWG; 2008]

During the development there is a substantial change in the percentages the various world regions contribute to the global renewable investment budget (Figure 12)[11]. While the majority of the investment initially stems from the OECD region (Europe, North America, and the Pacific), the distribution between OECD and non-OECD countries is already well balanced before 2020. This trend in development lasts until 2030. As a result, the share of the non-OECD countries exceeds seventy percent by 2030, with the biggest contributions coming from the most populated regions, China and South Asia (29% China and 14% South Asia). The lowest contribution to the global renewable investments comes from OECD Pacific (4.4 %), Latin America (5.1 %), and the Middle East, with 5.4 %. OECD Europe and OECD North America show about the same shares (approx. 12 %), but investments are already lower than those in South Asia.

11 The figure shows the development in the High Variant scenario, but there are only minor differences between the two scenarios.

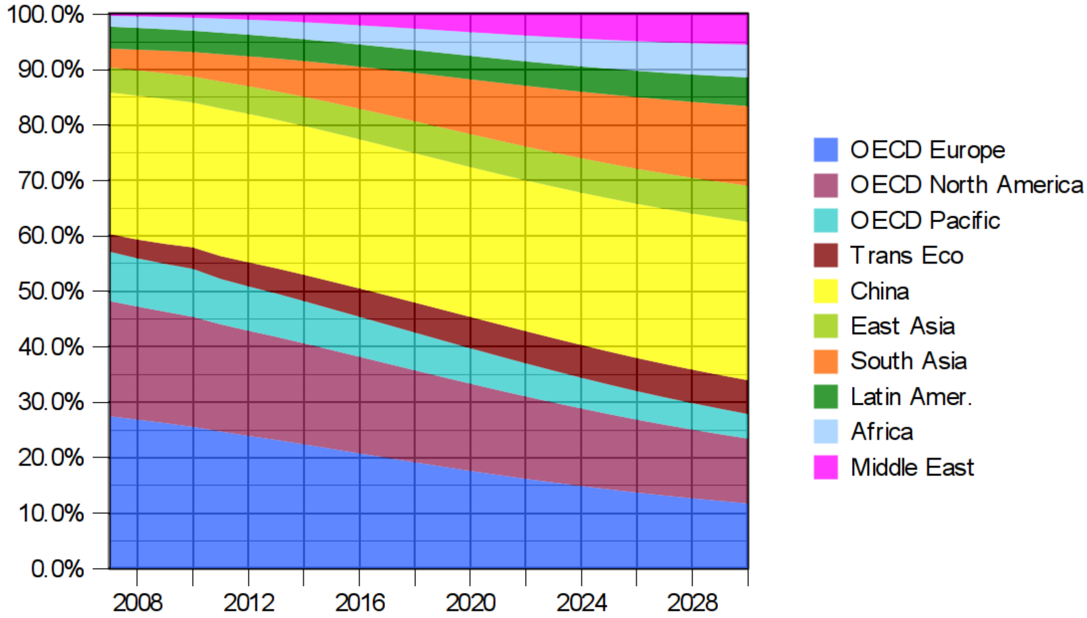


Figure 13: Development of shares at global investment budget in the "High Variant Scenario" [EWG; 2008]

To get a better feeling for what these investment figures mean in relation to today's real world, Figure 14 and Figure 13 show the development of the renewable investments as absolute values and per capita in comparison to the global military expenditures of 2005 [SIPRI; 2006]. Only in the "High Variant" does the renewable investments per capita come close to what was globally spent on the military in 2005 (black and grey markers). Although the absolute values, reached in the "High Variant Scenario" by 2030, are higher than the absolute military expenditures of 2005, the cumulative amount – i.e. the costs of the entire renewable capacity extension under the assumption of stable military spending – is much lower than the military expenditures that can be expected during that time.

Related to the current investments into the renewable energy sector (green dot), the 2007 investment budget in the "Low Variant" is somewhat lower than the real 2007 investments, while the budget is somewhat higher in the "High Variant Scenario". (Investments in 2007: about 84 billion €, "Low Variant": 76 billion €, "High Variant": 103 billion €)

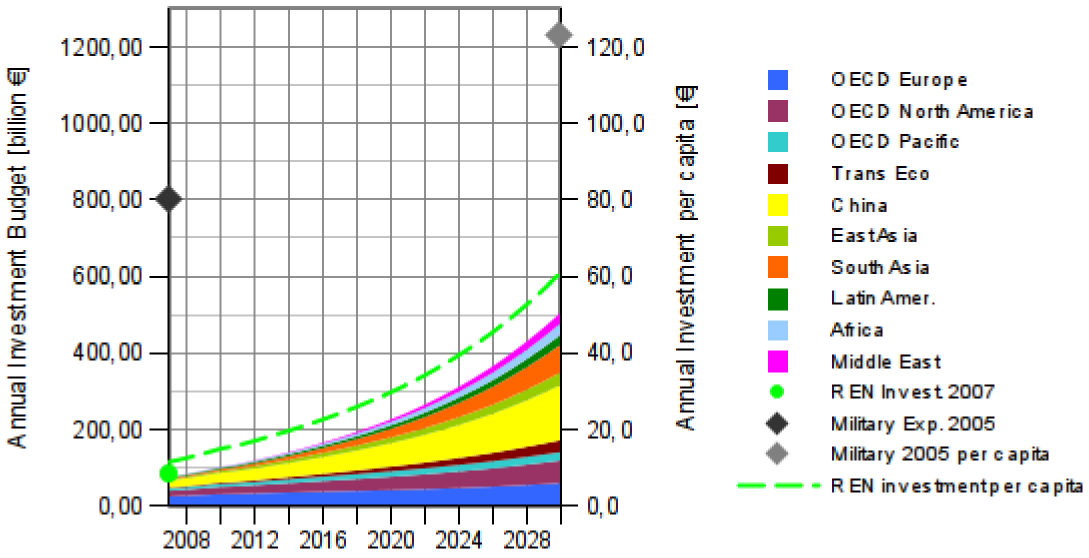


Figure 14: Development of investment budgets in the world regions in the "Low Variant Scenario" [EWG; 2008]. Data on military expenditures: [SIPRI; 2006]. Data on 2007 renewable energy investment: [UPI; 2008].

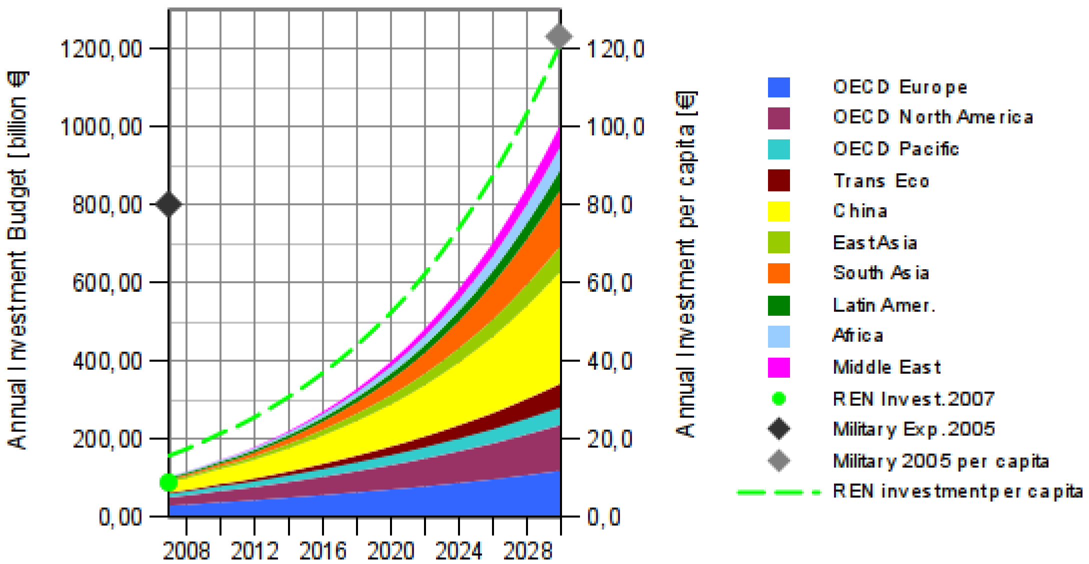


Figure 15: Development of investment budgets in the world regions in the "High Variant Scenario" [EWG; 2008]. Data on military expenditures: [SIPRI; 2006]. Data on 2007 renewable energy investment: [UPI; 2008].

Development of Electricity-Generating Capacities and Electricity Production

High Variant Scenario: General Development in the Global Context

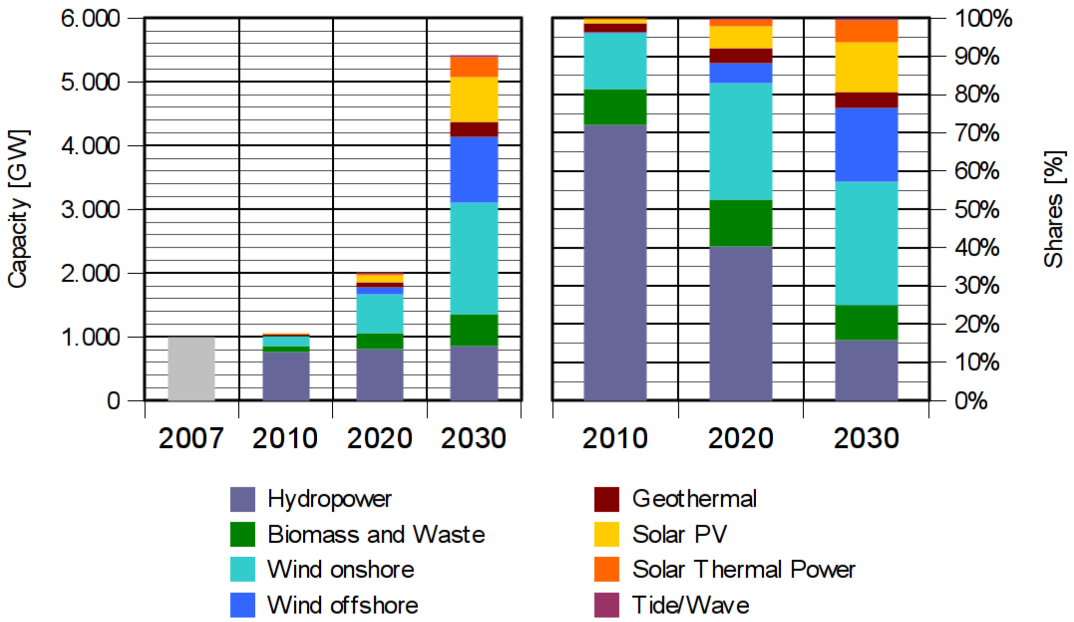


Figure 16: Development of renewable generating capacities in the "High Variant Scenario" on the global scale [EWG; 2007]. Data 2007: [REN 21; 2007]

Analysing the development of generating capacities in the "High Variant Scenario", Hydropower will still be the main contributor to renewable capacities by 2010[12]. Due to the massive extension of "new" renewable capacities (non-Hydropower), this picture changes dramatically during the further development stages. Hydropower's share in generating capacities is more than 70% on the global scale by 2010. Although Hydropower capacities increase by more than 90 GW (from 762 GW by 2010 to 856 GW by 2030), the share drops to 40% by 2020 and to only 16% by 2030. The biggest capacity additions result from the massive extension of Wind Energy[13]. While the total Wind Energy capacity is 156 GW by 2010, this figure grows to about 718 GW by 2020, a growth by a factor of more than 4.5. Until 2030, this capacity grows further to 2,792 GW, which is equivalent to an extension by a factor of almost 4 (2020 to 2030). The share of Wind Energy in total renewable capacities, about 15 % by 2010, increases to more than the half by

12 Although the further extension of hydropower capacities is not a part of the scenarios, planned capacity extensions – known to the working team - are considered in the renewable generating capacity figures. It has to be mentioned here that these planned hydropower extensions are considered as normal investments into energy supply in any of the regions, but they are not part of the investment budgets in the scenarios. In this sense investment budgets in the scenarios are for "new" renewables only.

13 This had to be expected due to the huge Wind Energy potential and the already good price competitiveness of Wind Energy.

2030. Offshore Wind Energy increases more dynamically than onshore Wind. Starting with an onshore/offshore ratio of about 97 % onshore and less than 3 % offshore, this picture subsequently changes substantially. By 2020, offshore Wind Energy already contributes 15 % to the total Wind Energy. After 2020, offshore Wind development even speeds up, so that – in the end – the onshore/offshore ratio is about two-thirds onshore and one third-offshore Wind.

Photovoltaic (PV) shows the second biggest growth in generating capacities, but – although capacity increases by about 690 GW from 2010 to 2030 (11 GW by 2010 and 701 GW by 2030) – this is not enough to reach hydropower's capacity by 2030. As with Wind energy, growth decreases in the second decade of development. While Photovoltaic capacity increases about tenfold from 2010 to 2020, the growth between 2020 and 2030 drops to a factor of just a bit higher than six.

Biomass & Waste, contributing about 100 GW to the renewable capacities by 2010, loses it's third place standing to PV by 2030. Capacity increases to about 245 GW by 2020 and further to 496 GW by 2030, a total capacity addition of almost 400 GW from 2010 to 2030. In terms of factored growth, capacity increases by about 2.5 times from 2010 to 2020, whereas capacity “only” doubles from 2020 to 2030. The development of Biomass's share in total renewable capacity is an exeption to other “new” renewables: While the share increases from about 9 % by 2010 to about 12 % by 2020, there is a decrease in the second decade of development, down to about 9 % again until 2030.

Solar Concentrating Power (SCP),generally insignificant in 2010 (2.4 GW or 0.2 % of renewable capacity), increases its capacity to about 40 GW by 2020, a factor of almost 29 compared with 2010, and to 313 GW by 2030, which is equivalent to a capacity increase by a factor of almost eight between 2020 and 2030. In terms of the SCP's share in of the total renewable generating capacity there is a growth from far less than one percent in 2010 to about six percent by 2030.

Geothermal Energy falls behind Solar Concentrating Power until 2030 on the global scale. Although Geothermal generating capacity is about ten times the capacity of SCP in 2010, the capacity increase to about 224 GW by 2030 results in about 90 GW capacity less than SCP's. Nevertheless, even Geothermal Energy's share of the total renewable capacities increases from slightly more than 2 % in 2010 to about 4 %, though in contrast to most other “new” renewables (except Biomass), there is virtually no further increase in share after 2020.

Tidal, Wave and other Maritimes (shortened as Tidal & Wave) are somehow like a poor cousin in the scenario. Although the capacity increases from almost zero to about 33 GW by 2030, at no point does this technology come close to contributing even one percent of the total renewable generating capacities. This assessment reflects the working team's conviction that these technologies will remain in the prototype and/or testing phase for quite a long while. One obvious difference between the renewable capacities' structure in the OECD and non-OECD regions is the capacity contributed by Wind Energy. While in the OECD region Wind Energy's contribution is almost 60%, this figure is less than 50% in the non-OECD region. As offshore

Wind Energy contributions are the same, the whole difference results from onshore Wind energy capacities.

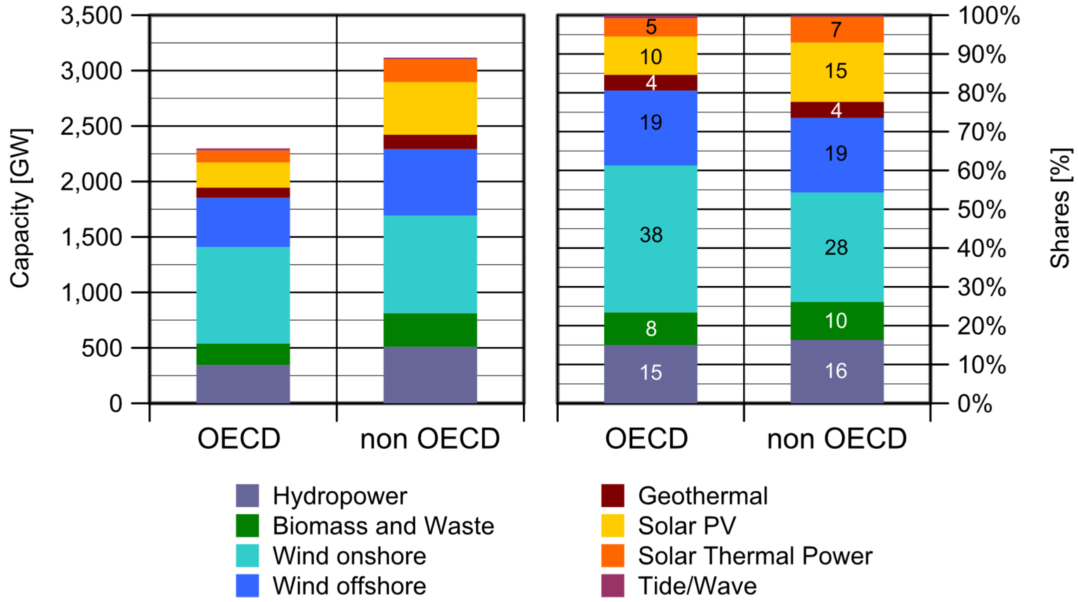


Figure 17: Structure of renewable capacities 2030 compared (OECD and non-OECD) [EWG; 2007].

Another considerable difference emerges from the use of solar energy, resulting from the fact, that many non-OECD countries are in geographical locations with high levels ofsolar irradiation. This comparably high percentage of countries with good solar irradiation in the non-OECD region results in Photovoltaic and Solar Concentrating Power having higher shares of the total renewable generating capacity when compared with the OCED regions. Of course, differences of this magnitude were anticipated.

There are also differences within the OECD regions as well as within the non-OCED regions. The share of Wind Energy in the OECD region (2030), for example, ranges from almost 50% in North America to more than 62% in Europe. In the non-OECD region, this ranges from about one third (Latin America) to about two thirds (Middle East). The low Wind Energy share in Latin America is not due to low investments in this technology, but rather to the extremely high share of Hydropower – this source already being one of the top contributors to the electricity supply and a technology whose expansion is already being planned. Actually, Latin America is a special case in the scenario: Renewables' contribution to the total generating capacity already exceeds that in other regions by far, which is also due to the massive hydropower capacities.

Photovoltaic and Solar Concentrating Power also manifest relatively large differences. The world leader in Solar Concentrating Power in the scenario is the Middle East, with more than 12% of the renewable capacity consisting of SCP (more than 13% for PV). Although the 13% PV in the Middle East has among the highest percentages in the interregional comparison, it is South Asia that has the lead, with PV constituting a massive 27 % of total renewable capacities . The reason for this extraordinary high share is the impressive population density by 2030 (more than 500 inhabitants per square kilometre).

Low Variant Scenario: General Development in the Global Context

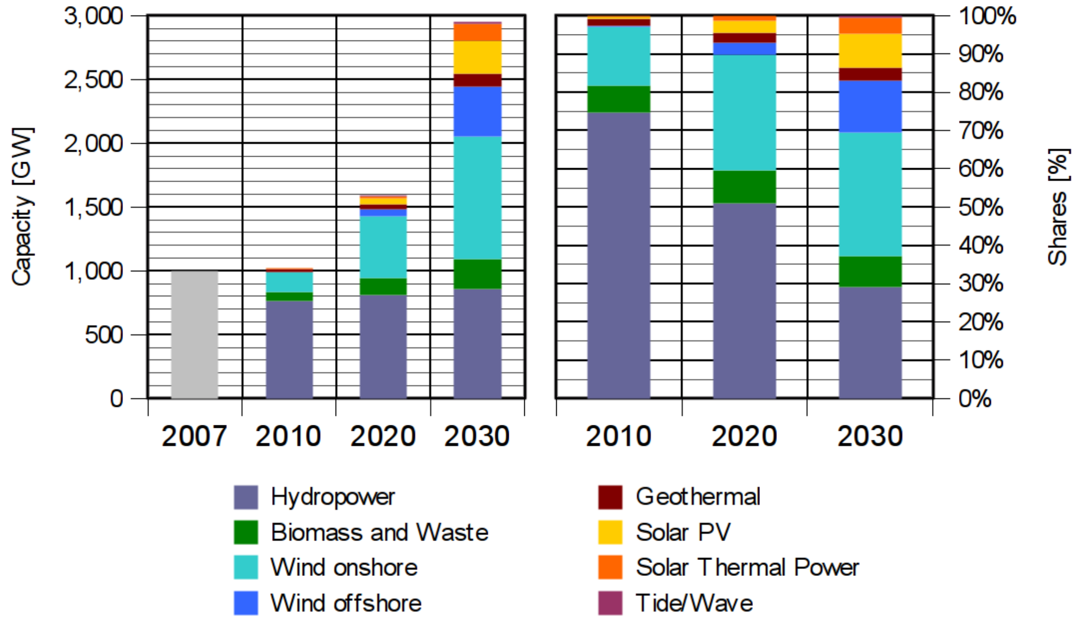


Figure 18: Development of renewable generating capacities in the "Low Variant Scenario" on the global scale [EWG; 2007]. Data 2007: [REN 21; 2007]

The development of generating capacities in the "Low Variant Scenario" shows Hydropower still having a share of more than half of the renewable capacities in 2020 (more than 70% by 2010). Although Hydropower capacities increase by more than 90 GW (from 762 GW in 2010 to 856 GW in 2030), the share drops to less than one third (29%) in 2030 due to the extension of "new" renewable capacities.

The general development of the "new" renewables is very similar to the "High variant Scenario", with the main difference being that the lower investments result in less dynamic development. Wind Energy shows the biggest increase in generating capacity, with 159 GW in 2010 and 1352 GW in 2030 (about 1,450 GW less than in the "High Variant"), Wind Energy contributes about 46% to the total renewable capacities by 2030 (about 15% in 2010). Offshore Wind Energy makes up about 30% of the total Wind Energy capacity (about 2% by 2010).

Photovoltaic (PV) shows the second-biggest growth in generating capacities (an increase of 251 GW, from 7 GW in 2010 to 258 GW in 2030), and takes the second position in terms of generating capacity then, just ahead of Biomass. Photovoltaic's share increases from less than one percent in 2010 to almost nine percent in 2030. Biomass itself grows from about 72 GW in

2010 to about 238 GW by 2030 (an increase of 166 GW), with shares of about 7% in 2010, 8.6% in 2020, and down again to 8 % in 2030.

Solar Concentrating Power (SCP), negligible in 2010 (2.4 GW or 0.2% of renewable capacity), increases to about 20 GW by 2020 and to 128 GW by 2030. SCP's share grows from far less than one percent in 2010 to slightly more than four percent by 2030.

Geothermal Energy falls behind Solar Concentrating Power until 2030 on the global scale. Although Geothermal generating capacity is about ten times the capacity of SCP in 2010, the capacity increase to about 102 GW by 2030 results in almost 30 GW less capacity than SCP. Nevertheless, the share of Geothermal Energy increases from slightly less than 2% in 2010 to three-and-a-half percent by 2030.

Tidal, Wave and other Maritimes (shortened as Tidal & Wave), which show a capacity increase to about 16 GW by 2030 (less than one GW in 2010), steadily contribute far less than one percent to the renewable generating capacities. The biggest difference among the structures of renewable capacities in the OECD and non-OECD regions is the capacity contributed by Wind Energy, Hydropower and Photovoltaic. While the OECD region sees a Wind Energy contribution of almost 55%, this figure is less than 40% in the non-OECD region. Hydropower makes up for one third of the renewable capacities in the non-OECD region, while this figure is one fourth in the OECD region. Photovoltaic's contribution to capacities in the non-OECD countries is about double its share in the OECD countries (6% OECD, 11% non-OECD).

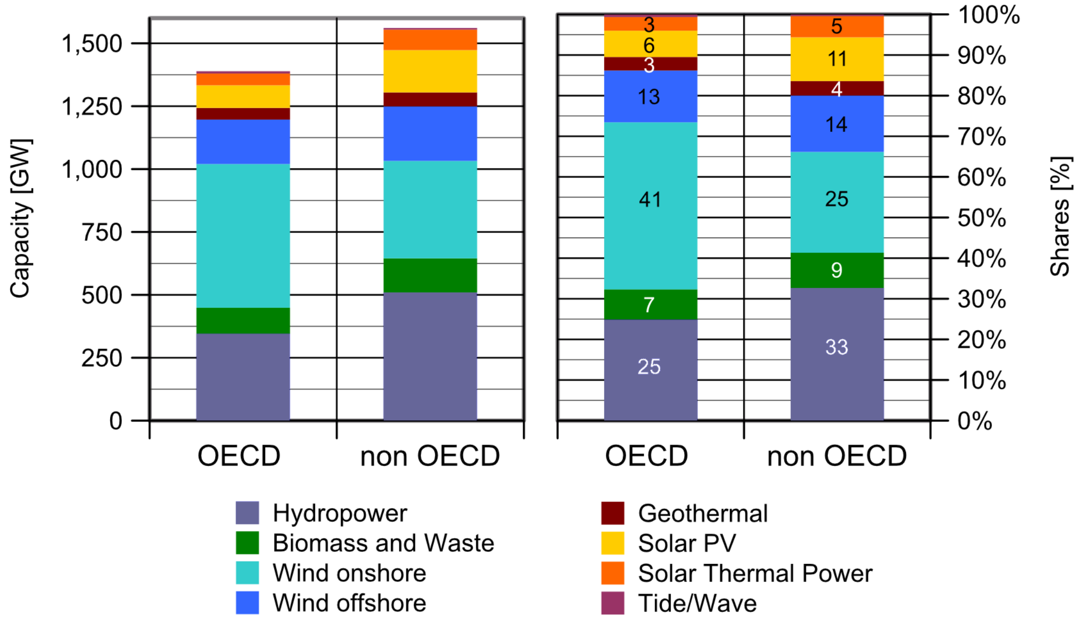


Figure 19: Structure of renewable capacities 2030 compared (OECD and non-OECD) [EWG; 2007].

Differences within the OECD and the non-OCED region are very similar to those described earlier in the "High Variant" section (see also "differences and specifics" in the "High Variant" section and the detailed description of the individual regions in the annex).

Electricity production in the "High Variant" Scenario

Naturally, energy production from renewables increases with growing generating capacities. However, the relation of generating capacities does not reflect the relation of energy production, as some technologies are more productive than others. Wind energy, for example, is less productive than Biomass or Geothermal energy. Relatively low productivity is more an attribute of fluctuation suppliers, i.e. wind energy and solar energy. Thus the predominance of wind energy in production capacities is not reflect the same way in the production figure.

Altogether, renewables in the "High Variant Scenario" provide about 4,000 Terrawatt-hours (TWh) of electricity by 2010. The production increases further to about 6,200 TWh by 2020 and to about 15,500 TWh by 2030[14].

The biggest producers by 2030 are Wind Energy, Hydropower and Biomass. Onshore Wind Energy production is slightly higher than electricity generation from Biomass (2,500 TWh from Biomass and more than 2,600 TWh from onshore Wind) but offshore Wind tops both by about

14 Although Hydropower is not part of the investment budgets, Hydropower's electricity production is considered as it is a renewable contribution to energy supply.

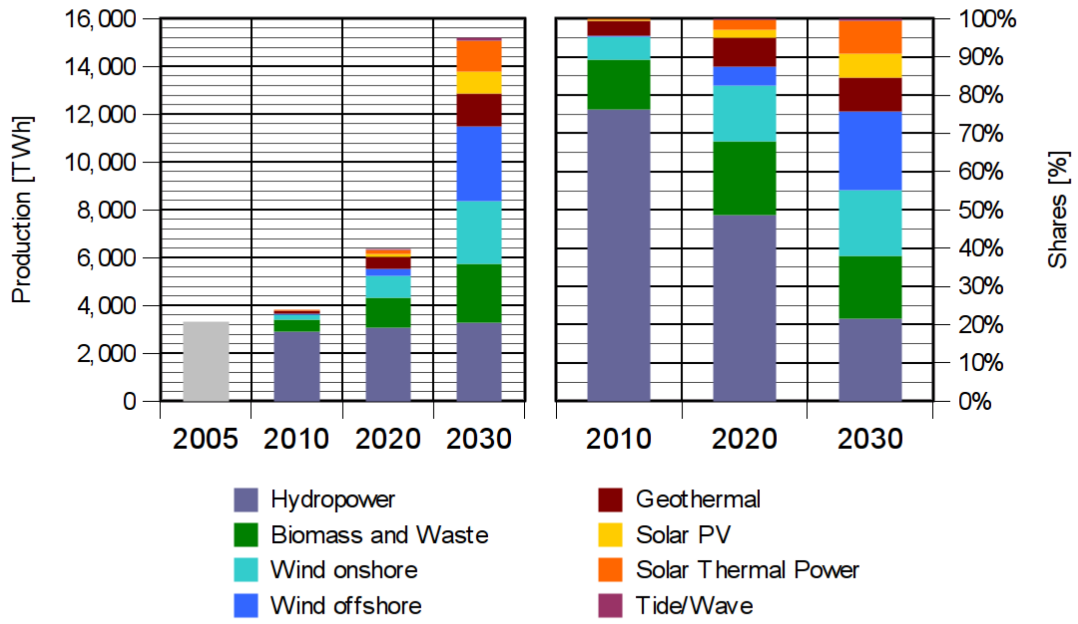


Figure 20: Development of electricity production from renewables in the "High Variant Scenario", 2010 to 2030 [EWG; 2007]. Data 2005: [IEA; 2007b]

500 TWh. Without Hydropower, the electricity generation from "new" renewables increases from about 900 TWh by 2010 to almost 12,000 TWh by 2030 (Figure 20).

The shares of Wind Energy and Photovoltaic in electricity generation do not reflect their shares in capacity, while the contributions of Hydropower, Biomass, Geothermal and Solar Concentrating Power are substantially higher than what could be expected if only looking at capacities.

Electricity Production in the "Low Variant" Scenario

Altogether renewables in the "Low Variant Scenario" provide about 3,600 terrawatt-hours (TWh) electricity in 2010. The production increases further to about 5,000 TWh by 2020 and to about 8,600 TWh by 2030 (Figure 21).

The biggest producers in 2030 are Wind Energy, Hydropower and Biomass. Offshore Wind Energy alone is on par with Biomass in terms of electricity generation. Without Hydropower, the electricity generation from "new" renewables increases from about 725 TWh in 2010 to more than 5,300 TWh by 2030.

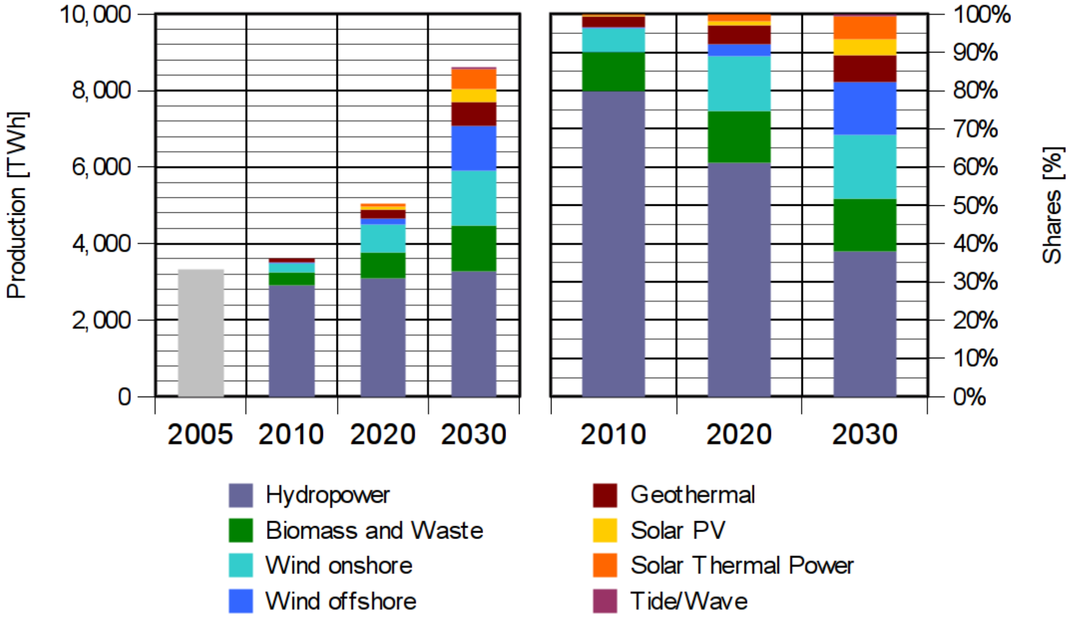


Figure 21: Development of electricity production from renewables in the "Low Variant Scenario", 2010 to 2030 [EWG; 2007]. Data 2005: [IEA; 2007b]

Development of Final Energy Supply

As the focus so far has been on electricity, it appears appropriate here to offer some information about heat, which is also an essential part of the scenarios. Heat production in the scenarios stems from Solar Thermal Collector systems on the one hand and from Biomass & Waste facilities and Geothermal cogeneration plants on the other. The related final energy figures, presented later in this chapter refer to this heat production as REN heat.

The “REO 2030” scenarios use the IEA's predictions of energy demand to calculate the shares in final energy supply in the scenarios. Reference tor rating energy production by renewables is final energy. Please also see the section on primary energy (page Fehler: Referenz nicht gefunden) for an explanation why these figures have not been used in this work.

Final Energy Demand in the WEO 2006, Alternative Scenario

According to the projection given by the “Alternative Policy Scenario” in the IEA's “World Energy Outlook 2006”, the global final energy demand is set to rise to over 122,600 TWh[15] (Terrawatt-hours) until 2030. OECD countries alone account for about 43% of this number.

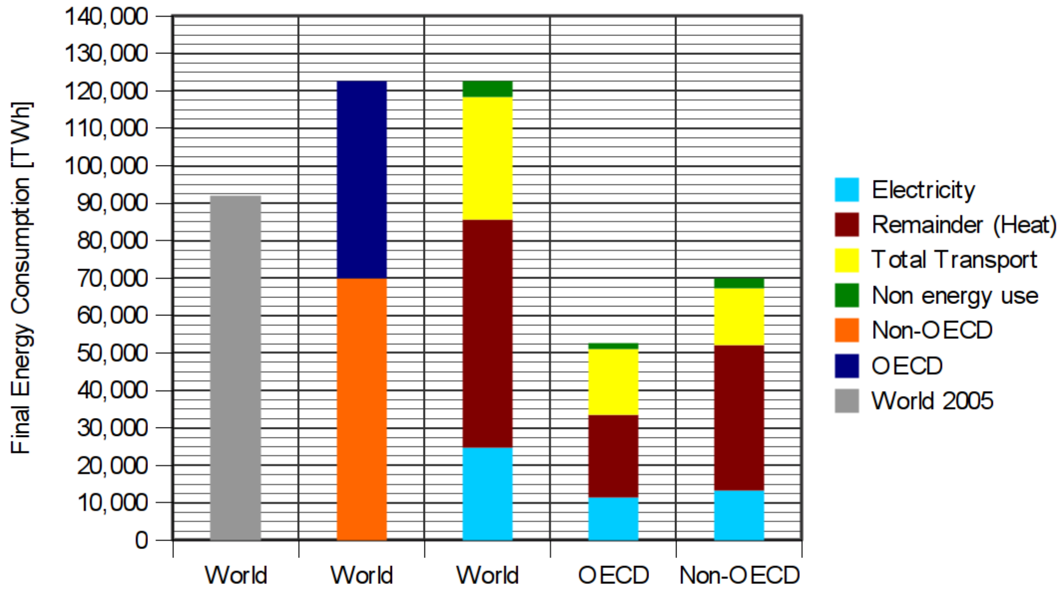


Figure 22: Global Final Energy consumption in OECD and in non-OECD countries. Data :[IEA; 2006]

In regard to the composition of final energy consumption, heat demand is responsible for half the final energy consumption, but this also comprises traditional biomass use, especially in the non-OECD countries. This is probably one good reason for the varying shares of heat in the OECD

15 This is more than 10,500 million tons of oil equivalent (Mtoe), with 1 Mtoe being 11.63 TWh

and non-OECD (42% OECD, 56% non-OECD). There are also significant differences in the transport sector's shares that might well be explained by the structural differences. While transport consumes one third of the final energy in the OECD, it is a bit more than one fifth in the non-OECD lands. Electricity shares are about the same: approximately one fifth (22% OECD; 19% non-OECD).

With regard to final energy demand development, the IEA projection suggests an increase by almost 40% from 2004 to 2030.

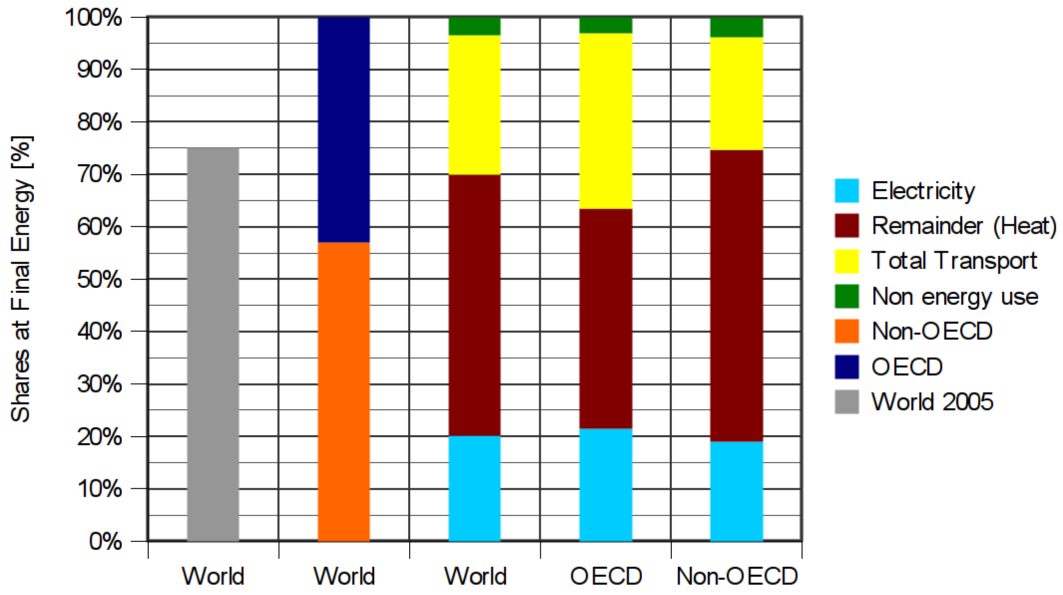


Figure 23: Distribution of final energy consumption between the OECD and non-OECD region and shares of electricity, heat, transport and non-energy use. Data converted from [IEA; 2006], [IEA; 2007a].

Although the working team has reservations regarding the IEA World Energy Outlook's view of the development of energy demand, it was taken as a reference to keep the "REO 2030" scenarios comparable to the ones published by the IEA.

Shares of Final Energy Supply in the "High Variant" Scenario

The figures for electricity and heat result in a total of approximately 25,000 TWh of energy production in the "High Variant Scenario"; about 15,200 TWh of that is electricity and about 9,800 TWh is heat (Figure 24). This is sufficient to boost renewables' share in final energy to somewhat less than one third (29%) until 2030. With regard to absolute energy production from renewables, this is significantly less in the OECD (9,130 TWh) than in non-OECD countries (15,830 TWh). (Figure 24 and Figure 25)

According to the scenario results, 54% of electricity and 13% of heat will stem from renewable sources in the OECD countries in 2030. This is significantly different in the non-OECD areas:

renewables contribute more than two thirds to final electricity demand (68 %) but only slightly less than one fifth to heat demand (17 %). Putting this together, the "High Variant Scenario" results point out that in 2030 almost 62 % of electricity will originate from renewable sources on the global scale but less than one fifth (16 %) of heat.

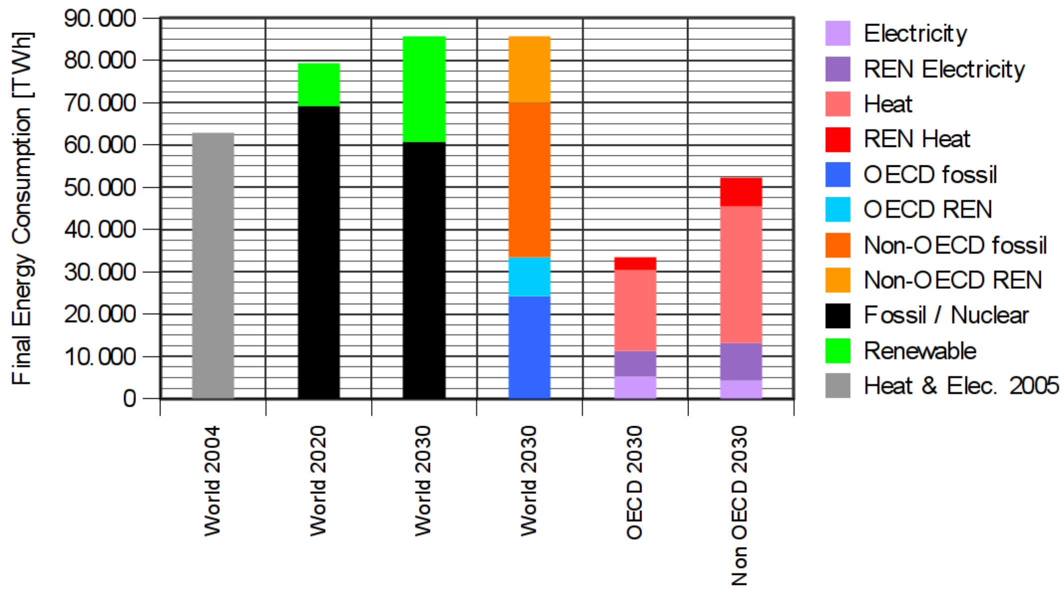


Figure 24: Renewable energy production in the "High Variant Scenario" in 2030 [EWG; 2008]. Data on energy demand converted from [IEA; 2006], [IEA; 2007a].

Although the absolute production from renewables differs in the OECD and non-OECD regions, the regional shares of renewables are comparable to a significant degree. In both regions renewables contribute about thirty percent to final energy demand (OECD 27%, non-OECD 30%)

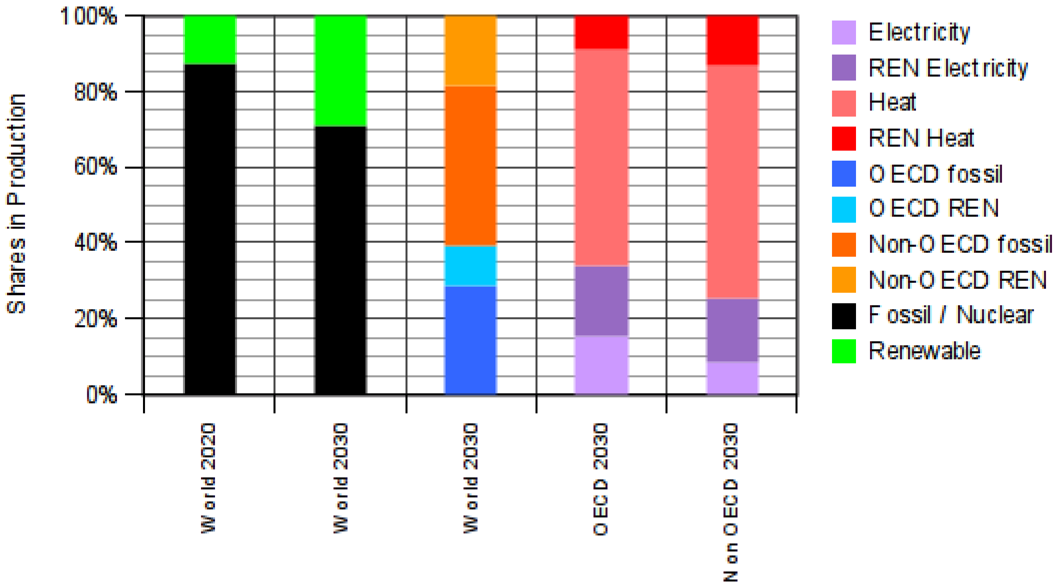


Figure 25: Renewable shares at final energy in the "High Variant Scenario" in 2030 [EWG; 2008]. Data on energy demand converted from [IEA; 2006], [IEA; 2007a].

Shares of Final Energy Supply in the "Low Variant" Scenario

The relation between the regions is quite similar to the "High Variant Scenario". An exception is the heat sector: the relatively low investments considered in the "Low Variant Scenario" led to the decision to favour the heat sector, in contrast to the "High Variant Scenario". Hence in this assessment, renewable shares in the heat sector do not decrease that much as in the case of electricity.

The total 2030 energy production from renewables amounts to about 14,900 TWh in the "Low Variant Scenario", of this electricity accounts for about 8,600 TWh and heat for 6,300 TWh heat (Figure 26). In relation to the "High Variant Scenario", this is a reduction of about 43 % in electricity generation and about 36 % in heat production[16].

As observed in the "High Variant", in the "Low Variant Scenario", too, the OECD and non-OECD regions differ in their absolute energy production from renewables, the gap, however, is somewhat less (5,600 TWh in OECD and 9,300 TWh in non-OECD). In both regions, renewables contribute about 17 (OECD) to 18 (non-OECD) percent to final energy supply, and the two regions together can supply 17% of the global final energy demand from renewables. (Figure 26 and Figure 27)

16 It has to be noted here, that electricity generation also includes hydropower, which is not a part of the investment budgets here. Not considering hydropower, the production from "new" renewables reduces by far more than the half.

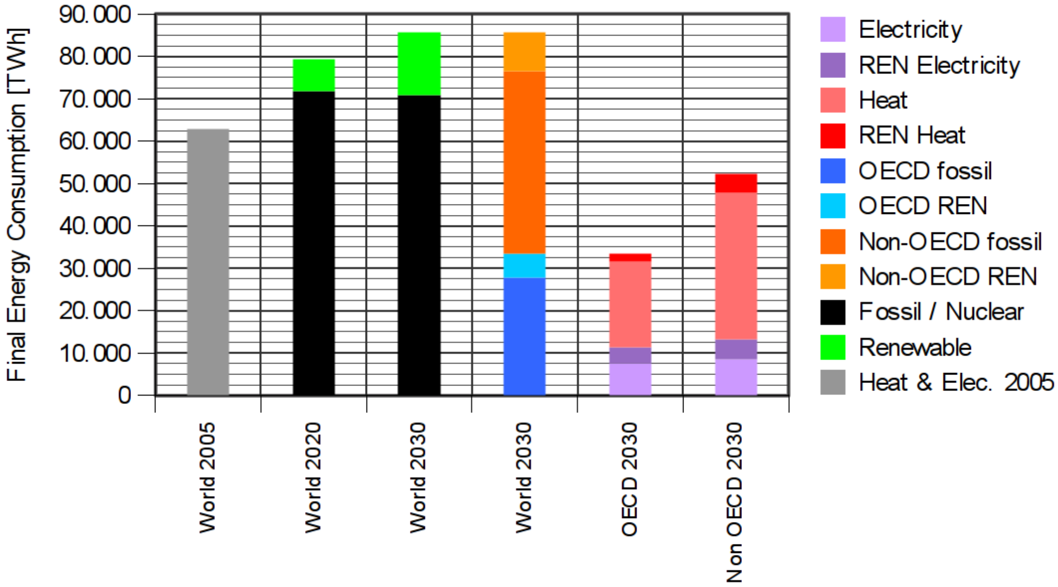


Figure 26: Renewable energy production in the "Low Variant Scenario" in 2030 [EWG; 2008]. Data on energy demand converted from [IEA; 2006], [IEA; 2007a].

A lower share of electricity and heat is supplied by renewables in the OECD region than in the non-OECD. In the former, one third of the final electricity and about 8% of the final heat demand will come from renewable technologies in 2030. The results for the non-OECD region show that almost 37% of electricity demand and about 11% of heat can be covered by renewable technologies.

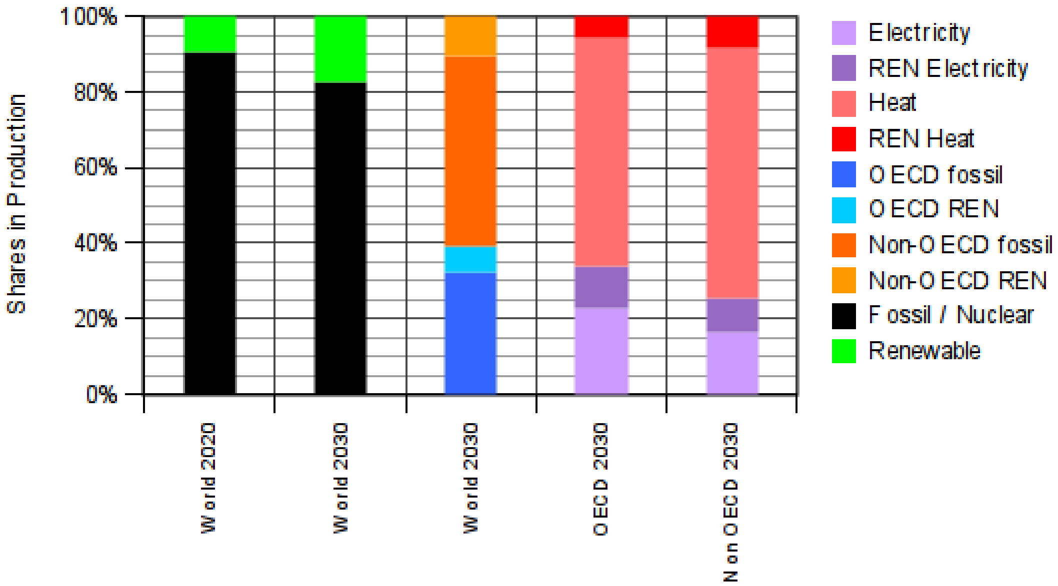


Figure 27: Renewable shares at final energy in the "Low Variant Scenario" in 2030 [EWG; 2008]. Data on energy demand converted from [IEA; 2006], [IEA; 2007a].

With regard to the global picture of electricity and heat supply in 2030, the ”Low Variant Scenario” achieves a 35% share in final electricity and about 10% in final heat.

Why This Study Does Not Show Primary Energy Figures

The working team decided not to show primary energy figures, as these statistics always contain conversions of final energy into an equivalent amount of primary energy, which themselves comprise assumptions of how to convert e.g. nuclear power or electricity from renewable sources. Primary energy balances usually adopt a factor of three to convert nuclear power into primary energy (i.e. a plant efficiency of 33%), and a factor of one for the conversion of renewable electricity.

In our opinion, this approach is not only inconsistent but also unfair in judging the renewable contribution to energy supply. If renewables contribute to primary energy supply in official statistics, why is only their final energy production considered? Wouldn't it be better to express the renewables' contribution as primary energy savings, since, in fact, it is primary energy consuming technologies that the renewables are replacing? The previous commonly used substitution approach tried to express the amount of primary energy that would have been necessary to produce an equivalent amount of electricity by conventional fossil plants. However, the accuracy of this approach can be questioned because an average fossil plant efficiency has to be assumed in order to convert renewably produced electricity into its primary energy equivalent. How can this problem be dealed with in scenarios involving middle to long-range projections? Isn't it a great deal of guessing brought into play if we try to predict an average global plant efficiency for 2030? Furthermore, if we are able to predict plant efficiency relatively precisely, will it not be the case that renewables replace less-effective plants first?

However, energy from renewable technologies will render a fraction of the previously used plants – or plants that might be projected – unnecessary, regardless of whether they use fossil fuel or nuclear-powered facilities., Thus, it will reduce the consumption of primary energy in comparison to a system without renewables.

The figure below (Figure 28) gives an overview of how the electricity production in the ”High Variant Scenario” (15,189 TWh) can be assessed under different assumptions: The dark blue bar (final energy) represents the conversion of green electricity into its primary energy equivalent as used today, even for such technologies as photovoltaic and wind energy. The other bars demonstrate assumptions of the primary energy requirements for producing identical amounts of electricity using various technologies.

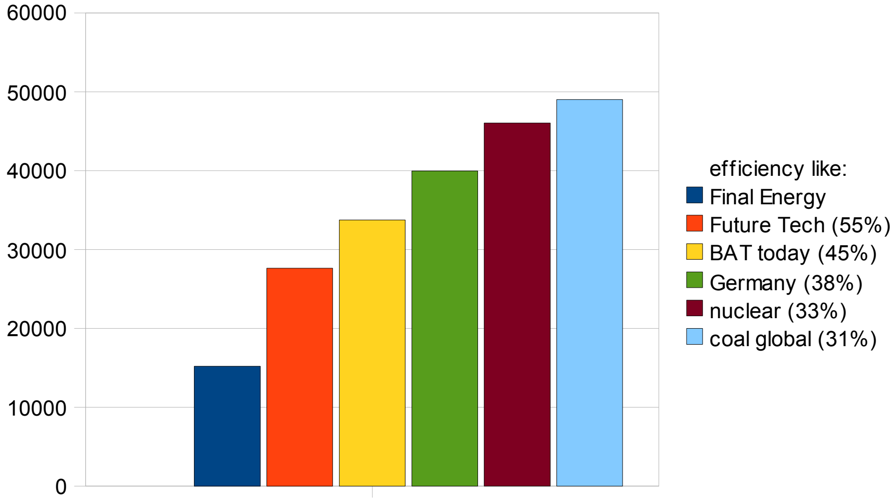


Figure 28: Converting electricity from renewable technologies into primary energy, different assumptions off plant efficiencies. [EWG; 2008]

Reality Check

One might ask the question: Could all these investments into renewables actually ever be made? To give an answer to this question it might be helpful to compare the total investments in the scenarios – i.e. summing up all investments from 2007 to 2030 – to actual expenditures in other sectors or for targets beside a clean energy supply. A simple illustration: Global military spending in 2005 totalled about 799 billion euros. Assuming that this figure will remain stable from 2007 until 2030, the resulting cumulative outlays can be compared meaningfully to the expenditures in the scenarios. If we take these military expenditures as 100%, 72% of this amount would be sufficient to realise the development described in the ”High Variant Scenario”. In relation to the ”Low Variant”, an amount equal to only about half of the military outlay would be adequate.

The Earth's life-support system is being affected by anthropogenic climate change. The severe consequences of this change, which is closely related to the way we satisfy our energy needs, is THE greatest threat facing humankind today. The authors of this report recommend that people the world over begin to ask themselves seriously whether the investments necessary to address these issues are not as worthwhile and productive as the money put into military matters.

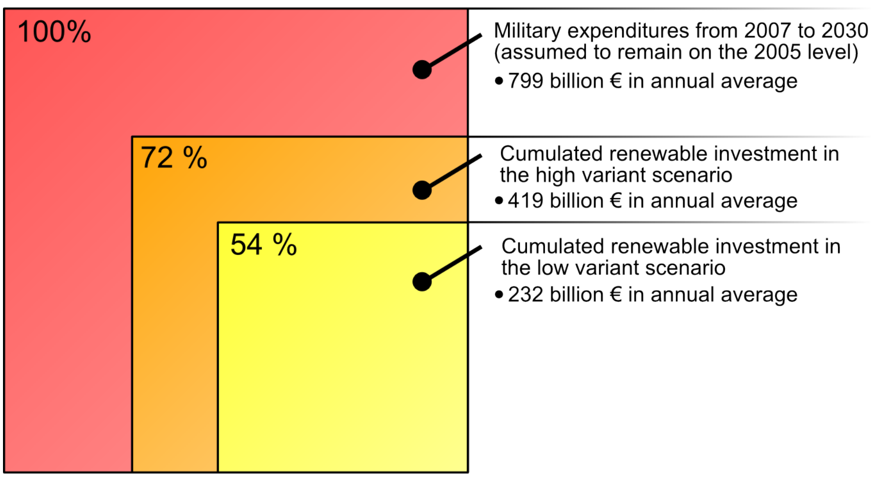


Figure 29: Comparison of Military expenses and the cumulated investments in the scenarios [EWG; 2008]. Data on military expenditures [SIPRI; 2007]

Another question that might arise relates to production capacities. Is it possible to extend production capacities in order to achieve an increase in generating capacities as described in the scenarios? Here again, comparing the scenario figures to our contemporary world can serve as a basis for people's own judgement.

The PV capacity added in the ”High Variant Scenario” in OECD Europe in 2030 is about 11,300 MW, which equals the output of about 78,000,000 m2 of solar cells at an efficiency of 15%. Assuming that all countries in OECD Europe install the same capacity per inhabitant, the

German share in capacity additions would be about 1,766 MW or about 11,773,333 square meters of solar cells. The production of insulating glass in Germany in 2005 was about 23,233,000 square meters, or about double the surface area seen as required for newly installed PV in 2030. Even considering the whole OECD Europe, the German insulating glass production in 2005 was already about 30% of the PV area to be installed in OECD Europe in 2030.

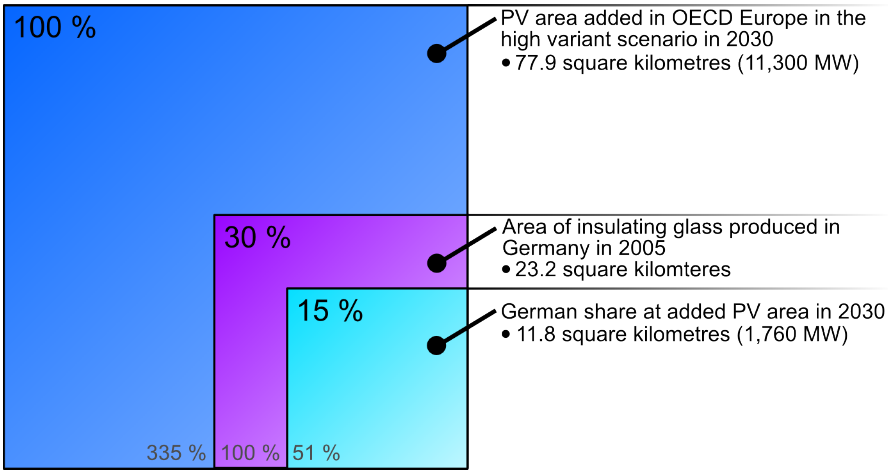


Figure 30: Added PV capacity in 2030 (High Variant) compared to insulation glass production in 2005 [EWG; 2008] Data on insulation glass production: [Destatis; 2005;]

Taking the German 2005 production of insulation glass as the 100% reference (grey, smaller numbers), the PV area added in Germany under the assumptions in the ”High Variant Scenario” equals about 51%. The PV area added in the whole of the OECD Europe region in 2030 (”High Variant Scenario”) is no more than about 3.3 times the German insulation glass production of 2005 (335%).

Only considering the installed capacities (1,766 MW in Germany in 2030), the new installed capacity in Germany in 2006 was 750 MW [BSW; 2007] and more than 1,100 MW in 2007 [Systeme Solaires; 2008], which is about 42% (2006) and 62% of the additions in the ”High Variant Scenario” in 2030.

The capacity of wind power plants added in OECD Europe in the ”High Variant Scenario” in 2030 is about 46,800 MW or 15,600 plants with 3 MW per plant (onshore and offshore). The German contribution would be about 7,070 MW or about 2,360 plants, if all countries in OECD Europe install the same amount per inhabitant. The highest annual added capacity in Germany has been about 3,247 MW or 2,328 plants [BWE; 2008], which is about the same number of plants and about 2.2 times the capacity already installed in Germany within one year.

Today's the global automobile production is about 65 million passenger cars per year and is set to rise to about 80 million by 2013 [PAWO; 2007]. Assuming an average power per car of 100 kW, the annual produced cars have a total output of 6,500 GW. This is about 1.2 times the capacity of the cumulative global generating capacity of all renewables including (predominantly already existing) Hydropower (5,415 GW) in the ”High Variant Scenario” by 2030.

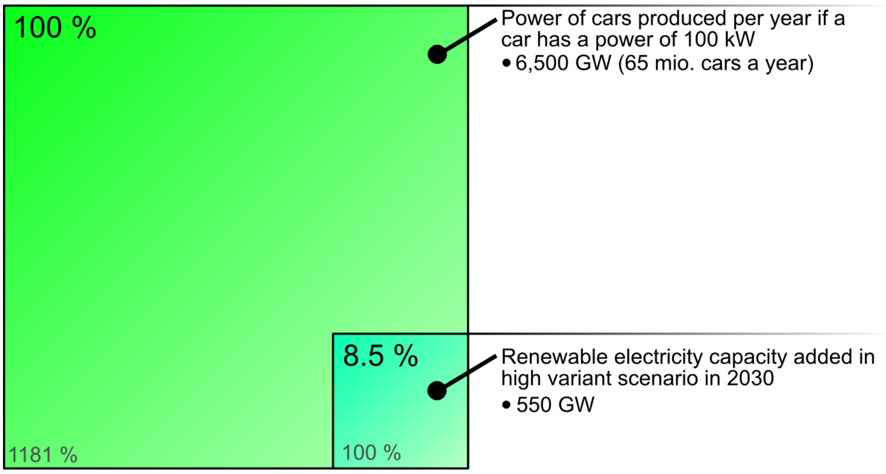


Figure 31: Power of cars produced pear year (today) compared to added renewable electricity generating capacity in the High Variant scenario in 2030 [EWG; 2008]. Car production: [PAWO; 2007].

The renewable electricity generating capacity added in 2030 in the “High Variant” scenario is 550.4 GW, which is less than one tenth of the actual power of car engines installed in cars produced in one year, or about the same power as Germany's annual automobile output.