Renewable Energy Potentials

Opportunities for the Rapid Deployment of Renewable Energy in Large Economies, Its Impacts on Sustainable Development and Appropriate Policies to Achieve It

Summary Report
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Background and overview

The debate on climate change has clearly shifted and the focus now is on mitigation and adaptation. To cut global greenhouse gas (GHG) emissions by at least half by 2050 and to achieve a peak and decline of emissions by 2020, reduction measures must be implemented immediately and sweeping actions prepared that will profoundly transform the world's production and consumption systems and patterns.

A major share of the potential for climate change mitigation lies in the energy sector. In the short term, energy efficiency (EE) and renewable energy (RE) are the major low-carbon options that are ready, viable, and available today.

A number of countries have introduced RE deployment policies in at least one of the three major markets: electricity, transportation, heating/cooling. Several of these countries can already demonstrate significant successes. Current annual global investment in RE power production assets surpasses investment in nuclear and most fossil fuel power, even when large hydropower – an already established RE technology – is not taken into account. Investment in biofuel assets is growing sharply and end-user investment in RE heat and cooling is accompanying the upward trend in energy efficiency.

It is being increasingly acknowledged that RE technologies have moved from the fringes to the mainstream of energy supply. However, there is a widespread preconception that RE technologies will not be able to reach a significant share of energy supply, even in the long run, because there would not be sufficient RE resources to produce the required power, heat, and fuels at an acceptable price.

The present report focuses on the world's large economies, which consume 80 percent of global primary energy and produce a similar share of global greenhouse gas emissions. Most of these economies are represented in the Gleneagles Dialogue. A significant increase in the use of RE and EE technologies in these countries will pave the path to a low-carbon future.

The report focuses on energy production potentials from renewable energy sources, their cost and regional distribution, as well as the extent to which RE technologies are able to provide sufficient and cost-efficient supply over the next 40 years. It identifies the **long-term supply opportunities renewable energy technologies offer in the energy markets** in the Gleneagles Dialogue countries (i.e. how much is realistically possible) based on the technical potentials, but taking into account the constraints that may hinder the realisation of the potentials (e.g. competition for land-use, technology cost, stock turnover, and others).

Addressing the sustainable development issues discussed in the Gleneagles Dialogue, the report also highlights the opportunities renewable energies present, not only for climate change mitigation and other environmental objectives, but also for economic development and employment, as well as for energy security. It makes the case for **the fast and large-scale deployment of renewable energy.**

The report also offers suggestions for achieving **deployment potentials**. The main elements and principles of national RE promotion policies are presented based on experiences to date in a number of countries. Finally, possibilities for removing barriers and promoting RE technologies in international policies and regimes are outlined and design elements suggested.

Scope and diversity of renewable energy sources

Renewable energies, more so than fossil fuels, represent a very broad and diverse array of energy resources - biomass, hydro, geothermal, wind, solar, marine or ocean energy, as well as conversion processes and applications - combustion, thermal, mechanical, electromagnetic, chemical, photovoltaic processes. Renewable energy sources and technologies are extremely versatile. The term "renewables" includes several families of resources (biogenic, geological, direct or indirect solar, magnetism) from which energy carriers including electricity, heat, and solid or liquid fuels can be produced and used for any kind of energy service needed (traction, process heat, lighting, heating, cooling, and others). **From a technical point of view, there is not an energy application for which renewable energy technologies would not be suited.**

Efforts to estimate RE potentials are rather recent and still cannot compare in scope and intensity with those to determine fossil fuel resources and reserves. This has resulted in asymmetric information and a high degree of uncertainty about RE resource potentials in many regions.

The present report draws on existing global databases and related assessment approaches. Data were inferred from those collected for related purposes, such as an existing global climate measurement system. Detailed bottom-up studies using specific equipment in some cases contradict the results of global studies. Unfortunately, bottom-up reports are still patchy and only available for limited numbers of countries or parts of countries. Moreover, they generally identify higher technical potentials, but sometimes also lower potentials. The authors of this report feel confident about the order of magnitude of the global assessment presented. Regional assessments, in particular for wind energy, should be considered with caution and substantiated with regional and local studies.

It is crucial that the information on RE resources be improved. Much more work is necessary to compile a global RE resources inventory to be able to provide governments and investors with reliable data.

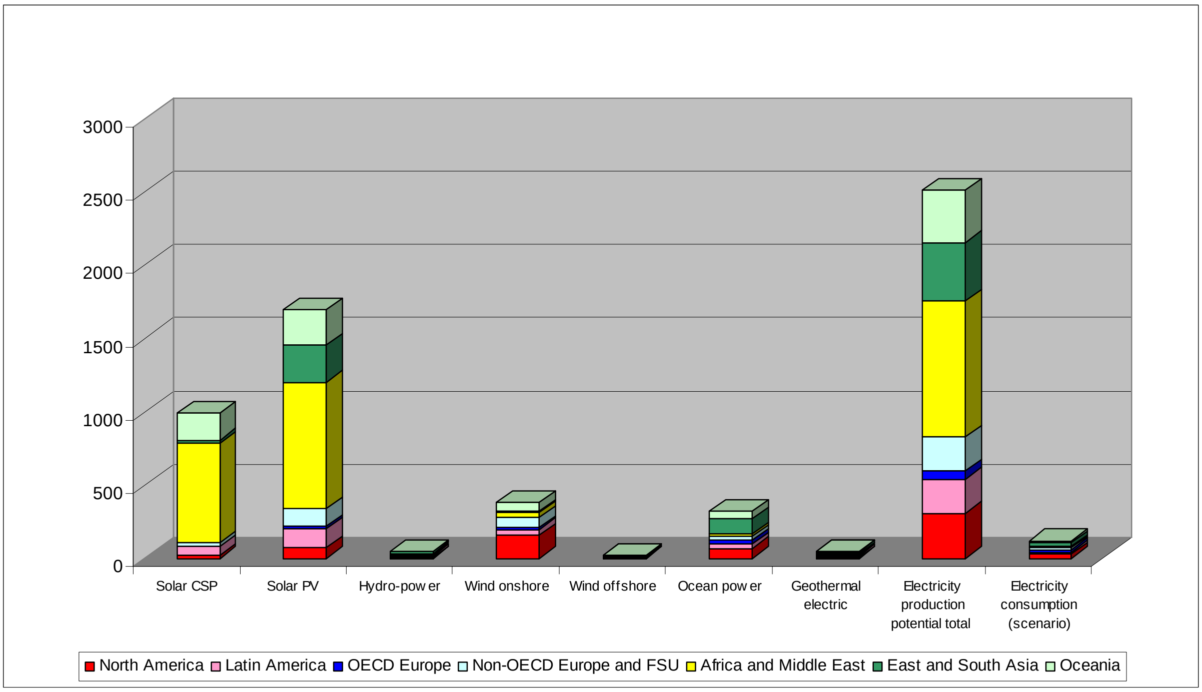
Energy production potentials from renewable energy sources

The overall technical potential for renewable energy – i.e. the total amount of energy that can be produced, taking into account the primary resources, the socio-geographical constraints, and the technical losses in the conversion process **– is very large and several times the current total energy demand. This is particularly due to the vast potentials of RE sources suited for direct *electricity generation***. According to the International Energy Agency's 2006 Energy Technologies Perspectives, global electricity consumption in 2050 could be between 113 and 167 Exajoule (EJ).[1] The technical electricity production potential of RE technologies, excluding biomass, is almost 2500 EJ/year. (Figure 1)

Solar photovoltaic (PV) technology can be applied almost everywhere, and its potential is estimated at over 1500 EJ/year, followed closely by concentrating solar thermal power (CSP). Since these two solar technologies would require much of the same land resource, however, their potentials cannot simply be added together.

Onshore wind has enormous potentials, with almost 400 EJ/year beyond the order of magnitude of future electricity consumption. The estimate for offshore wind potentials (22 EJ/year) is conservative, as it includes only wind-intensive areas on ocean shelves and outside shipping lines and protected areas.

Figure 1 – Technical Potential (ExaJoule per year), for RE Power Generation and Electricity Markets by 2050 (sources: Ecofys NL, REN21)

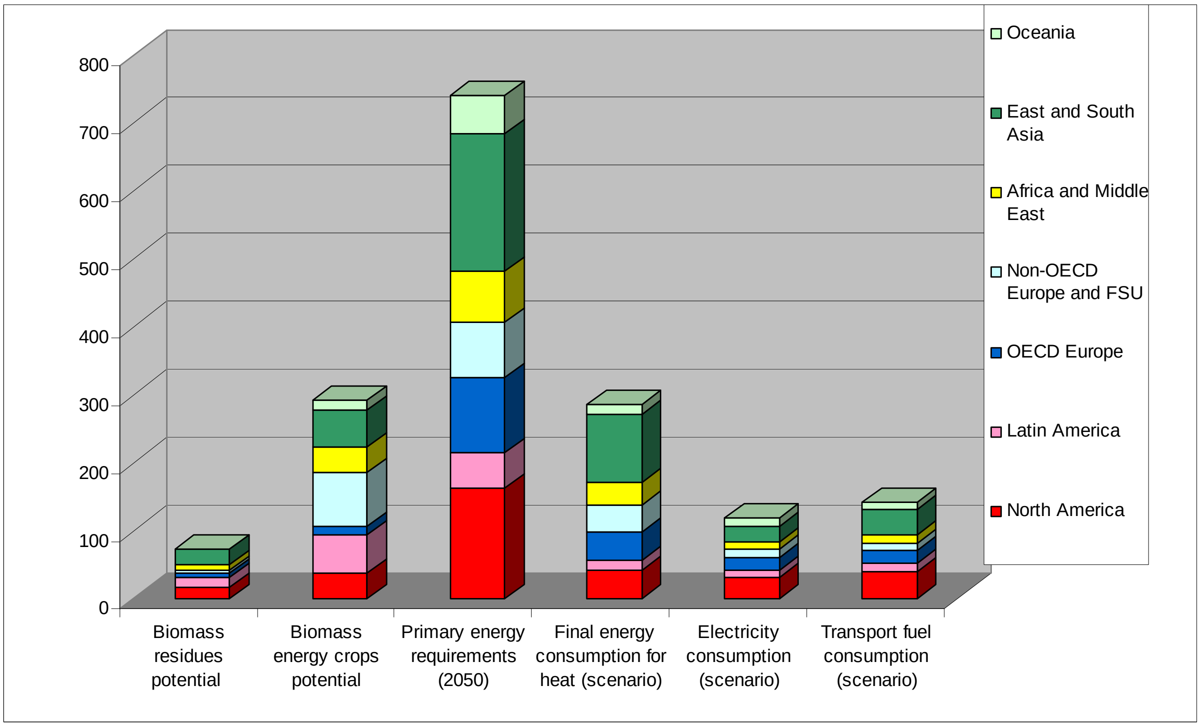


The potentials for ocean or marine energy add up to a similar magnitude, mostly from ocean waves. More cautious estimates arrive at around 50 EJ/year. The technical potentials estimates for hydro and geothermal power resources are well-established and are calculated at around 50 EJ/year for each.

Experts are presently debating the technical potential of bioenergy from crops. Whereas the estimates for biomass residues are less controversial, there are some differences in how residue and crop are defined. The present report assumes 360 EJ/year (70 EJ/y from residues and 290 EJ/y from energy crops) as a rather conservative, middle-of-the-road estimate within a range from 180 to 520 EJ/year. This would still leave sufficient land and biomass resources for food production.

Biomass can be used for both *electricity generation and heat supply*, as well as a basis for *transport fuels*. A comparison of the bioenergy potentials with the total primary energy requirements to cover future expected final energy consumption in the three markets[2] shows that there is clearly not enough biomass potential to cover all markets, as the total primary requirements would amount to over 700 EJ/year (Figure 2).

Figure 2 – Technical Bioenergy Potential (ExaJoule per year) and Energy Markets 2050 (sources: Ecofys NL, REN21)



From a global perspective, the rational choice of application for available biomass would seem to be feedstock for transport fuel, since there are other RE sources that could be used for electricity. Assuming that the entire potential of 360 EJ/year was transformed into biofuels, this would result in approximately 10 billion tons of oil equivalent (toe) fuels being available in the form of gasoline, diesel, or other. Using climate-friendly feedstock like sugarcane and lignocelluloses would avoid greenhouse gas emissions. The low potential estimate would result in about five billion toe, which would compare to the five to seven billion toe transport fuel consumption expected for 2050 according to the IEA ETP scenarios.[2]

That would mean, however, that no biomass sources could be used for either heat or electricity, implying that the often-cited two billion people relying on biomass for cooking and heating would no longer have access to it for these purposes.

This preliminary rough calculation indicates that biofuels will not be able to satisfy the total transport market demand. Faced with these choices, individual countries will set their own priorities. Some may use available biomass in the electricity sector for efficient carbon mitigation, preferably in combined heat and power production. Others will choose to replace fossil fuel in the transport sector.

Direct geothermal energy can be used for *heating and cooling*. The potential is huge and could cover 20 times the current world energy demand for heat. The potential for solar heating, including passive solar building design, is virtually unlimited. However, transporting heat is expensive to and therefore only the potentials of geothermal heat and solar water heating that are close enough to consumption areas should be considered (see also below: The challenge of matching supply and demand). Passive solar technology, which in fact contributes significantly to heating services, is not considered a (renewable energy) supply source in this analysis, but as an efficiency factor that is implicitly accounted for in the demand.

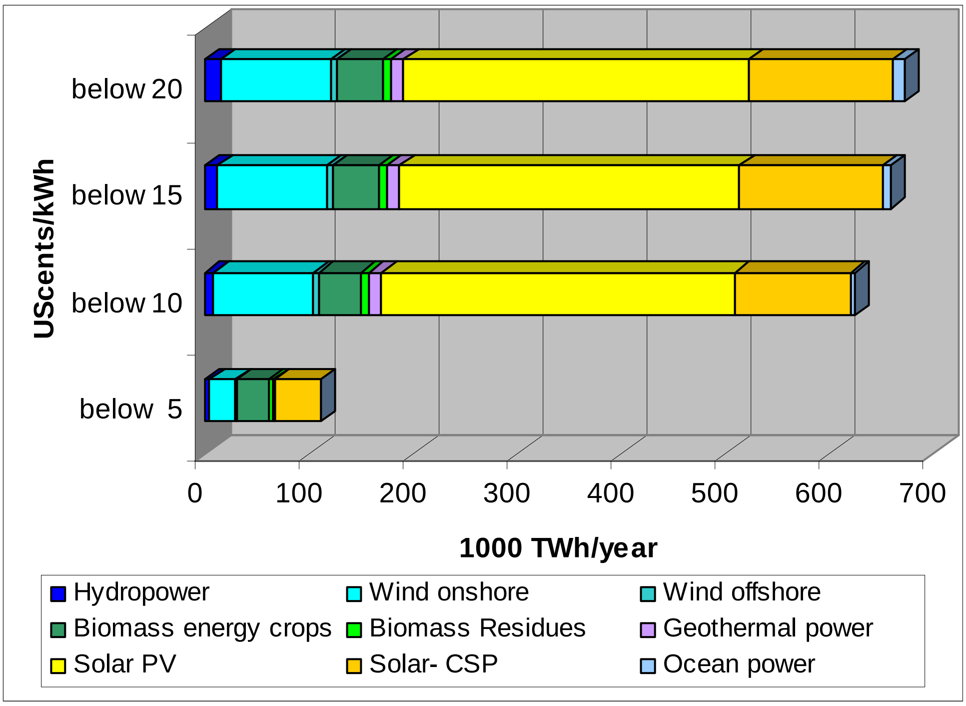
Expected cost of energy production from renewables

The renewable energy technologies for *power generation* are currently at different stages of technology development, with hydropower already a sophisticated technology and onshore wind and some biomass power well established. As they mature, offshore wind, concentrating solar thermal power and solar PV, geothermal, and marine power are also becoming less costly. **Following hydro, wind, and biomass, all RE technologies are becoming cost-competitive with other low-carbon technologies *in electricity generation.***

By 2050, a substantial part of the technical global power potential of RE sources could be transformed into electricity at costs between US$0.05 and US$0.10/kWh[3]. The potential of producing power on plant site from renewables at a cost below 10 cents per kWh would amount to 600 TWh per year. Solar has the largest potential. Concentrating solar thermal power (CSP) and solar photovoltaics (PV) could together produce 450 TWh.

Approximately 100 GWh of this electricity could be produced at costs below US$0.05/kWh, mostly from onshore wind, biomass, and solar CSP in favourable locations, as well as hydropower and even some geothermal.

Figure 3 – Potential for RE Power Generation below Cost Benchmarks
(Sources: Ecofys NL, REN21)



There is still some unexploited potential of hydropower at relatively low cost. About a third of the onshore wind potential also has low production costs. Offshore wind power is expected to be available at specific locations at below US$0.10 /kWh. For geothermal power generation most of the potential is in geologically active and the cost is expected to be below US$0.10 /kWh. Its high capacity factor (in the 90 percent range) often makes geothermal an attractive option.

Concentrating solar power is a rapidly maturing RE technology for electricity generation. It is expected that costs can be cut by more than 50% relative to current demonstration projects. Production, however, would be concentrated in areas with very high insolation. By 2050, large parts of the abundant solar PV potential will be available at below US$0.10 /kWh, also in regions with medium intensity of sunlight.

Since the most promising ocean power technologies are still at an early stage of development, their costs are still uncertain. It is expected that some costs will be below US$0.15 /kWh and may even be lower in places with strong tides and regular waves.

Modern biomass sources have a high technical potential for electricity production at low cost. Most of the biomass crop potential can be transformed to electricity at low cost when very low feedstock costs are assumed. Residues offer additional low-cost opportunities. In the estimates presented here, most of the primary biomass sources from crops and residues would be used for electricity generation. If, however, a considerable part of the biomass potential were allocated to transport fuel, the potentials for electricity generation would be that much lower.

The production cost of *transport fuels* from biomass is competitive with that of fuels from crude oil. Ethanol from biomass will cost between US$0.25 and 0.35 (from sugar cane) and US$0.40 to 0.60 (from various kinds of lignocelluloses, the next generation technology) per liter equivalent to gasoline. Biodiesel is expected to cost between US$0.40 (animal fats and vegetable oils) and US$0.65 to 0.80 when produced from residues or short rotation forestry crops in a Fischer-Tropsch synthesis process. These biofuels become increasingly competitive with gasoline and diesel when oil prices pass the US$45 per barrel threshold.

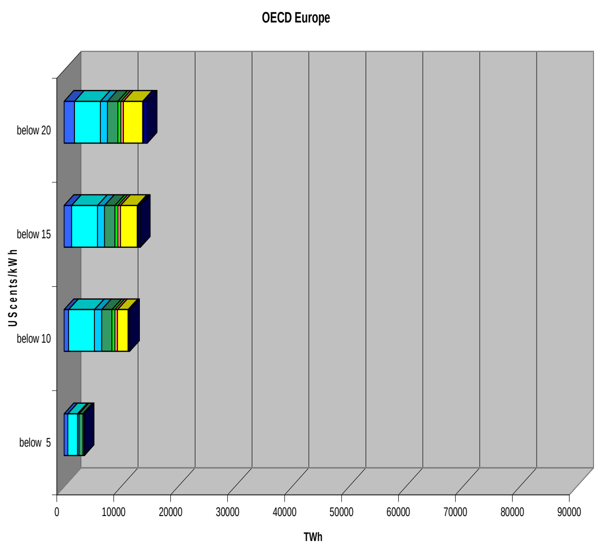
Production costs depend not only on the production process, but also on the costs of transporting the feedstock. Therefore, collecting all the biomass feedstocks for producing fuels in industry-size production would become increasingly costly. Therefore, fuel-cost considerations, apart from competing uses of feedstocks for heat and electricity, would determine the availability of biofuels.

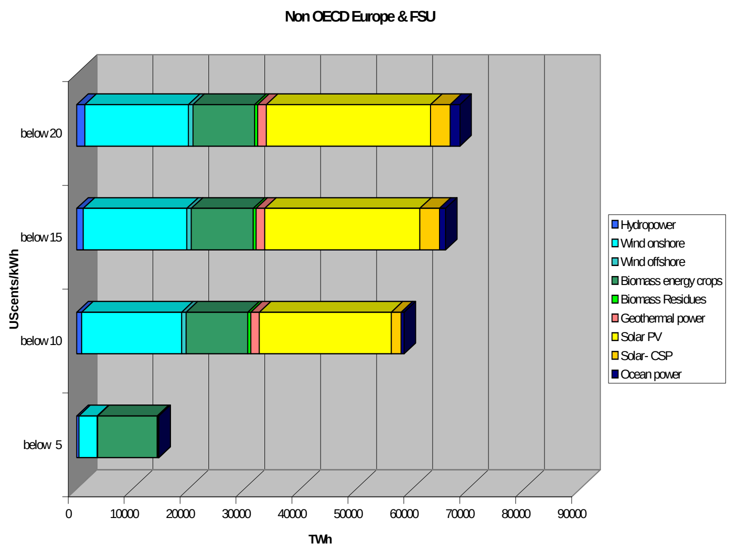
Biomass can provide heating at US$5/GJ (residues) to US$30/GJ (pellets) and **provides the most cost-competitive renewable energy technologies for *heating* applications**. Geothermal heat pumps based on shallow geothermal systems applied for both heating in winter and cooling in summer can be cost-competitive at approximately 25US$/GJ. Deep geothermal energy, were it easily accessible, would be the cheapest power source. Solar thermal water and space heating in 2005 cost on average 60 US$/GJ in industrialised countries and much less in China. Costs are expected to drop by 40% in industrialized countries by 2030. Solar-assisted cooling cost up to 400 US$/GJ in 2005, but is expected to see a reduction of around 50% by 2030.

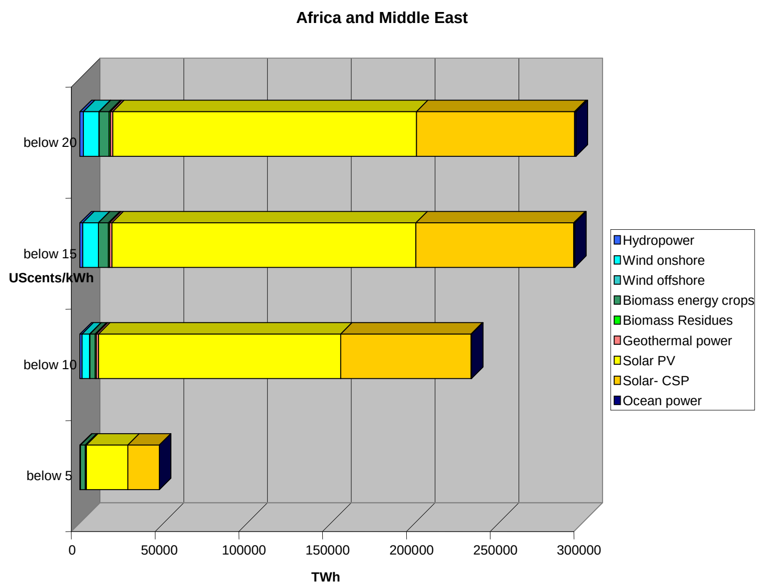
Regional renewable energy potentials and cost

OECD Europe has relatively limited low-cost power production potentials from renewable energy sources. Potential supplies to cover its expected electricity consumption of 5 to 6 TWh by 2050 would cost above US$0.05/kWh. OECD Europe could import electricity produced from RE sources in Africa, as well as from non-OECD Europe & the Former Soviet Union. Both could produce electricity at low cost in large quantities in excess of their demand – from Africa based on solar PV and CSP, from Eastern Europe based on wind and biomass.

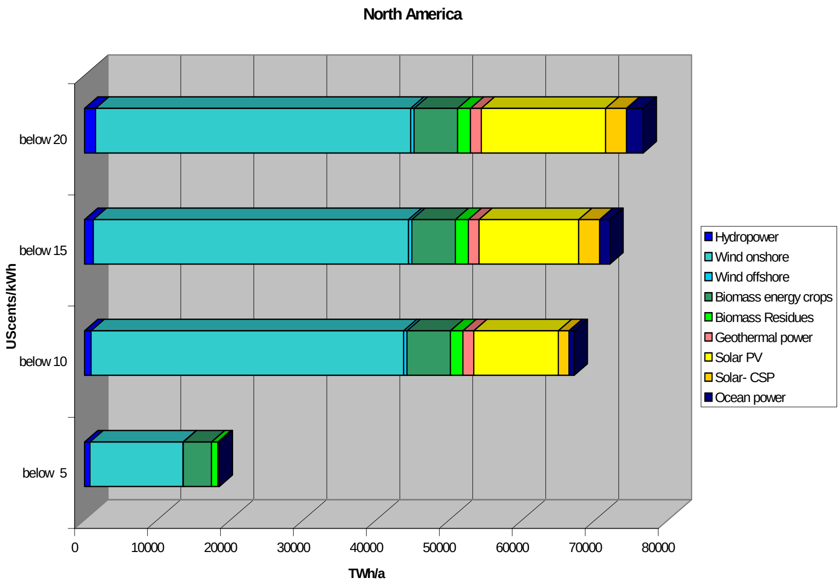
Figures 4: Regional Potentials for RE Power Generation
(sources: Ecofys NL, REN21)

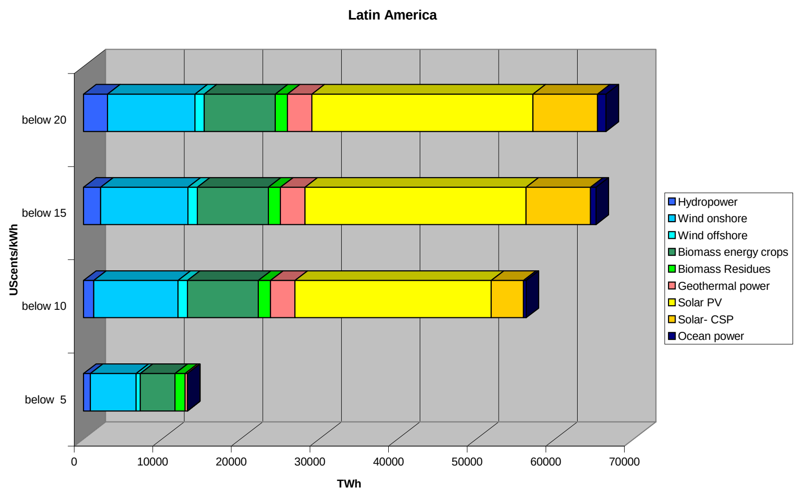






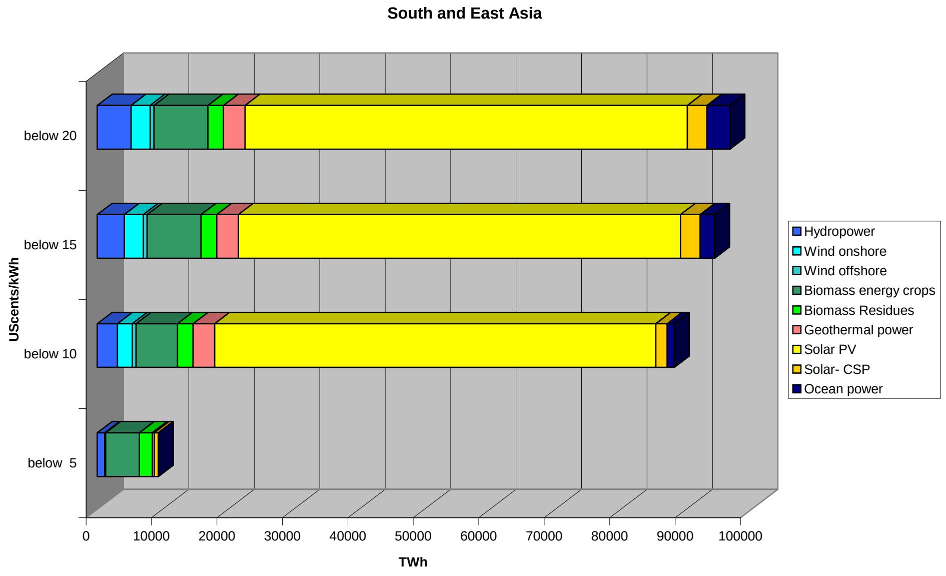
North America is in a better situation than Western Europe, with opportunities to use large wind and biomass power potentials, and at somewhat higher costs more wind, solar, and geothermal potentials.

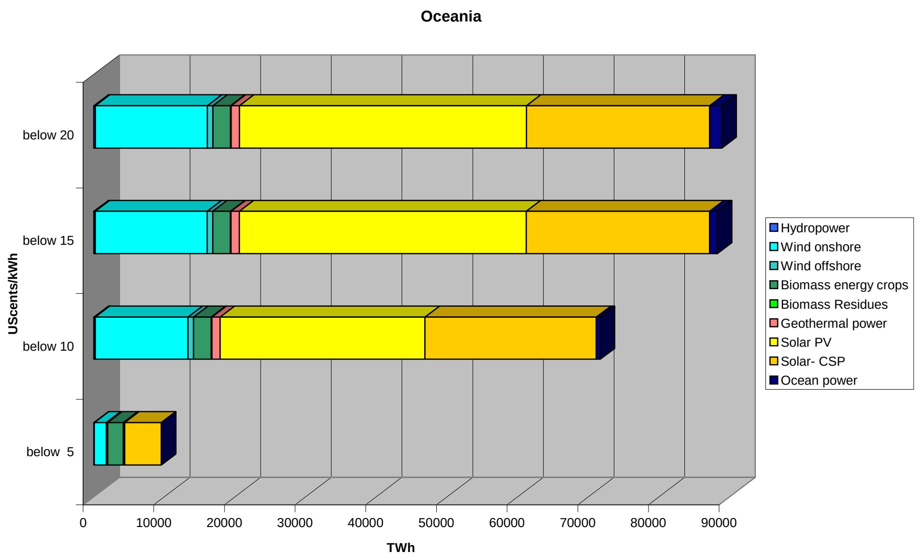




Latin America has large low-cost wind potentials, although mostly at the southern tip and far away from consumption areas. Low-cost biomass power potentials and hydropower are more readily available. Solar and geothermal energy enter the picture at somewhat higher costs.

East and South Asia, as well as Oceania, have enormous solar potentials. Some countries have particularly good potentials in hydro, biomass, and geothermal.





The challenge of matching supply and demand

The cost assessments presented consider production cost where and when the renewable energy source is available. Meeting demand for electricity, heat, and transport fuel requires storage and transportation, which involves additional costs.

In the case of *transport fuel* the semi-finished or finished product can be stored and transported in conventional ways, even over large distances, at a fraction of the production cost. Transport fuel can therefore be viewed as a global market. However, it is instructive to note the regional balances of future transport-fuel consumption and biofuel potentials. In a purely mathematical comparison Western Europe is far from being able to produce the biofuel it would need to meet 100 percent of its transport fuel demand. North America, despite the high potential it has, is also unable to produce all of the biofuel it needs. And even South and East Asia would hardly have sufficient potential to serve their fast-growing transport fuel markets. The same applies relatively to Africa and the Middle East. There are only two regions that may have surplus and export potentials on the basis of their high potentials: Latin America and non-OECD Europe. Trade patterns, however, follow willingness to pay and are driven by tariff and non-tariff barriers and incentives. As a result, biofuels will be exported from regions that could very well use the biofuel domestically.

By contrast, storing and transporting *heat* is very costly and only justifiable for short periods of time and over short distances. Heat is used locally where it is produced. Therefore, most of the high potentials existing for low-temperature geothermal heat are not available for heating purposes, because they are remote from demand. The same applies to solar water heating, the potentials of which are calculated exclusively from rooftop installations within settlements.

In the case of *electricity,* matching supply from RE sources and demand is a challenge, particularly for the use of variable, non-steady resources such as wind. However, the claim that meeting large-scale demand with wind is too costly because of the system additions needed (grid integration, capacity and frequency backup, transport, and storage) no longer holds. Scandinavia has demonstrated that even where the wind resource is very variable, an integrated local and sub-regional market accommodating more than 30% wind in a part of the market can be developed at little additional cost.

In 2050, some of the large (energy) consumers such as Europe, North America and perhaps Latin America, and the Former Soviet Union will become interrelated electricity markets. Some sub-regions like Australia, China, and India will also be integrated. Strong connections are expected between North Africa, Middle East, Eastern and Western Europe with the option to transmit electricity from any production site to any consuming site at a limited cost. The exceptionally low cost of production will even allow transmitting wind-generated electricity from the southern tip of South America or solar power from North Africa to the consumption centres.

Additional system components therefore do not pose insurmountable obstacles or add high costs. Additional system costs associated with supplying electricity from RE sources and aligning supply and demand are in the range of US$0.01 to 0.02/kWh and do not significantly alter the competitiveness of RE sources in the future electricity markets.

It must be noted here that in the discussions about reaching a low-carbon economy, renewable energy sources are competing with such technologies as carbon capture and storage and nuclear energy. Neither of these technologies is currently available at a competitive level of cost, acceptable risk, or technical feasibility.

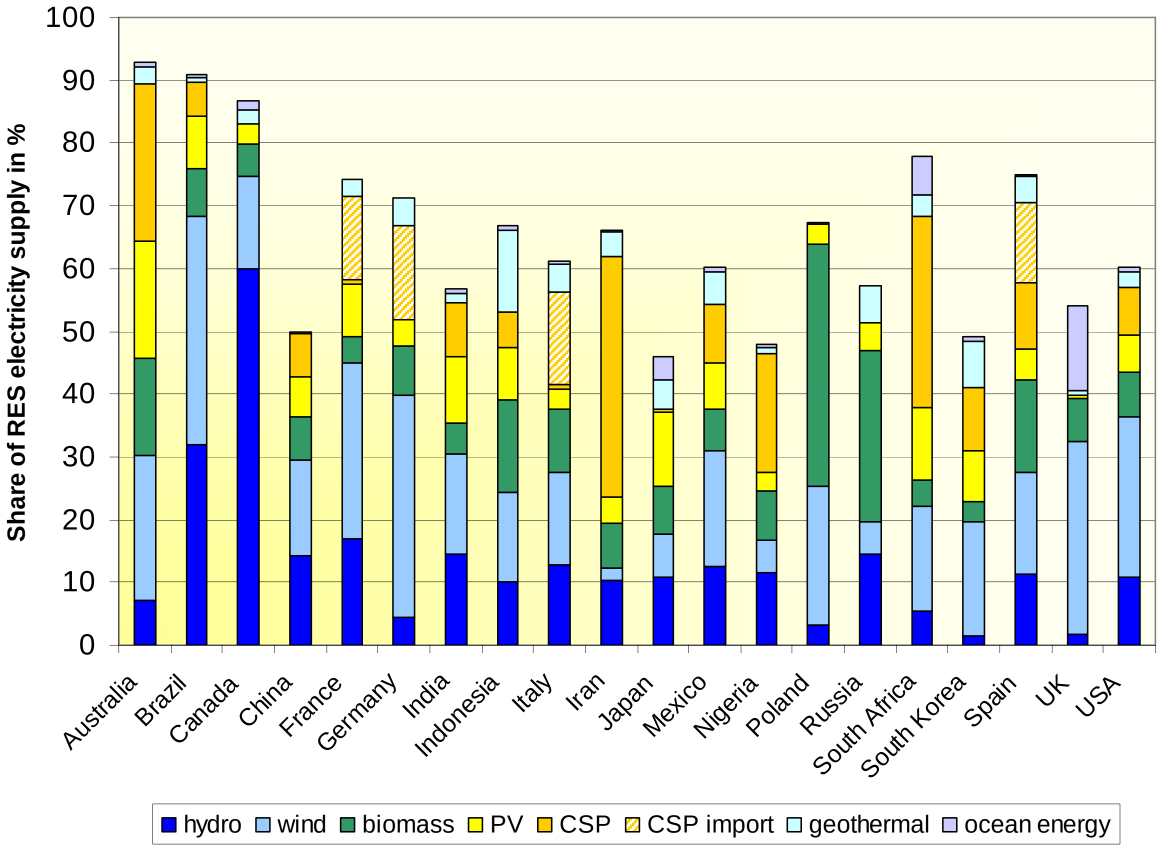
The following assessment of the deployment potentials takes into account the physical and economic conditions of matching supply and demand in the three markets: *heat, power and transport fuel.*

Deployment potentials in large economies

REN21 has asked experts to assess the long-term potential share of renewable energy in each large country and major market, based on the technical potentials and their prospective costs. This assessment of deployment potential[4] coupled with efficiency, which reduces supply requirements, assumes a strong growth in renewables within the framework of each economy's energy demand growth.

Renewable energy could contribute at least half of all *electric power* in each of the large economies by 2050, even those with significantly higher electricity demand. In several countries over two-thirds is realistic, in some countries renewables could contribute over 90 percent.

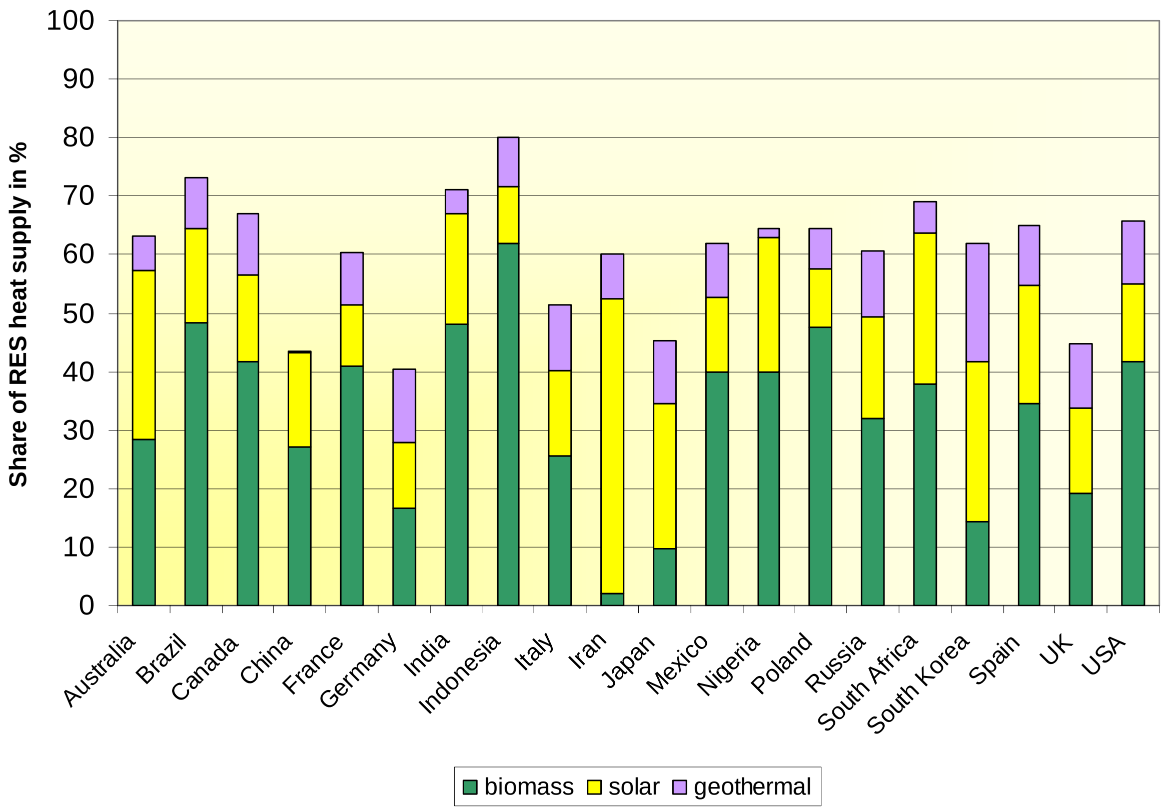
Figure 5 – Deployment Potential of Renewable Energy in Electricity Supply in Large Economies 2050 (sources: DLR, REN21)



The picture for 2050 will include a wider variety of RE resources contributing to power generation than is the case today. Once hydropower potentials have been exploited, additional demand will be covered by other renewables. Even taking into account intermittency, wind, biomass, CSP, and solar PV are expected to become equal to hydro in importance (Figure 4). Countries will focus their efforts on the RE technologies that are most available to them. For example, Australia may concentrate on solar and wind, Canada on hydro and wind, Russia on hydro and biomass, UK on wind and ocean energy, Indonesia, Mexico and Italy may add considerable amounts of geothermal power. Some European countries will import solar power from Africa.

In the *intermediate term -- 2030*, wind energy as well as biomass may already achieve a considerable market share in addition to hydropower, which will reach its full potential during this period. These sources can meet a major proportion of incremental electricity needs and replace obsolete carbon-intensive capacities in the short and medium term when combined with energy efficiency to reduce demand growth. CSP and solar PV, as well as geothermal in some countries, can already contribute significantly to power generation before 2030, with more potential to be exploited after 2030. **Starting the transformation of the power supply system to RE sources now puts RE on the path to attaining high market shares by 2050**.

Figure 6 – Deployment Potential of Renewable Energy in Heat Supply in Large Economies by 2050 (sources: DLR, REN21)

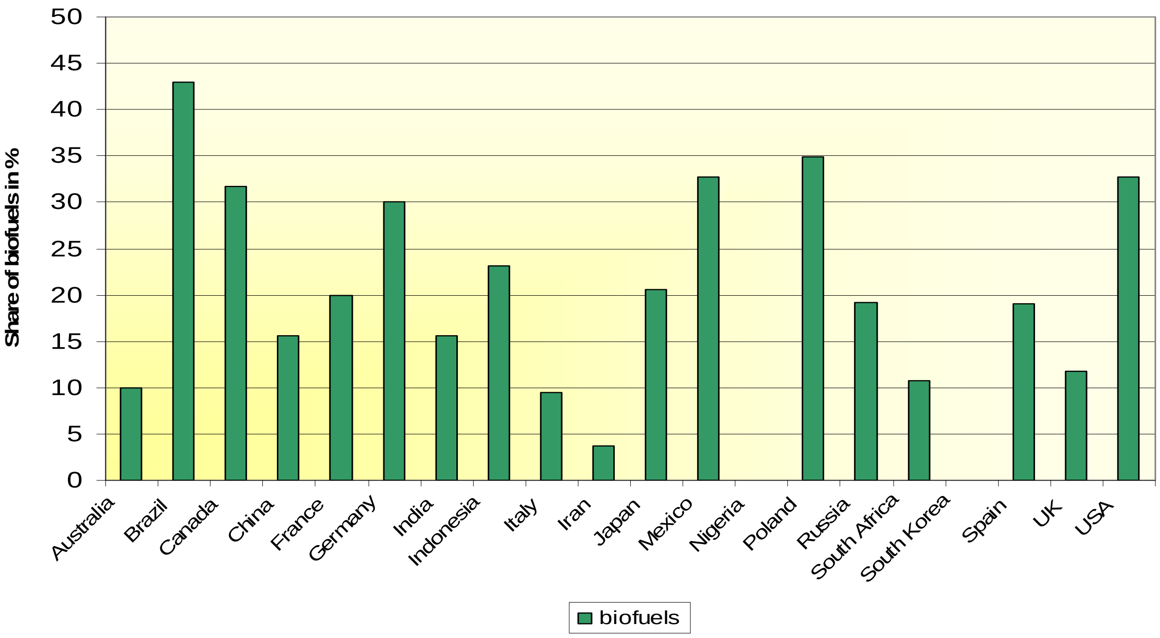


For the ***heating and cooling markets*** RE technologies can realistically achieve very high market shares of between 40 and 80% by 2050. Apart from biomass, solar water heating can contribute significantly, and geothermal will be a leading resource (Figure 6). **However, low-carbon energy supply can only achieve large market shares when very energy-efficient heating and cooling systems are utilized.** Energy efficiency works hand in hand with renewable energy, even more so in building and industrial energy than in any other sectors. Combined heat and power from biomass, or biogas additions to the gas supply systems, may jointly serve electricity and heat markets.

A transitional situation arises in *the intermediate term 2030*. Some countries will still have a relatively high usage of traditional forms of biomass (though less than at present), as it will take time to fully replace the older technologies with modern forms of biomass, solar heat and geothermal.

The 2050 potential of RE is more limited in the *transport fuel markets* than in the electricity and heat sectors. In large economies, when only domestic biomass is used (and preferably for heat and electricity because of its higher mitigation impact), bioenergy will only be able to cover up to 45 percent of the transport fuel demand (Figure 7). Brazil would be at the high end, Canada, Germany, Mexico, and USA would reach around 30 percent. In some countries domestic biomass may not be used for biofuels. When priority is given to electricity and heat, in most countries biofuels will only be able to only cover 15 percent of the transport fuel market by 2030. If priority is given to the transport market over that of electricity, market shares may be higher by 2030, particularly in Brazil. Competition for land, water, and food supply and the success of new technologies will ultimately determine how much biomass is available for energy uses.

Figure 7 – Deployment Potential of Biofuels in Transport Fuel Markets in Large Economy Shares by 2050 (sources: DLR, REN21)



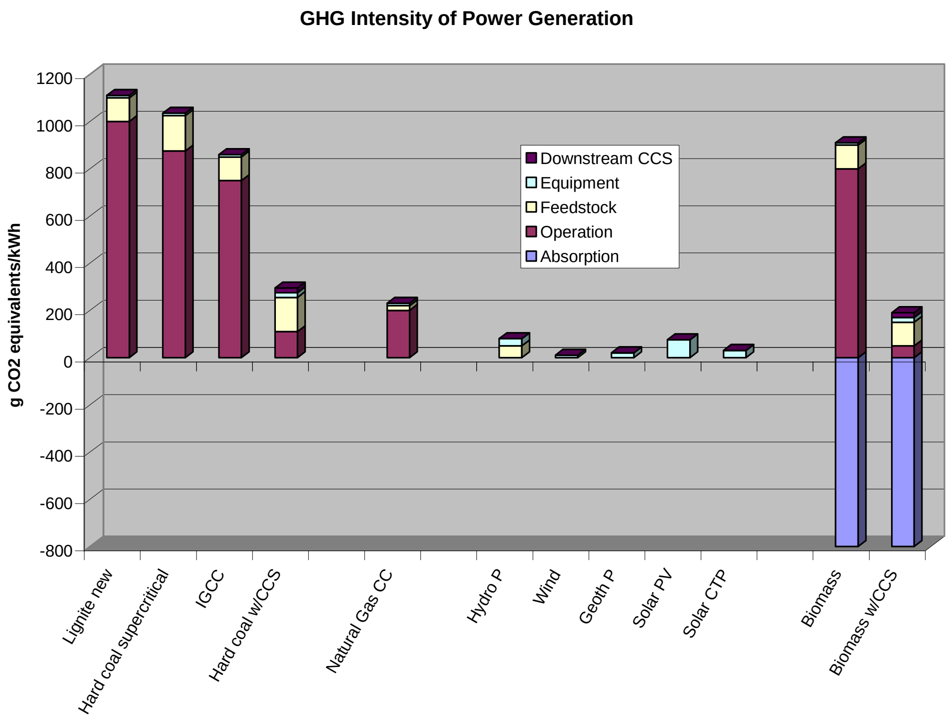
Which transport technology and infrastructure will ultimately be chosen for the future remains uncertain. **Biomass fuels can support but not sustain the transition away from the current oil-based system.** In the long run, oil products may be largely replaced by either electricity or hydrogen-based systems. Both alternatives would need renewables as the primary energy input.

Climate change mitigation impacts

Implementing the renewable energy deployment potentials outlined above in the large economies would bring these countries and the world a long way towards reducing greenhouse gas (GHG) emissions. In fact, the sharp reduction of GHG emissions required to attain the objectives for 2050 and to reduce emissions before 2020 **is only possible with low-carbon technologies like renewables, which dramatically reduce emissions of power and heat production.**

In 2005, global average carbon intensity of *electricity generation* was slightly higher than 600g CO2 equivalent per kWh. Without carbon capture and storage (CCS), coal-fuelled power has GHG intensities of at least 750 g CO2e per kWh, even with newest technologies like ultra super critical plants or Integrated Gasification Combined Cycle (IGCC). When the GHG emissions in the upstream value chain are included, the CO2 intensity is even higher. Even with CCS, CO2 emissions per kWh can barely be reduced below 200 CO2e when the disposal process of CCS is included, which makes it comparable to natural gas power (see Figure 8).

Figure 8: GHG Intensities of Power Generation Technologies
(sources: Öko-Institut e.V.and REN21)



The GHG intensity of hydro-, wind-, solar- and geothermal power is below or around 100g CO2e, even when the upstream value chain is taken into account (equipment manufacturing, etc.) In the case of power from biomass the net effect may reach 100g, as GHG emissions from operations and upstream are partly compensated by the absorption of CO2 during plant growth. If CCS were to be coupled to biomass power generation, a negative GHG emission intensity could be achieved.

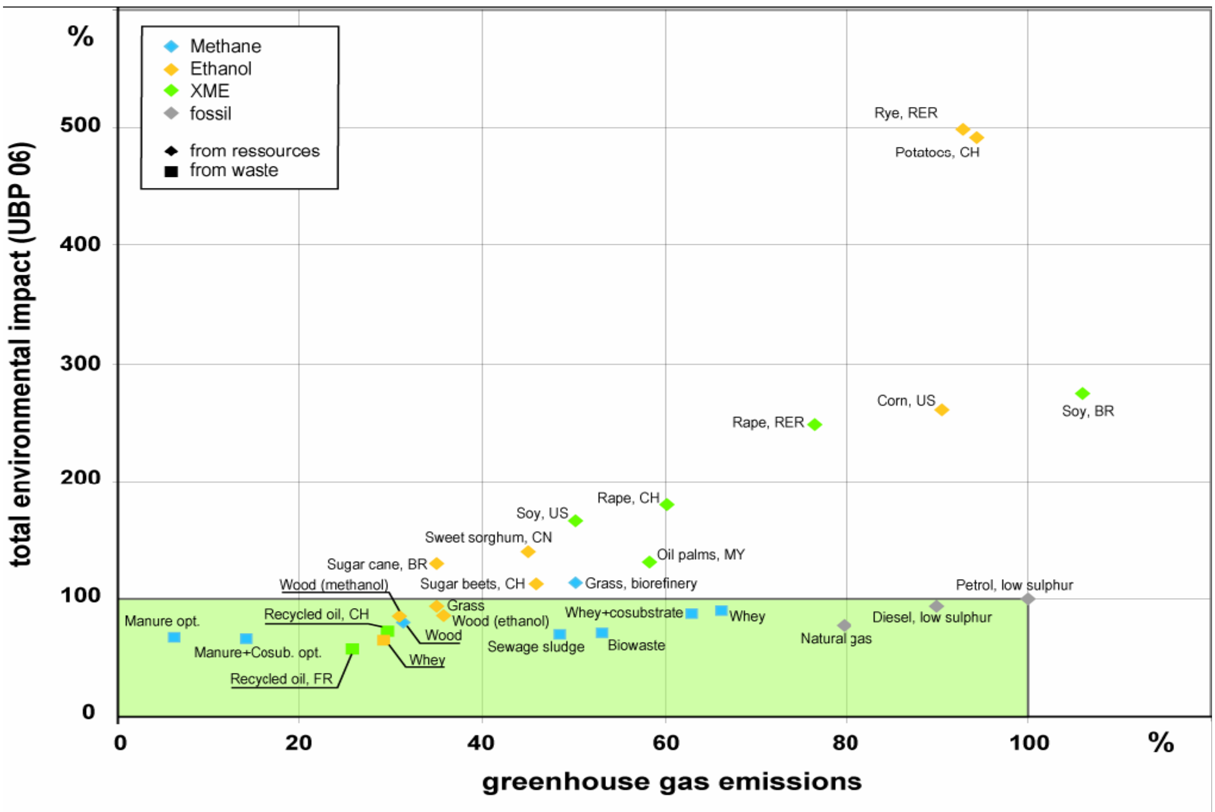
Thus, **a high share of RE power would greatly reduce GHG emissions from electricity generation,** especially if it replaced fossil fuel power, in particular coal power without CCS.

Furthermore, the deployment of renewables also drastically reduces the intensity of other emissions such as SO_2, NOx, and particulate emissions from the power sector, although these emissions also can be reduced by using specially designed equipment.

The penetration of renewables in the *transport fuel* market would have a similar impact on GHG emissions when they replace oil-based fuels. Greenhouse gas emissions of oil-based transport fuels are around 5 kg CO2 equivalent per litre gasoline or diesel, including the emissions caused upstream in production and processing. Greenhouse gas emissions from oil shale and oil sand are even higher, and transport fuels from coal liquefaction cause close to 10 kg CO2 equivalent per litre.

In Figure 9 the results of a recent study on greenhouse gas emissions and total environmental impact of numerous biofuels technologies are presented, normalised to low sulphur petrol (=100).

Figure 9: Environmental Impact of Transport Fuel Production and Consumption (source: EMPA)



Some of the current biomass-to-liquid (BTL) or biofuel production technologies, i.e. the ethanol from fermentation of maize and grain, cause GHG emissions in the same order of magnitude as crude-based fuels and thus do not contribute to climate change mitigation (but are promoted for energy security and agricultural policy reasons). Sugar cane-based ethanol and diesel from vegetable oils clearly have higher GHG reduction benefits, as has ethanol from lingocellulosic fermentation, which uses forestry and agricultural non-food feedstock. Unfortunately, some of the biofuel technologies that have a positive GHG balance carry significant environmental risks (loss of biodiversity, water shortage, etc.). Therefore, sustainability criteria and/or product quality specifications need to be applied.

Even if only less than half of the global transport fuel demand could be met by biofuels that comply with sustainability criteria, the contribution to GHG abatement would be substantial. Renewables could contribute indirectly to a reduction of oil products and their respective GHG emissions in the transport sector when the share of electricity is increased through mass transport and electric or hybrid electric vehicles and the electricity is produced from renewables.

Finally, in the *heat* market renewables could substitute for oil and natural gas. Together with energy efficiency and passive solar design in buildings, the deployment of geothermal heat and solar water heating and cooling are the main options to substantially reduce GHG emissions from the heat market.

The specific GHG intensity of an energy unit of heating or cooling is structurally similar to that of power generation with coal, heating oil, or gas at the upper end. Geothermal and solar water heating do not emit GHG gases during operation. Biomass fuel basically emits as much CO2 as it absorbs during growth. Environmental concerns are related to traditional biomass use and, in particular, to the low efficiency of the charcoal value chain.

Investment requirements, economic development and employment impacts

The renewable energy deployment potentials outlined above present significant opportunities for the respective economies, not only for addressing the challenge of mitigating climate change, but also for creating value and employment. In fact, **implementation of these deployment potentials will transform the energy and related sectors.**

According to DLR Germany, implementation of these potentials would require some US$400 billion per year in energy production assets between now and 2050, about US$250 billion per year of which in the electricity sector alone. If the remaining 20% of countries not covered in this study are taken into account, this would mean US$500 billion per year globally.

Investment in renewable energy has increased over the last five years, According to the UNEP/New Energy Finance Global Trends in Sustainable Energy Investment 2008 report,[5] the total value of renewable energy transactions in 2007 was $148.4 billion, up 60% from 2006. Of this, $98.2 billion went into new renewable energy generation and $50.1 billion went into technology development and manufacturing scale-up. Obviously, this trend must continue for many years in order to reach the average of approximately US$400 billion per year, and the UNEP report predicts that renewable energy investment will reach $450 billion a year by 2012 and more than $600 billion a year by 2020. This would appear to be achievable, considering that the IEA estimates that US$22 trillion in investment will be needed in energy-supply infrastructure by 2030, which means an average of US$830 to 920 billion per year. US$400 billion would represent half of the annual energy investment required.

Depending on the technology being substituted, this investment could displace up to 60-80% of investment in other technologies of energy supply sectors like fossil fuel power generation, and supply chains of fossil fuels. In the heat markets implementation of the deployment potential would mean more district heating and cooling grids in cities, as well as more technology investment in buildings and industrial plants. In addition, several tens of billions would be required to build a transmission and transport infrastructure, which would be different from a system supplied by fossil fuel and nuclear power. The additional transmission lines, the change in network configurations, storage, and backup would require additional investment.

Overall, net investment requirements for a renewable energy system are higher than those for a fossil energy system to supply the same amount of energy. **The increased capital costs, however, are amortized by the lower energy bills**.

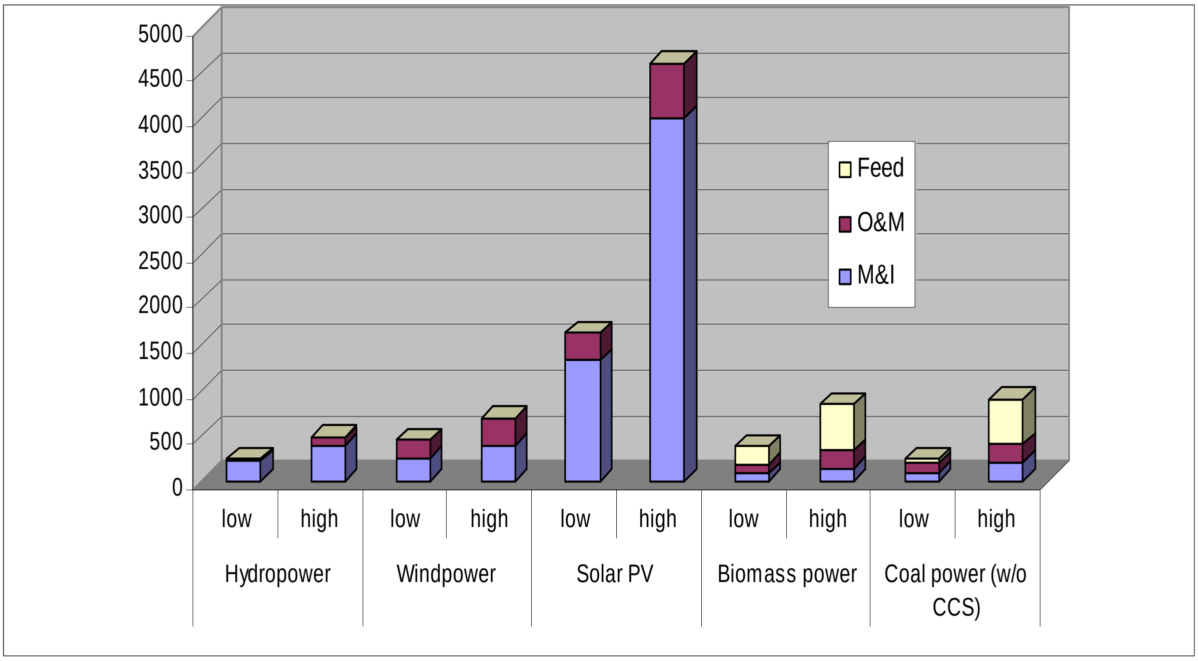
The renewable energy deployment modifies the geographical pattern of investments. **In an energy system dominated by renewable energy, investments tend to be located in energy-consuming rather than energy producing countries.** Investment in wind, solar, and other energy-generating facilities will not only replace investment in coal and gas power plants, but also investment in the fuel supply chain. The growth of biofuels in the transport markets would also increase domestic investment in countries where the biofuel products are grown, processed and brought to the market, not only in production assets but also in the feedstock supply chain. On a global scale, this investment would replace investment in fossil fuel feedstock chains, much of it in oil producing countries.

In addition to investment in production and feedstock supply assets (including their respective network and storage systems), a substantial amount must be invested in the varied and sometimes multistage equipment manufacturing and installation value chain, since RE technologies are mostly new technologies. In any case the equipment manufacturing and installation business structures for the energy sector will also change. Different technologies give rise to different players and countries in the supply chain. Forward-looking technology companies have already incorporated RE technologies in their product line. Countries are making sure they have the technologies at their disposal.

Renewable energy equipment manufacturing and installation (M&I) is high-quality labour-intensive. RE asset operations require services, while biomass feedstock supply establishes a whole new value chain.

Figure 10 gives the results of preliminary quantification of the employment effects in the value chains related to some major RE technologies for electricity generation and, as a benchmark, compares them to similar calculations for conventional coal power. Very little empirical research exists in this area and the numbers should be taken as indicative.

Figure 10: Employment Effects of Power Generation Value Chains in jobyears per TWh (sources: ZSW, IEA IA Bioenergy, Kammen LBL, RE Policy Project, REN21)



What becomes evident in this comparison is that, apart from PV, the total employment intensity of the entire value chain related to a unit of electricity produced hardly differs between coal and renewables. However, **the branches of the value chains show substantial differences in scale and scope of the RE technologies**: biomass power technologies have a labour-intensive feedstock chain, which does not apply for wind, solar, and others, but does for fossil fuel power in the primary energy supply chain. Solar PV has labour-intensive manufacturing and installation stages of the value chain, while hydropower has a labour-intensive construction stage, which we include in the M&I chain. Wind power has significant labour intensity in operation and maintenance, as does solar PV power. In the case of coal the labour intensity of the value chain is largely determined by the type of mining, as employment varies widely between open pit and deep mining.

These features are being used by some countries and regional and local governments in their business development policies. Developing markets for electricity, heat, and/or fuel from RE sources and the installation of RE production assets like wind farms or solar roofs is combined with the localization of respective equipment industries and services and, in case of rural development interest, the establishment of biomass feedstock chain and processing.

Some countries have taken the lead as first movers and have already achieved significant employment in one or more RE technology areas. During the recent surge of renewable energy, the value added and the number of jobs created have become very significant. Overall, Germany is currently reporting around 260,000 jobs in renewable energy and related industries. Other countries, provinces, and federal states, as well as companies report similar success stories. The multiple benefit of associating RE market development with RE business development is increasingly understood by many countries, in particular by energy importing countries. Even large fossil fuel producers like China have shaped their policy to make sure they benefit economically from renewables. REN21 Global Status Reports estimate that 2.4 million people were employed in the RE industry in 2006.

Increasing shares of renewable energy in the energy supply means decreasing shares of fossil fuel and also means jobs in fossil fuel industries are being replaced with jobs in RE industries. **An increased share of renewables in the energy mix positively affects employment, especially in energy importing countries, provided the respective national and local governments pursue appropriate industrial and employment policy goals**.
The fear that value creation and jobs would migrate to energy-consuming countries partly explains why large fossil fuel exporting countries used to oppose RE and were reluctant to use RE technologies in their own countries. Now, however, many of these countries recognise that RE technologies provide an opportunity for them to replace fossil fuels in some applications and save fossil fuels for export and premium markets like transport and the chemical industry. In fact, many fossil fuel exporting countries in the Middle East and North Africa, as well as Venezuela, Nigeria, South Africa and Australia have excellent renewable energy potentials.

The argument that RE sources and technologies are more expensive and thus increase costs and reduce competitiveness of an economy is no longer valid today for many renewables. Moreover, as was illustrated above for the more expensive RE technologies, costs are expected to come down at different times in the future. When good-quality RE sources are available, more of these technologies will become cost-effective during the next decade, in particular, when carbon-intensive fossil fuel technologies are no longer eligible under a climate change mitigation and adaptation regime.

When fossil fuel-based technology is replaced with renewable energy systems to produce a unit of secondary energy, energy is replaced with labour and capital, often with input of labour upstream. The substitution effect (skilled labour for fossil fuel) is even greater when energy efficiency and renewable technologies are used in combination to produce energy services such as space heating.

Some of the large developing economies and many of the smaller ones still have significant populations that do not have *access to good quality energy*. Individual RE systems and RE mini-grids can be a cost-effective way to bring sustainable development to remote areas, as compared to grid extension, by providing the energy needed for creating business opportunities and improving social services. The objectives of improving education, health, and the standard of living in rural areas, as enumerated in the Millennium Development Goals, can be more easily attained if there is access to energy. In addition, the construction, operation, and maintenance of the local energy plants and, in case of biofuel use, the feedstock supply are economic activities that create value and jobs. **Thus, electrification based on renewable energy has multiple effects on local remote economies if local resources can be used.**

Energy security and RE deployment

Renewable energy technologies can also make significant contributions to domestic *energy security*. Implementing the RE deployment potentials presented would improve security of supply in the three main energy markets and overall.

Renewable energy technology can contribute to *energy security at the macro level.* In all oil and gas-importing countries the balance of payments is affected by volatile oil prices. Some countries can compensate rising prices with higher exports to oil-importing countries, but many cannot. Therefore, rising fossil fuel prices cause a redistribution of global income. High and volatile oil prices keep the governments of many importing countries from investing in technical and social infrastructure. As a result, their businesses become less competitive and private households spend more on energy and less on domestic demand, which leads to reduced economic activity. Medium and low-income economies that import fossil fuels are particularly vulnerable. Renewables can reduce the amount of absolute imports and increase the diversity of electricity and fuel sources, providing a buffer against rising prices and price shocks. **Deploying a broad array of RE technologies is an effective strategy for hedging against fluctuating and increasing fossil fuel prices.**

National security of energy-importing countries could be greatly improved if renewables reduced the nation’s reliance on fossil fuels, especially in combination with energy efficiency. Improving efficiency and diversifying fuel choices will reduce the pressure from rising energy prices, while allowing diplomatic and security decisions to be based on national interests and values.

In terms of geopolitical security, increasing renewables in the energy mix and reducing the relative position of some suppliers and the exposure of some consumer countries to political pressure can reduce security risks. In general, renewable energy risks are very different from – and lower than - fossil fuel supply risks. Even imported renewables like bioenergy feedstocks effectively diversify import portfolios.

With regard to *specific market-related security issues*: introducing a broad array of renewable generating plants - hydro, wind, solar, geothermal, wave and tidal, and biomass – would dramatically change ***electricity*** systems. There would be a more integrated high-voltage grid connecting continents, spanning different regions and countries within continents to bring power from the best RE sources sites to the demand centres. The regional grids would be much more intertwined, showing more nodes and many more points of entry, where many small to medium-sized generating plants would be located close to the load, integrated at either the transmission or the distribution level. In addition, power produced by consumers would feed into the grid.

Such a grid system will clearly increase network resilience and grid flexibility and reduce the risks of supply disruption. It would be less prone to technical failures, more resilient to extreme weather events, and far less vulnerable to sabotage. The distributed nature of many renewable energy technologies thus helps reduce the risk of accidental grid failures or deliberate disruption causing serious damage. Small amounts of capacity available at peak load times (including solar PV located at key spots) could prevent certain types of blackouts.

Some renewable energy technologies such as hydro, wind, solar PV, and tidal power depend on different natural cycles and are therefore subject to variability on differing time scales. If properly taken into account in the planning and operation of systems, this cyclical variability can help guarantee stability, reliability, and operation of electricity grids.

The broad scope of RE sources used in the deployment potentials would multiply the energy supply sources and thus diversify the electricity generation mix. This diversification is another insurance against dramatic failures or supply interruption. In fact, diversification is the classical strategic element of energy security.

The electricity sector in developing countries has been particularly affected by oil and gas price volatility, which causes a drain of funds or disruption, or both. Renewable energy systems broaden the set of options for electricity resources, while reducing dependence on fuels marked by significant price volatility and availability concerns. Portfolio-based analyses in the US have indicated that adding PV, wind, and other fixed-cost renewable technologies to a portfolio of fossil fuels lowers the overall cost and risk. Similarly, the analysis of the European Union's renewables targets and energy security objectives using a similar approach shows that the current EU generating mixes are sub-optimal, and including more wind or other fixed-cost renewables in the portfolio would lower generating costs and risk. It would also improve energy security.

These findings indicate that electricity-generating mixes can reduce generating costs and risks by including shares of fixed-cost renewable generation. This is an additional argument for starting early with RE deployment, even when RE costs appear somewhat higher.

In the *heat* market the use of renewables instead of fossil fuels in combination with much higher efficiency, as suggested in the deployment potentials, would effectively protect the individual consumers from physical supply and price risks. Urban households today are captive users of fossils fuels for heating. Supply shortages due to extreme weather events, accidental or deliberate physical interruption, or political interference generally translates into price increases for the individual consumer, similar to market situational shortages. The risks of such events that can threaten business or household budgets and plans can be minimised through high efficiency and the use of renewables such as solar water heating, biomass, and geothermal heating systems.

The introduction of RE technologies for industrial processes (i.e. higher temperature use) would allow industry to protect itself from fossil fuel cost increases. Biomass use would be extremely beneficial for the security of energy supply of businesses in developing countries, particularly in more remote areas.

In some countries feeding biogas into the natural gas network is becoming more common. This will increase the opportunities of biogas use away from the production site and contribute to diversifying the energy mix of the heat market.

Many governments perceive biofuels as a solution to the high dependence on imported oil and oil products in the *transport* sector. Increasing shares of domestically produced biofuels can reduce supply risk in several ways. Biofuels can be produced at both the large scale (limited by local feedstock resource availability) and small scale (limited by maintaining fuel quality standards and higher costs). High gas and oil prices would be reduced, as well as the risk of devastating price volatility.

A large share of biofuels will also diversify the infrastructure of refineries and other processing, pipelines, making them less vulnerable and more resilient to everything from natural disasters to terrorist attacks.

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Achieving the potentials: national renewable energy policies

Experience in some of the large energy economies over the past two decades has shown that a rapid increase in renewable energy is feasible when there is political will and the right mix of stable policies. This section draws together experiences made in several large economies with strategies that have brought about a significant contribution of renewables to the energy supply. Every country makes its own decisions as to which RE opportunities it wants to pursue, to what degree, and by what means. But to be competitive in a carbon-constrained global market, conventional energy suppliers will have to reinvent their business. **Strong policies are needed to bend the strong resistance to change that is common among incumbent conventional energy industries.**

According to the REN21 Renewables Global Status Report 2007, many countries have enacted some type of specific policy to promote renewable energy (also called a *market deployment* policy):

- Quantitative RE policy targets exist in at least 66 countries worldwide, including many states, provinces and increasingly in municipalities in the US, Canada and India. Currently, the allocation of targets for each of the 27 EU countries is under way. In 2007, the EU decided on a set of binding renewable energy targets for 2020--an overall 20 percent target, and a 10 percent target specifically for transport fuel.

- At least 60 countries, including 23 developing countries, have national electric market transformation policies that support renewable energy technologies. Over 31 states and provinces in the United States and Canada have specific renewable electricity mandates.

- At least 17 countries have already enacted national deployment policies for biofuels, mostly in the form of blending rules. Many more countries are preparing such policies. In some countries, bioethanol and biodiesel benefit from substantial fiscal incentives.

- At least five countries have also enacted mandatory rules for utilizing renewable energy technologies in the heating sector, in particular solar water heating. Such rules are being increasingly enacted by numerous municipalities and other local governments all over the world.

Experience and studies have shown that a combination of policies rather than single policies is most effective in building the renewables market, and that these policies must provide a predictable long-term framework to encourage investment in the renewables sector.

General energy and environment policies are important, but they cannot replace a specific renewables policy. Clearly, there must be coherence between general policy and specific renewables policy. Renewables promotion policy can be complementary to CO_2 taxes or similar ecologically motivated taxes, and also be complementary to cap and trade policies and emission trading systems. Subsidies for fossil fuel production or use, which still exist in many countries and are significant, are not compatible with renewable promotion policies. If energy markets were less distorted in the first place, i.e. if fossil fuels were not subsidised and the social cost they cause were included in their price, there would be much less need for specific support of renewables.

An effective renewable energy policy portfolio consists of:

- Supporting Policies (technology push approaches) and
- Deployment Policies (market pull approaches)

Supporting Policies increase market readiness and public receptivity of technologies, as well as fostering research and development. They include capacity building, public awareness and education, as well as certification and labeling. While supporting policies are important for renewable energy development, they cannot create a stable investment environment on their own.

Deployment Policies include policy frameworks that support market transition to clean technologies, encourage infrastructure development, and create financial incentives. **A deployment policy allows renewable energy to cross the threshold between pre-commercialization and commercialization.** Before coming to the details of such policies in the three markets and some illustrations below, it is important to highlight general principles.

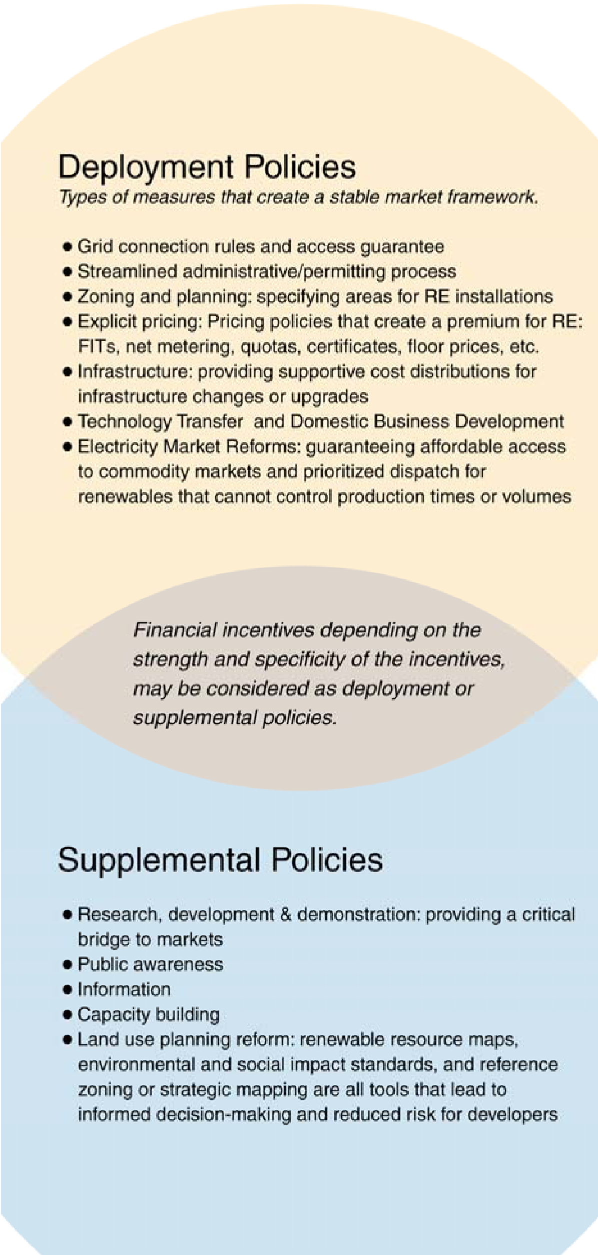
In order to benefit long-term domestic market development, successful market deployment policies must address the differences between the specific renewable technologies—in terms of maturity and other technology-specific characteristics. The basic actions required for long-term support of new technologies include:

- Massive deployment of the market-ready renewable energy technologies, as they become available, using technology specific incentives;
- Exploiting the effects of manufacturing scale and scope to further bring down the costs;
- Intensive basic and applied research & development, from both public and private funds, to bring technologies to market readiness and accompany the market introduction of new technologies and applications;
- Multiplying education and capacity building to create the knowledge and skills required, offering personal development for the workforce and new generations;
- Developing local business in parallel development;
- Assuring the sustainability and international framework conditions are in place for renewable energy system development; and
- Setting creditable renewable energy targets as a way of providing market signals to support large financial investments.

The most successful policy combinations are those that have clear goals and comprehensive sector-based approaches. Such policies must:

- Be long-term and consistent;
- Have a secure and predictable income or payment mechanism;
- Provide fair and open access to distribution channels, such as the transmission grid;
- Eliminate non-economic barriers (grid, administrative, social acceptance);
- Possess good governance conditions and administration procedures with low transaction costs;
- Have strong public acceptance and support; and
- Be enforceable.

RE Market Uptake in the Electricity Sector



The two most widely-used market deployment policies ***in the electricity sector*** are the price-setting regulation (also known as the feed-in-tariff, or FIT) and the quantity-setting regulation or quota obligation (commonly referred to as renewable portfolio standards, or RPS). The question of "which policy is better?" is perhaps misdirected. Instead, experience has shown that good deployment policies, whether FITs or quotas, combined with well-developed supporting policies can lead to increased market uptake. The success of the core deployment policy depends on barriers such as lack of grid access and overly difficult permitting bureaucracy being overcome.

In an FIT, a specific price is set for a particular technology, along with an agreement to purchase power from all eligible technologies. Thus, the price is known, but the quantity that may ultimately be acquired is not known. FITs encourage investment by guaranteeing a premium price for renewable energy to be paid to renewable electricity producers over some reasonably long period of time. FITs have been implemented in over 40 countries worldwide and have resulted in major market successes for renewables in Germany, Spain and Denmark.

In an RPS the purchase of a certain amount of power from RE is required, so that the quantity of renewables that will be acquired is known but not the cost of acquisition. RPS programs are often combined with tradable green certificates schemes (TGC). Several countries in Europe, the US, and elsewhere have implemented RPS. RPS programs tend to favor the cheapest, short-term technology option, although they can be implemented with technology bands to encourage a broader cluster of technologies. (RPS are much more likely to succeed if penalties for non-compliance/non-fulfilment of the target are included. FITs, have in fact, tended to produce more robust results because they often benefit more than one renewable energy technology and they often start with a higher price than competitively bid quota systems.

For populations in both large and developing economies without access to good quality energy or in remote rural areas without access to electric grids, individual RE systems and RE mini-grids can facilitate sustainable development. Quota and tendering systems can facilitate government support for such implementation. New forms of credit including micro-credit, vendor-supplied credit and rental models are likewise bringing RE technology to otherwise energy impoverished areas.

In the ***heating and cooling market***, solar thermal, biomass and geothermal can, in the long run, provide major parts of the heating energy supply, although in many localities such technologies are not yet cost competitive with conventional systems. Increased interest in renewable heating potential has seen more countries combining financial incentive schemes (carrots), regulatory schemes (sticks) and educationally based schemes (guidance) in efforts to support market development.

For example, in Sweden energy taxes have been used in combination with carbon and sulfur taxes since 1991, which has resulted in biomass-based heat becoming less expensive than coal. In Spain, the solar thermal market grew by 700% from 2002 to 2005, largely as a result of combining technology specific renewable heating targets with a broad package of measures, such as significant public investments, tax incentives, and building code requirements.

With 60 percent of the world's installed solar water heaters, China is the primary solar water heater market in the world. To support this maturing market, China's recent Renewable Energy Law sets targets for solar thermal, including performance standards, and mandates for local authorities and planning officials to provide space for solar water heaters on new buildings.

RE Market Uptake in Transport Fuels

Deployment Policies

Types of measures that create a stable market framework.

- CO_2-based Fuel Tax: taxing greenhouse gas contributing emissions, specifically carbon dioxide, allows renewable transport fuels to compete with the incumbent fuels
- Mandated Blending Rules: a percentage is set, mandating all transport fuels to be mixed with this percentage of renewables
- Distribution Access: mandating service stations to provide customers with a renewable transport fuel option, for example a biodiesel pump

In addition, eventually: biofuel quality standards (internationally agreed), addressing the efficiency of the product. Sustainability criteria: addressing issues such as food versus fuel and biodiversity

Encouraging Technological Adaptation

Financial incentives and tax exemptions for biofuels complement deployment policies and help to overcome prejudice in the marketplace, allowing renewable energy to compete with incumbent energy sources.

Supplemental Policies

- Research, Development & Demonstration: second-generation cellulosic fuels and efficiency of conversion to fuel
- Capacity building
- Public awareness
- Voluntary standards, such as blending
- Agricultural policies: for example, domestic policies paying farmers not to plant food crops on particular tracks, in order to secure a high price in a global market, might be revised to allow for biofuel crop planting

Biofuels can contribute a considerable share but less than half, of the future needs in ***the transport market*** because of restricted bioenergy resources. Other energy technologies, possibly electricity or hydrogen based, and certainly other transport schemes will be required to arrive at a low carbon transport sector.

Solid policy--in the form of fuel efficiency and blending standards, as well as financial incentives--facilitates market penetration for biofuels and other renewable energy technologies in the transport sector. Carbon pricing, where the pollution caused by the conventional fuel product is internalized into the fuel price, is being considered across all modes of transport e.g. in the UK. Efficiency standards require manufacturers to meet a mile-per-gallon or kilometer-per-liter fuel efficiency standard for automobiles. Blending rules allow, or mandate, conventional fuels to be mixed with a percentage of biofuels without having to be sold as an alternative product.

Changes to distribution and infrastructure require vision, as well as social and political will, to change the status quo. In Brazil and Germany, ethanol and biodiesel respectively, have garnered political and popular support in the face of rising fossil fuel prices and increasing perception of risks to energy security. Creating policies that encourage access to distribution channels and proper consideration in planning and updating of infrastructure is critical for renewable energy technologies in the transport fuel sector.

Achieving the potentials: shaping the international climate change framework

International agreements and collaboration are essential for the development of renewable energy markets. Institutional frameworks on climate change, development, and international trade need to be shaped, current and potential future issues resolved accordingly.

A major focus of the **United Nations Framework Convention on Climate Change (UNFCCC)** and its Kyoto Protocol is the reduction of greenhouse gas emissions. Renewable energy is one option individual countries may employ to reach their emissions targets. Specific elements in the UNFCCC and Kyoto Protocol are highly relevant for RE deployment:

- **Long-term goal**: The ultimate objective of the UNFCCC is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system"[6] within an acceptable timeframe. In its current formulation, this objective does not have a direct impact on RE development. The discussion on long-term emission or energy-related targets is highly relevant for RE.

- **Emission reduction targets**: The major instrument of the Kyoto Protocol is the legally binding requirement for industrialized countries to limit their greenhouse gas emissions by a fixed amount against an agreed baseline, thereby enabling the creation of a global 'carbon market' in emissions reductions. More stringent, long-term emission reduction targets should be agreed upon, leading to increased RE support.

- **Joint implementation (JI):** Industrialized countries can invest in projects in other industrialized countries to comply with their emission reduction targets. Emission allowances are only transferred from one country to another – therefore the rules for JI are less strict than for the clean development mechanism (see below). Some economies in transition can easily reach their emission reduction targets, enabling them to sell some allowances through JI projects. It is projected that the use of JI will decrease because targets will become more ambitious, leading to fewer excess allowances.

- **Clean Development Mechanism (CDM):** Industrialized countries can use allowances generated from emission reduction projects in developing countries to comply with their own emission reduction targets. The number of CDM projects is quickly increasing, but efforts to channel CDM towards particular technologies have not been successful. To qualify for CDM a project must satisfy "additionality" criteria, meaning that the project would not have been realised without CDM funding. Creating a positive list of preferred technologies under the CDM that includes renewable technologies could provide a positive *market pull* in the future. However, developing countries may implement policies in support of renewable energy that negate additionality and make them ineligible for CDM. Therefore, the future impact of the CDM on RE is uncertain.

- **Technology transfer and financial mechanisms:** Provisions under the UNFCCC and the Kyoto Protocol should stimulate technology transfer, including renewable technologies. Currently, about one third of the spending of the Global Environmental Facility (GEF) on climate change is for the support of renewable energy– significantly smaller than financial flows generated through CDM. Because it is sourced by irregular voluntary contributions, lack of resources has been an obstacle for the GEF. It is unlikely that technology transfer through a fund will be a major instrument in the future unless the fund is filled automatically, for example through a levy on emission trading.

- **New forms of participation by developing countries in the carbon market:** These new forms are usually in-between existing options. The intention is to provide incentives for developing countries to participate, but usually only after they have made some effort themselves. New forms will be major instruments for large developing countries in the near future, superseding the CDM. One example of higher impact for RE would be a country setting an emission baseline for its entire electricity sector, in which case the additionality criterion of the CDM would not be an obstacle for any projects above this baseline.
- **Supplementing technology research and deployment agreements:** Emission reduction targets by industrialized countries need to be supplemented by international agreements on research and development for specific technologies or technology areas. In the future, such agreements could encourage renewable energy development.

Achieving the potentials: shaping the international trade framework

International trade with renewable energy technologies is still lagging behind its potential, partly due to import restrictions. A suggested solution is a ‘positive list’ for RE technologies for which trade should be liberalized in the shortest time possible, even when an Environmental Goods and Services compromise has not been achieved.

Renewable energy certificate trading between countries that have emissions reductions targets would enable countries to invest in RE development outside their own country/region, which might be the most efficient way for such countries to meet their targets. Trade with countries that do not have targets (e.g. some developing countries) is also possible. In the future, trading may be extended from electricity to biogas, heat or hydrogen.

International trade of biomass for energy use is growing rapidly. The issues of **sustainability of biomass** must be resolved, however, because these could become a non-tariff trade barrier. The following sustainability criteria for biomass fuels are included in most of the current standards and initiatives:

Environmental criteria:
- Preservation of above- and below ground carbon stocks
- Biodiversity conservation
- Sustainable water use
- Air quality
- Soil conservation

Social criteria:
- Land rights

- Labor conditions
- Compliance with national and international regulations
- Food security

Displacement effects act across borders and commodities, and can occur when the production of biofuels displaces certain activities in other areas where they may cause negative land use changes, such as deforestation. Three ways to prevent displacement effects are to produce bio-mass on idle land, through higher yields on existing plantation, or from waste products and residues.

A bioenergy sector certification system must either include the other sectors of the economy, or ensure land use planning that is in line with sustainability criteria in the biofuels production countries.

Achieving the potentials: assisting with international cooperation

Official Development Assistance (ODA) for financing development and capacity building plays an increasingly important role for renewable energy deployment in developing countries. For poorer developing countries, the resources that flow from donor countries through bilateral and multilateral agencies are often the only external source of direct funding for RE, whereas for newly industrialised countries they support the transfer of knowledge and technology.

ODA will continue to play a key role in developing RE resources by providing
a) technical assistance, building on the indigenous capacities within each country:

- Build and increase technical capacity and knowledge to enable the rapid growth in operation and maintenance, feedstock processing and manufacturing and installation of RE technology, principally in domestic utilities, engineering, industry and trade, but also among users, policy makers and the financial sector;
- Facilitate access to improved technologies and strengthen the capacity to plan, design, construct, and integrate such technologies into the energy supply sector;
- Introduce business models better suited to renewable energy and energy efficiency, including distributed generation.

b) financial assistance, complementing private and public domestic sources of funding:

- In some countries, financial assistance is a major external source, assuring financial viability of projects and scale-up. In other countries it is a supplementary source for public sector investment;
- Increase access to pre-investment and investment financing, and introduce risk management and credit enhancement instruments;
- Complement and benefit from new instruments, such as those offered by the carbon markets;
- Mobilize other funds, in particular private public partnerships,

- Contribute to developing specific options including:
    - A special RE target for industrialized countries on investments in developing countries;
    - An additional tax on airline tickets to source a fund for developing countries (e.g. French government and several NGOs).

To contribute to the development of dynamic markets for RE, ODA continues to shift its approach away from project-based assistance towards a more **sector-oriented approach**. Adequate political and economic framework conditions are crucial for market development that encourages local business development. ODA also may help to promote adherence to good environmental and social management principles and ensure that all parties benefit -- from consumers and affected communities to energy suppliers and financiers.

Conclusion

Renewable energies, especially in combination with energy efficiency, have the potential to substantially mitigate climate change and contribute to energy security, economic and social development, and employment.

With increasing scope, scale, research and development, the costs of renewable energy technologies will come down, allowing RE to make major contributions to electricity generation, heating and cooling, and transport. From now on, RE technologies should be given priority in incremental and replacement investments.

National deployment policies that transform market framework conditions and increase incentives are required to create market pull. Technology-push policies such as R&D are necessary, but not sufficient on their own to accelerate and scale up deployment. International cooperation and agreements on climate change, trade, and development cooperation will be essential for a massive global uptake of renewable energy.

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1 For comparison with the potentials, the electricity, transport fuel and heat demand of 2050 is taken from IEA: Energy Technology Perspectives, OECD/IEA Paris 2006. The presentation in Figures 1 and 2 refers to the Accelerated Technology (ACT) scenario.

2 IEA Energy Technology Perspectives…Paris 2006

3 The costs presented refer to levelized unit costs for the long term using a discount rate of 10 percent. They are given in real terms USD. The costs are on location of resource and do not take into account transmission and grid balancing costs, which are reduced when the non-dispatchable RE technologies achieve large scale.

4 Deployment potential is defined as potential market share. The assessment is based on the long-term renewable energy deployment potentials in each individual country, which assume a strong growth in these technologies within the framework of the demand, taking into account the technical and economic potentials of the respective renewable energy resources, as well as potential structural constraints, which include the country's current supply structure, the power plant stock turnover etc. The fulfilment of these potentials requires strong and stable policy support to foster the market introduction of renewable energies and to stimulate the market dynamics needed throughout the economic learning curve of these technologies.

5 Global Trends in Sustainable Energy Investment 2008, UNEP Sustainable Energy Finance Initiative and New Energy Finance. Paris. 2008 http://www.sefi.unep.org/english/global trends

6 United Nations Framework Convention on Climate Change (UNFCCC), Article 2