energy [r]evolution

A SUSTAINABLE ITALY ENERGY OUTLOOK

EREC
EUROPEAN RENEWABLE ENERGY COUNCIL

GREENPEACE

report national energy scenario

foreword

Of all the sectors of a modern economic system, the one that appears to be getting the maximum attention currently is the energy sector. While the fluctuating oil prices certainly requires some temporary measures to tide over the problem of increasing costs of oil consumption particularly for oil importing countries, there are several reasons why the focus must now shift towards longer term solutions. First and foremost, of course, are the growing uncertainties related to oil imports both in respect of quantities and prices, but there are several other factors that require a totally new approach to planning energy supply and consumption in the future. Perhaps, the most crucial of these considerations is the threat of global climate change which has been caused overwhelmingly in recent decades by human actions that have resulted in the build up of greenhouse gases (GHGs) in the Earth's atmosphere.

"will we look into the eyes of our children and confess

that we had the **opportunity**,
but lacked the **courage?**
that we had the **technology**,
but lacked the **vision?"**

contents

image THE PS10 CONCENTRATING SOLAR TOWER PLANT USES 624 LARGE MOVABLE MIRRORS CALLED HELIOSTATS. THE MIRRORS CONCENTRATE THE SUN'S RAYS TO THE TOP OF A 115 METER (377 FOOT) HIGH TOWER WHERE A SOLAR RECEIVER AND A STEAM TURBINE ARE LOCATED. THE TURBINE DRIVES A GENERATOR, PRODUCING ELECTRICITY, SEVILLA, SPAIN.
cover image A WIND FARM IN ITALY.

Impacts of climate change are diverse and serious, and unless the emissions of GHGs are effectively mitigated these would threaten to become far more serious over time. There is now, therefore, a renewed interest in renewable sources of energy, because by creating and using low carbon substitutes to fossil fuels, we may be able to reduce emissions of GHGs significantly while at the same time ensuring economic growth and development and the enhancement of human welfare across the world. As it happens, there are major disparities in the levels of consumption of energy across the world, with some countries using large quantities per capita and others being deprived of any sources of modern energy forms. Solutions in the future would, therefore, also have to come to grips with the reality of lack of access to modern forms of energy for hundreds of millions of people. For instance, there are 1.6 billion people in the world who have no access to electricity. Households, in which these people reside, therefore, lack a single electric bulb for lighting purposes, and whatever substitutes they use provide inadequate lighting and environmental pollution, since these include inefficient lighting devices using various types of oil or the burning of candles.

Future policies can be guided by the consideration of different scenarios that can be linked to specific developments. This publication advocates the need for something in the nature of an energy revolution. This is a view that is now shared by several people across the world, and it is also expected that energy plans would be based on a clear assessment of specific scenarios related to clearly identified policy initiatives and technological developments. This edition of Energy [R]evolution Scenarios provides a detailed analysis of the energy efficiency potential and choices in the transport sector. The material presented in this publication provides a useful basis for considering specific policies and developments that would be of value not only to the world but for different countries as they attempt to meet the global challenge confronting them. The work carried out in the following pages is comprehensive and rigorous, and even those who may not agree with the analysis presented would, perhaps, benefit from a deep study of the underlying assumptions that are linked with specific energy scenarios for the future.

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Greenpeace International, European Renewable Energy Council (EREC)

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introduction

"NOW IS THE TIME TO COMMIT TO A TRULY SECURE AND SUSTAINABLE ENERGY FUTURE – A FUTURE BUILT ON CLEAN TECHNOLOGIES, ECONOMIC DEVELOPMENT AND THE CREATION OF MILLIONS OF NEW JOBS."

© GREENPEACE/MARKEL REDONDO

image WORKERS EXAMINE PARABOLIC TROUGH COLLECTORS IN THE PS10 CONCENTRATING SOLAR TOWER PLANT IN SEVILLA, SPAIN. EACH PARABOLIC TROUGH HAS A LENGTH OF 150 METERS AND CONCENTRATES SOLAR RADIATION INTO A HEAT-ABSORBING PIPE INSIDE WHICH A HEAT-BEARING FLUID FLOWS. THE HEATED FLUID IS THEN USED TO HEAT STEAM IN A STANDARD TURBINE GENERATOR.

Humankind is at a critical crossroads. Since the industrial revolution, the planet has warmed by 0.74°C, a distortion of the climate system caused by human activities such as the burning of carbon-intensive fossil fuels.[1] The impacts we are witnessing are occurring far sooner than had been predicted. Droughts in many parts of the world, the near-total loss of the Arctic ice-cap and an additional 300,000 deaths per year[2] indicate that we are already experiencing dangerous climate change.

The challenge humanity faces now is to avoid "runaway" climate change. Climate scientists warn that if we warm the atmosphere by more than 2°C from pre-industrial levels, we invite catastrophic climate change and trigger processes that result in even more emissions being released, taking global warming beyond our control. The warming we have already experienced, plus an additional degree expected due to the "lag" effect of greenhouse gases already in the atmosphere, takes us to the brink. If we pass this threshold, the economic, social, political, cultural and environmental impacts will be almost indescribable.

In presenting the greatest threat the planet faces, climate change also presents an opportunity. We can avert runaway climate change and at the same time revolutionise the way we harness and use the resources available to us. We can create a sustainable society, using technologies and behaviours that are low-carbon intensive. However, we do not have much time and the transition must begin immediately.

Action is required on all fronts. Internationally, it is critical that parties to the Kyoto Protocol reach an agreement that ensures global emissions fall substantially by the year 2020. Domestically, there is much Europe can do to take a leading role in the climate debate, as well as get ahead of the game as the world moves to a low-carbon future. Currently, Europe is still one of the worst greenhouse-polluting countries in the world on a per-capita basis. Renewable energy is forced to compete on an uneven playing field, as the lion's share of political and financial support is enjoyed by the powerful fossil fuel industry. However, this can and must be turned around. Europe is fortunate to have some of the best renewable energy resources in the world and, with the political will, could become a renewable energy leader. It is also well placed to become much more energy efficient and reduce costs of energy as well as emissions. By setting strong targets to reduce greenhouse pollution domestically and taking the lead on climate change, Europe could steer international negotiations towards a binding agreement that ensures global greenhouse gases fall to levels that avoid runaway climate change.

"Europe is fortunate enough to have some of the best renewable energy resources in the world and, with the political will, could become a renewable energy leader."

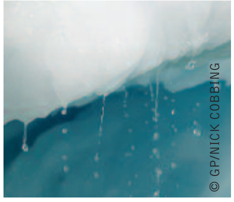

image ICEBERG MELTING ON GREENLAND'S COAST.

energy [r]evolution scenario: italy

This scenario is based on the European energy scenario produced by The European Renewable Energy Council (EREC) and Greenpeace International, which demonstrates how Europe's CO_2 emissions can be reduced by almost 80% by 2050. The Italian scenario provides an exciting, ambitious and necessary blueprint for how emission reductions can be made in the energy and transport sectors and how Italy's energy can be sustainably managed up to the middle of this century.

our renewable energy future

This report demonstrates that renewable energy is mature, ready and can be deployed on a large scale. Decades of technological progress have seen renewable energy technologies such as wind, solar photovoltaic, geothermal power plants and solar thermal collectors move steadily into the mainstream. They will play a vital role in providing secure, reliable and zero-emission energy in the future.

The global market for renewable energy is booming internationally; installed capacity of wind grew by 29% globally[3] in 2008 while solar photovoltaics grew by 70%.[4] As renewable energy is scaled up, we can begin turning off polluting coal-fired power plants, starting with the oldest and dirtiest. Decisions made today by governments and power utilities will determine the energy supply in decades to come and coal-fired power plants are incompatible with an energy mix that helps us avoid runaway climate change. An energy revolution that drives down emissions will be a result of today's political action.

the forgotten solution: energy efficiency

The Italian Energy [R]evolution Scenario takes advantage of the enormous potential for Italy to become more energy efficient. Energy efficiency offers some of the simplest, easiest and most cost effective measures for reducing both greenhouse gas emissions and cost to end-users.

Market based measures that reduce emissions will result in the cost of fossil fuels increasing. Removal of government subsidies, emissions trading and carbon taxes will all result in the cost of fossil fuels increasing, perhaps to a level that truly reflects the damage they cause. As fossil fuels are phased out, it will be necessary to protect those most vulnerable to energy price increases. Energy efficiency presents opportunities for people to be protected from the economic impacts of the inevitable shift away from fossil fuels.

keeping it fair

The Italian Energy [R]evolution Scenario describes a major restructuring of energy and transport markets. An integral part of the inevitable transition from fossil fuels to renewable energy will be ensuring that social and economic impacts are kept to a minimum and the opportunities for new employment, investment and innovation are maximized.

The transition away from fossil fuels opens up new opportunities in skills development and sharing, manufacturing and infrastructure development. Early planning will help ensure that a skilled workforce is ready to deliver the low-carbon future and that the socio-geography of our energy supply is maintained as much as possible. Moving to a renewable energy-based society can be done smoothly and justly.

on the front foot

Avoiding runaway climate change will require the most far-reaching structural reforms carried out by human society. Business as usual is simply not an option. Furthermore, there can be no half measures, or falling short of the required emission reductions. The risk of passing the threshold of runaway climate change is not one that humankind can afford to take. The Energy [R]evolution Scenario demonstrates that making the necessary transformation in how we use energy is achievable, and provides a wealth of opportunities to stimulate economic growth and ensure social security.

We call on political leaders to turn the Energy [R]evolution Scenario into reality and to begin the inevitable transition from fossil-fuels to renewable energy now, delivering immediate reductions in emissions, minimising economic and social disruption and maximising opportunities for the European economy to prosper from the transition.

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GREENPEACE INTERNATIONAL

JUNE 2009

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executive summary

"TOWARDS A SUSTAINABLE ENERGY SUPPLY SYSTEM."

© PAUL LANGROCK/ZENIT/GREENPEACE

image CONSTRUCTION OF THE OFFSHORE WINDFARM AT MIDDELGRUNDEN NEAR COPENHAGEN, DENMARK.

energy [r]evolution: a sustainable pathway to a clean energy future for Italy

The Energy [R]evolution Scenario reduces carbon dioxide emissions from Italy's energy sector by some 11% below 1990 levels by 2020 (26% below 2005 levels) and over 70% by 2050. This, in concert with additional greenhouse gas savings in other sectors, is necessary to keep the increase in global temperature is much below +2°C as possible.

A second objective of the energy [r]evolution is to keep Italy nuclear free. To achieve these targets, the scenario is characterised by significant efforts to fully exploit the large potential for energy efficiency. At the same time, all cost-effective renewable energy sources are accessed for both heat and electricity generation, as well as the production of sustainable bio fuels.

Today, renewable energy sources account for 6.7% of the Italian primary energy demand. Hydro is the main renewable energy source for power generation. Geothermal and biomass are main renewable options used for heating. The share of renewable energies for electricity generation is 17.2%. The contribution of renewables to primary energy demand for heat supply is around 2.7%. About 93% of the Italy's primary energy supply today still comes from fossil fuels.

The Energy [R]evolution Scenario describes a development pathway which turns the present situation into a sustainable energy supply for Italy:

- Exploitation of the existing large energy efficiency potentials will reduce primary energy demand from the current 7,884 PJ/a (2005) to 5,366 PJ/a in 2050. This dramatic reduction in primary energy demand is a crucial prerequisite for achieving a significant share of renewable energy sources in the overall energy supply system and for reducing the consumption of fossil fuels.
- The increased use of combined heat and power generation (CHP) increases the supply system's energy conversion efficiency. Fossil fuels for CHP are increasingly being substituted by biomass and geothermal energy. The availability of district heating networks is a key precondition for achieving a high share of decentralised CHP. In the long term, the decreasing demand for heat and the large potential for producing heat directly from renewable energy sources limit the further expansion of combined heat and power generation.
- The electricity sector will continue to be the forerunner of RES utilisation. By 2050, 76% of the electricity will be produced from renewable energy sources. A capacity of 104 GW will produce 290 TWh/a RES electricity in 2050.

image A WELDER WORKING AT VESTAS WIND TURBINE FACTORY, CAMPELLTOWN, SCOTLAND.

- In the heat supply sector, the contribution of renewables will continue to grow, reaching more than 64% in 2050. In particular, solar collectors, geothermal energy and biomass, will substitute conventional systems for direct heating and cooling.
- Before sustainable bio fuels are introduced in the transport sector, the existing large efficiency potentials have to be exploited. As biomass is mainly bound in stationary applications, the production of bio fuels is limited by the availability of biomass. Electric vehicles will play an increasingly important role from 2020 onwards.
- By 2050, 61% of the primary energy demand will be covered by renewable energy sources.

To achieve an economically attractive growth of renewable energy sources, a balanced and timely mobilisation of all RES technologies is of great importance. Such mobilisation depends on technical potentials, actual costs, cost reduction potentials, and technological maturity.

development of CO_2 emissions

While energy-related CO_2 emissions in Italy will increase by 33% under the Reference Scenario until 2050 and are thus far removed from a sustainable development path, under the Energy [R]evolution Scenario CO_2 emissions will decrease from 444 Mill. t in 2005 to 112 Mill. t in 2050. Annual per capita emissions will drop from 7.6 t/capita to 2.1 t/capita. In spite of a slightly increasing electricity demand especially in the transport sector, CO_2 emissions will decrease in the electricity sector enormously. Efficiency gains and the increased use renewable electricity for vehicles and some limited sustainable bio fuels will reduce CO_2 emissions in the transport sector by about 78%. The transport sector and the power sector will be the two largest sources of CO_2 emissions in Italy, both with a share of 25% of total CO_2 emissions in 2050.

According to latest scientific findings, further emissions reductions may be necessary. These would require the further development of currently less developed renewable energy sources, such as ocean energy, and even further going efficiency measures. We believe that this is possible, but it will require further research and development funding, as well as bold political measures. At the same time, lifestyle and behaviour changes could become increasingly important.

To complement these savings in the energy sector, further reductions of carbon dioxide and other greenhouse gas emissions have to be achieved through the phase-out of fluorinated gases, a strict stop on deforestation and the increase of the natural carbon sequestration potential by forests and soils, for example by the regeneration of forests and sustainable farming practices.

costs

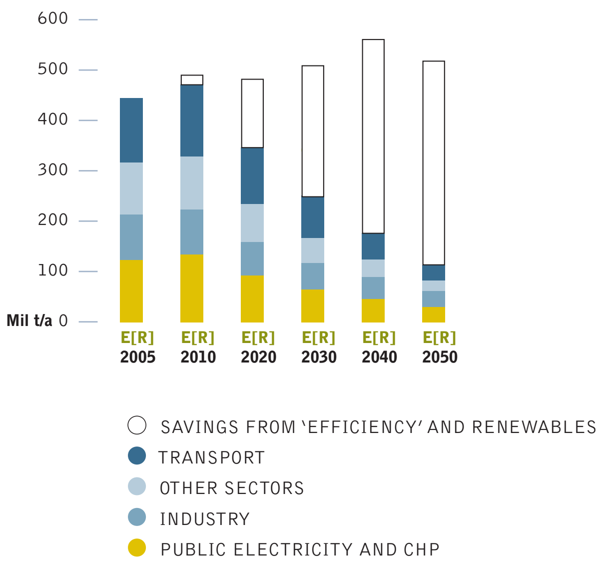
The introduction of renewable technologies under the Energy [R]evolution Scenario slightly increases the costs of electricity generation compared to the Reference Scenario. This difference will be less than 0.5 cents/kWh up to 2015. Because of the lower CO_2 intensity of electricity generation, by 2020 electricity generation costs will become economically favourable under the Energy [R]evolution Scenario, and by 2050 generation costs will be more than 4 cents/kWh below those in the Reference Scenario. Due to growing demand, we face a significant increase in society's expenditure on electricity supply. Under the Reference Scenario, the unchecked growth in demand, the increase in fossil fuel prices and the cost of CO_2 emissions result in total electricity supply costs rising from today's €28 billion per year to more than €79 bn in 2050. Figure 0.1 shows that the Energy [R]evolution Scenario not only complies with Italy's CO_2 reduction targets but also helps to stabilise energy costs and relieve the economic pressure on society. Increasing energy efficiency and shifting energy supply to renewables leads to long term costs for electricity supply that are one third lower than in the Reference Scenario. It becomes clear that pursuing stringent environmental targets in the energy sector also pays off in terms of economics.

To make the energy [r]evolution real and to avoid dangerous climate change, Greenpeace and EREC demand for the energy sector that the following policies and actions are implemented:

1. Phase out all subsidies for fossil fuels and nuclear energy.
2. Internalise the external (social and environmental) costs of energy production through "cap and trade" emissions trading.
3. Mandate strict efficiency standards for all energy consuming appliances, buildings and vehicles.
4. Establish legally binding targets for renewable energy and combined heat and power generation.
5. Reform the electricity markets by guaranteeing priority access to the grid for renewable power generators.
6. Provide defined and stable returns for investors, for example by feed-in tariff programmes.
7. Implement better labelling and disclosure mechanisms to provide more environmental product information.
8. Increase research and development budgets for renewable energy and energy efficiency.

figure 0.1: italy: development of CO_2 emissions by sector under the energy [r]evolution scenario

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)



the energy [r]evolution

1

"clearly, tackling the causes and effects of climate change will require fundamental change."

JOSÉ MANUEL BARROSO
PRESIDENT OF THE EUROPEAN COMMISSION

The climate change imperative demands nothing short of an energy revolution. The expert consensus is that this fundamental change must begin very soon and be well underway within the next ten years in order to avert the worst impacts. What we need is a complete transformation in the way we produce, consume and distribute energy and at the same time maintain economic growth. Nothing short of such a revolution will enable us to limit global warming to far less than a rise in temperature of 2°C, above which the impacts become devastating.

Current electricity generation relies mainly on burning fossil fuels, with their associated CO_2 emissions, in very large power stations which waste much of their primary input energy. More energy is lost as the power is moved around the electricity grid network and converted from high transmission voltage down to a supply suitable for domestic or commercial consumers. The system is innately vulnerable to disruption: localised technical, weather-related or even deliberately caused faults can quickly cascade, resulting in widespread blackouts. Whichever technology is used to generate electricity within this old fashioned configuration, it will inevitably be subject to some, or all, of these problems. At the core of the Energy [R]evolution there therefore needs to be a change in the way that energy is both produced and distributed.

key principles

the energy [r]evolution can be achieved by adhering to five key principles:

1. **respect natural limits – phase out fossil fuels by the end of this century** We must learn to respect natural limits. There is only so much carbon that the atmosphere can absorb. Each year we emit over 25 billion tonnes of CO_2; we are literally filling up the sky. Geological resources of coal could provide several hundred years of fuel, but we cannot burn them and keep within safe limits. Oil and coal development must be ended.

   The Energy [R]evolution Scenario has a target to reduce energy related CO_2 emissions to a maximum of 10 Gt (Giga tonnes) by 2050 and phase out fossil fuels by 2085.

2. **equity and fairness** It is imperative to have a fair distribution of benefits and costs within societies. At one extreme, a third of the world's population has no access to electricity, whilst the most industrialised countries consume much more than their fair share.

   The effects of climate change on the poorest communities are exacerbated by massive global energy inequality. If we are to address climate change, one of the principles must be equity and fairness, so that the benefits of energy services – such as light, heat, power and transport – are available for all: north and south, rich and poor. Only in this way can we create true energy security, as well as the conditions for genuine human wellbeing.

   The Energy [R]evolution Scenario has a target to achieve energy equity as soon as technically possible. By 2050 the average per capita emission should be between 1 and 2 tonnes of CO_2.

3. **implement clean, renewable solutions and decentralise energy systems** There is no energy shortage. All we need to do is use existing technologies to harness energy effectively and efficiently. Renewable energy and energy efficiency measures are ready, viable and increasingly competitive. Wind, solar and other renewable energy technologies have experienced double digit market growth for the past decade.

   Just as climate change is real, so is the renewable energy sector. Sustainable decentralised energy systems produce less carbon emissions, are cheaper and involve less dependence on imported fuel. They create more jobs and empower local communities. Decentralised systems are more secure and more efficient. This is what the Energy [R]evolution must aim to create.

"THE STONE AGE DID NOT END FOR LACK OF STONE, AND THE OIL AGE WILL END LONG BEFORE THE WORLD RUNS OUT OF OIL."

Sheikh Zaki Yamani, former Saudi Arabian oil minister

   To stop the Earth's climate spinning out of control, most of the world's fossil fuel reserves – coal, oil and gas – must remain in the ground. Our goal is for humans to live within the natural limits of our small planet.

4. **decouple growth from fossil fuel use** Starting in the developed countries, economic growth must fully decouple from fossil fuels. It is a fallacy to suggest that economic growth must be predicated on their increased combustion.

   We need to use the energy we produce much more efficiently, and we need to make the transition to renewable energy – away from fossil fuels – quickly in order to enable clean and sustainable growth.

5. **phase out dirty, unsustainable energy** We need to phase out coal and nuclear power. We cannot continue to build coal plants at a time when emissions pose a real and present danger to both ecosystems and people. And we cannot continue to fuel the myriad nuclear threats by pretending nuclear power can in any way help to combat climate change. There is no role for nuclear power in the Energy [R]evolution.

image ICE AND WATER IN THE NORTH POLE. GREENPEACE EXPLORERS, LONNIE DUPRE AND ERIC LARSEN MAKE HISTORY AS THEY BECOME THE FIRST-EVER TO COMPLETE A TREK TO THE NORTH POLE IN SUMMER. THE DUO UNDERTAKE THE EXPEDITION TO BRING ATTENTION TO THE PLIGHT OF THE POLAR BEAR WHICH SCIENTISTS CLAIM COULD BE EXTINCT AS EARLY AS 2050 DUE TO THE EFFECTS OF GLOBAL WARMING.

from principles to practice

In 2005, renewable energy sources accounted for 13% of the world's primary energy demand. Biomass, which is mostly used for heating, is the main renewable energy source. The share of renewable energy in electricity generation was 18%. The contribution of renewables to primary energy demand for heat supply was around 24%. About 80% of primary energy supply today still comes from fossil fuels, and 6% from nuclear power[5].

The time is right to make substantial structural changes in the energy and power sector within the next decade. Many power plants in industrialised countries, such as the USA, Japan and the European Union, are nearing retirement; more than half of all operating power plants are over 20 years old. At the same time developing countries, such as China, India and Brazil, are looking to satisfy the growing energy demand created by expanding economies.

Within the next ten years, the power sector will decide how this new demand will be met, either by fossil and nuclear fuels or by the efficient use of renewable energy. The Energy [R]evolution Scenario is based on a new political framework in favour of renewable energy and cogeneration combined with energy efficiency.

To make this happen both renewable energy and cogeneration – on a large scale and through decentralised, smaller units – have to grow faster than overall global energy demand. Both approaches must replace old generating technologies and deliver the additional energy required in the developing world.

As it is not possible to switch directly from the current large scale fossil and nuclear fuel based energy system to a full renewable energy supply, a transition phase is required to build up the necessary infrastructure. Whilst remaining firmly committed to the promotion of renewable sources of energy, we appreciate that gas, used in appropriately scaled cogeneration plant, is valuable as a transition fuel, and able to drive cost-effective decentralisation of the energy infrastructure. With warmer summers, tri-generation, which incorporates heat-fired absorption chillers to deliver cooling capacity in addition to heat and power, will become a particularly valuable means to achieve emissions reductions.

a development pathway

The Energy [R]evolution envisages a development pathway which turns the present energy supply structure into a sustainable system. There are two main stages to this.

step 1: energy efficiency The Energy [R]evolution is aimed at the ambitious exploitation of the potential for energy efficiency. It focuses on current best practice and technologies which will become available in the future, assuming continuous innovation. The energy savings are fairly equally distributed over the three sectors – industry, transport and domestic/business. Intelligent use, not abstinence, is the basic philosophy for future energy conservation.

The most important energy saving options are improved heat insulation and building design, super efficient electrical machines and drives, replacement of old style electrical heating systems by renewable heat production (such as solar collectors) and a reduction in energy consumption by vehicles used for goods and passenger traffic. Industrialised countries, which currently use energy in the most inefficient way, can reduce their consumption drastically without the loss of either housing comfort or information and entertainment electronics. The Energy [R]evolution Scenario uses energy saved in OECD countries as a compensation for the increasing power requirements in developing countries. The ultimate goal is stabilisation of global energy consumption within the next two decades. At the same time the aim is to create "energy equity" – shifting the current one-sided waste of energy in the industrialised countries towards a fairer worldwide distribution of efficiently used supply.

A dramatic reduction in primary energy demand compared to the IEA's "Reference Scenario" (see Chapter 6) – but with the same GDP and population development - is a crucial prerequisite for achieving a significant share of renewable energy sources in the overall energy supply system, compensating for the phasing out of nuclear energy and reducing the consumption of fossil fuels.

step 2: structural changes

decentralised energy and large scale renewables In order to achieve higher fuel efficiencies and reduce distribution losses, the Energy [R]evolution Scenario makes extensive use of Decentralised Energy (DE).This is energy generated at or near the point of use.

DE is connected to a local distribution network system, supplying homes and offices, rather than the high voltage transmission system. The proximity of electricity generating plant to consumers allows any waste heat from combustion processes to be piped to buildings nearby, a system known as cogeneration or combined heat and power. This means that nearly all the input energy is put to use, not just a fraction as with traditional centralised fossil fuel plant.

DE also includes stand-alone systems entirely separate from the public networks, for example heat pumps, solar thermal panels or biomass heating. These can all be commercialised at a domestic level to provide sustainable low emission heating. Although DE technologies can be considered 'disruptive' because they do not fit the existing electricity market and system, with appropriate changes they have the potential for exponential growth, promising 'creative destruction' of the existing energy sector.

A huge proportion of global energy in 2050 will be produced by decentralised energy sources, although large scale renewable energy supply will still be needed in order to achieve a fast transition to a renewables dominated system. Large offshore wind farms and concentrating solar power (CSP) plants in the sunbelt regions of the world will therefore have an important role to play.

cogeneration The increased use of combined heat and power generation (CHP) will improve the supply system's energy conversion efficiency, whether using natural gas or biomass. In the longer term, decreasing demand for heat and the large potential for producing heat directly from renewable energy sources will limit the further expansion of CHP.

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5 'ENERGY BALANCE OF NON-OECD COUNTRIES' AND 'ENERGY BALANCE OF OECD COUNTRIES', IEA, 2007

renewable electricity The electricity sector will be the pioneer of renewable energy utilisation. All renewable electricity technologies have been experiencing steady growth over the past 20 to 30 years of up to 35% annually and are expected to consolidate at a high level between 2030 and 2050. By 2050, the majority of electricity will be produced from renewable energy sources. Expected growth of electricity use in transport will further promote the effective use of renewable power generation technologies.

renewable heating In the heat supply sector, the contribution of renewables will increase significantly. Growth rates are expected to be similar to those of the renewable electricity sector. Fossil fuels will be increasingly replaced by more efficient modern technologies, in particular biomass, solar collectors and geothermal. By 2050, renewable energy technologies will satisfy the major part of heating and cooling demand.

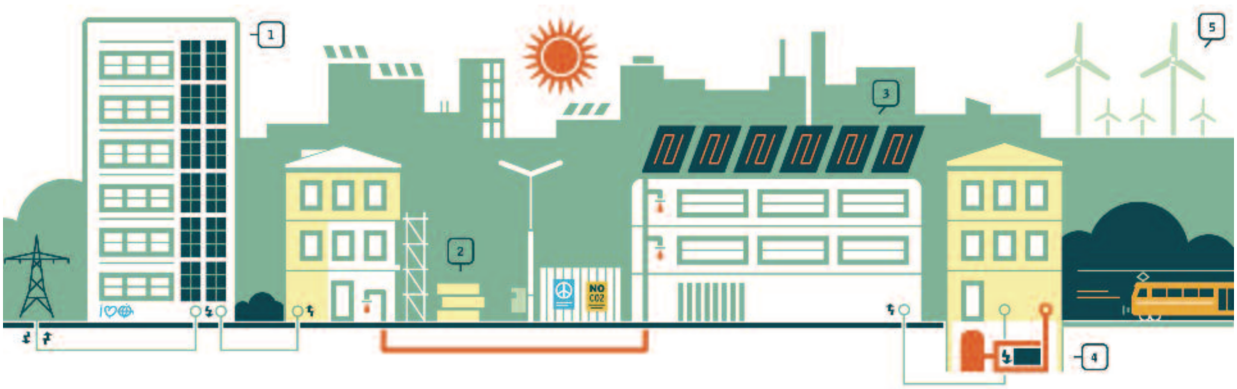
transport Before new technologies such as hybrid or electric cars or new fuels such as bio fuels can play a substantial role in the transport sector, the existing large efficiency potentials have to be exploited. In this study, biomass is primarily committed to stationary applications; the use of bio fuels for transport is limited by the availability of sustainably grown biomass[6]. Electric vehicles will therefore play an even more important role in improving energy efficiency in transport and substituting for fossil fuels.

Overall, to achieve an economically attractive growth in renewable energy sources, a balanced and timely mobilisation of all technologies is essential. Such a mobilisation depends on the resource availability, cost reduction potential and technological maturity. Besides technology driven solutions, lifestyle changes - like simply driving less and using more public transport – have a huge potential to reduce greenhouse gas emissions.

figure 1.1: a decentralised energy future

EXISTING TECHNOLOGIES, APPLIED IN A DECENTRALISED WAY AND COMBINED WITH EFFICIENCY MEASURES AND ZERO EMISSION DEVELOPMENTS, CAN DELIVER LOW CARBON COMMUNITIES AS ILLUSTRATED HERE. POWER IS GENERATED USING EFFICIENT COGENERATION TECHNOLOGIES PRODUCING BOTH HEAT (AND SOMETIMES COOLING) PLUS ELECTRICITY, DISTRIBUTED VIA LOCAL NETWORKS. THIS SUPPLEMENTS THE ENERGY PRODUCED FROM BUILDING INTEGRATED GENERATION. ENERGY SOLUTIONS COME FROM LOCAL OPPORTUNITIES AT BOTH A SMALL AND COMMUNITY SCALE. THE TOWN SHOWN HERE MAKES USE OF – AMONG OTHERS – WIND, BIOMASS AND HYDRO RESOURCES. NATURAL GAS, WHERE NEEDED, CAN BE DEPLOYED IN A HIGHLY EFFICIENT MANNER.

city

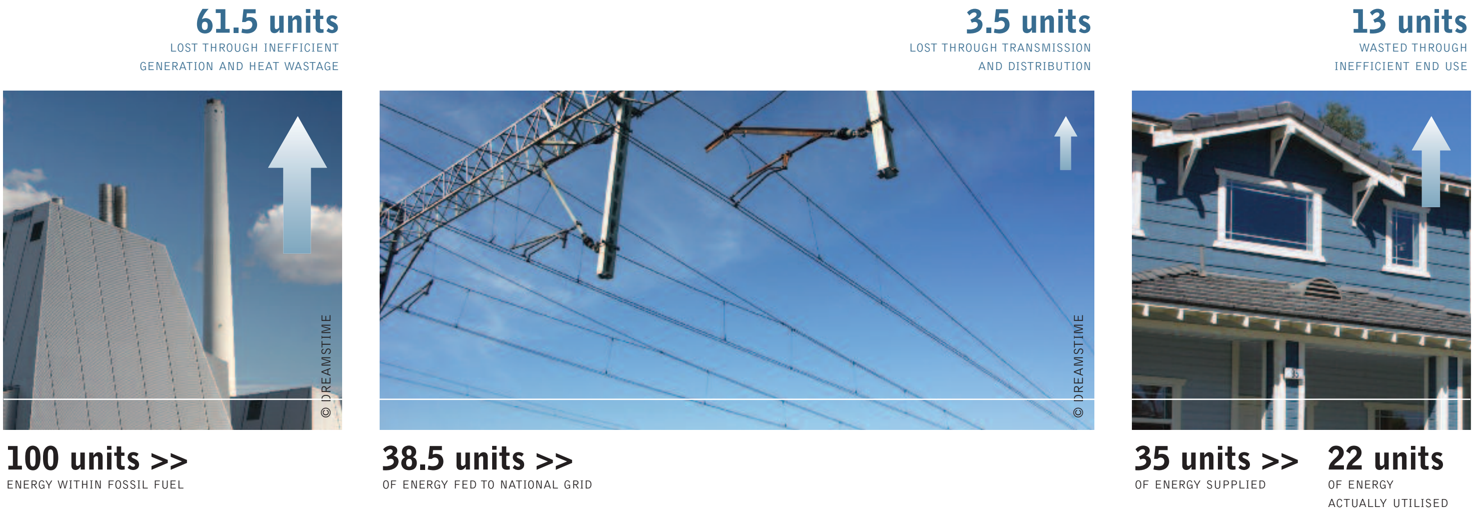


1. **PHOTOVOLTAIC, SOLAR FAÇADES** WILL BE A DECORATIVE ELEMENT ON OFFICE AND APARTMENT BUILDINGS. PHOTOVOLTAIC SYSTEMS WILL BECOME MORE COMPETITIVE AND IMPROVED DESIGN WILL ENABLE ARCHITECTS TO USE THEM MORE WIDELY.
2. **RENOVATION CAN CUT ENERGY CONSUMPTION OF OLD BUILDINGS** BY AS MUCH AS 80% - WITH IMPROVED HEAT INSULATION, INSULATED WINDOWS AND MODERN VENTILATION SYSTEMS.
3. **SOLAR THERMAL COLLECTORS** PRODUCE HOT WATER FOR BOTH THEIR OWN AND NEIGHBOURING BUILDINGS.
4. **EFFICIENT THERMAL POWER (CHP) STATIONS** WILL COME IN A VARIETY OF SIZES - FITTING THE CELLAR OF A DETACHED HOUSE OR SUPPLYING WHOLE BUILDING COMPLEXES OR APARTMENT BLOCKS WITH POWER AND WARMTH WITHOUT LOSSES IN TRANSMISSION.
5. **CLEAN ELECTRICITY** FOR THE CITIES WILL ALSO COME FROM FARTHER AFIELD. OFFSHORE WIND PARKS AND SOLAR POWER STATIONS IN DESERTS HAVE ENORMOUS POTENTIAL.

references
6 SEE CHAPTER 13

image A COW INFRONT OF A BIOREACTOR IN THE BIOENERGY VILLAGE OF JUEHNDE. IT IS THE FIRST COMMUNITY IN GERMANY THAT PRODUCES ALL OF ITS ENERGY NEEDED FOR HEATING AND ELECTRICITY, WITH CO_2 NEUTRAL BIOMASS.

figure 1.2: centralised energy infrastructures waste more than two thirds of their energy



optimised integration of renewable energy

Modification of the energy system will be necessary to accommodate the significantly higher shares of renewable energy expected under the Energy [R]evolution Scenario. This is not unlike what happened in the 1970s and 1980s, when most of the centralised power plants now operating were constructed in OECD countries. New high voltage power lines were built, night storage heaters marketed and large electric-powered hot water boilers installed in order to sell the electricity produced by nuclear and coal-fired plants at night.

Several OECD countries have demonstrated that it is possible to smoothly integrate a large proportion of decentralised energy, including variable sources such as wind. A good example is Denmark, which has the highest percentage of combined heat and power generation and wind power in Europe. With strong political support, 50% of electricity and 80% of district heat is now supplied by cogeneration plants. The contribution of wind power has reached more than 18% of Danish electricity demand. At certain times, electricity generation from cogeneration and wind turbines even exceeds demand. The load compensation required for grid stability in Denmark is managed both through regulating the capacity of the few large power stations and through import and export to neighbouring countries. A three tier tariff system enables balancing of power generation from the decentralised power plants with electricity consumption on a daily basis.

It is important to optimise the energy system as a whole through intelligent management by both producers and consumers, by an appropriate mix of power stations and through new systems for storing electricity.

appropriate power station mix: The power supply in OECD countries is mostly generated by coal and – in some cases – nuclear power stations, which are difficult to regulate. Modern gas power stations, by contrast, are not only highly efficient but easier and faster to regulate and thus better able to compensate for fluctuating loads. Coal and nuclear power stations have lower fuel and operating costs but comparably high investment costs. They must therefore run round-the-clock as 'base load' in order to earn back their investment. Gas power stations have lower investment costs and are profitable even at low output, making them better suited to balancing out the variations in supply from renewable energy sources.

load management: The level and timing of demand for electricity can be managed by providing consumers with financial incentives to reduce or shut off their supply at periods of peak consumption. Control technology can be used to manage the arrangement. This system is already used for some large industrial customers. A Norwegian power supplier even involves private household customers by sending them a text message with a signal to shut down. Each household can decide in advance whether or not they want to participate. In Germany, experiments are being conducted with time flexible tariffs so that washing machines operate at night and refrigerators turn off temporarily during periods of high demand.

This type of load management has been simplified by advances in communications technology. In Italy, for example, 30 million innovative electricity counters have been installed to allow remote meter reading and control of consumer and service information. Many household electrical products or systems, such as refrigerators, dishwashers, washing machines, storage heaters, water pumps and air conditioning, can be managed either by temporary shut-off or by rescheduling their time of operation, thus freeing up electricity load for other uses.

generation management: Renewable electricity generation systems can also be involved in load optimisation. Wind farms, for example, can be temporarily switched off when too much power is available on the network.

energy storage: Another method of balancing out electricity supply and demand is through intermediate storage. This storage can be decentralised, for example by the use of batteries, or centralised. So far, pumped storage hydro power stations have been the main method of storing large amounts of electric power. In a pumped storage system, energy from power generation is stored in a lake and then allowed to flow back when required, driving turbines and generating electricity. 280 such pumped storage plants exist worldwide. They already provide an important contribution to security of supply, but their operation could be better adjusted to the requirements of a future renewable energy system.

In the long term, other storage solutions are beginning to emerge. One promising solution besides the use of hydrogen is the use of compressed air. In these systems, electricity is used to compress air into deep salt domes 600 metres underground and at pressures of up to 70 bar. At peak times, when electricity demand is high, the air is allowed to flow back out of the cavern and drive a turbine. Although this system, known as CAES (Compressed Air Energy Storage) currently still requires fossil fuel auxiliary power, a so-called "adiabatic" plant is being developed which does not. To achieve this, the heat from the compressed air is intermediately stored in a giant heat store. Such a power station can achieve a storage efficiency of 70%.

The **forecasting** of renewable electricity generation is also continually improving. Regulating supply is particularly expensive when it has to be found at short notice. However, prediction techniques for wind power generation have become considerably more accurate in recent years and are still being improved. The demand for balancing supply will therefore decrease in the future.

the "virtual power station" [7]

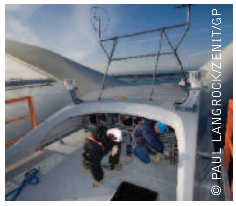
The rapid development of information technologies is helping to pave the way for a decentralised energy supply based on cogeneration plants, renewable energy systems and conventional power stations. Manufacturers of small cogeneration plants already offer internet interfaces which enable remote control of the system. It is now possible for individual householders to control their electricity and heat usage so that expensive electricity drawn from the grid can be minimised – and the electricity demand profile is smoothed. This is part of the trend towards the 'smart house' where its mini cogeneration plant becomes an energy management centre. We can go one step further than this with a 'virtual power station'. Virtual does not mean that the power station does not produce real electricity. It refers to the fact that there is no large, spatially located power station with turbines and generators. The hub of the virtual power station is a control unit which processes data from many decentralised power stations, compares them with predictions of power demand, generation and weather conditions, retrieves the available power market prices and then intelligently optimises the overall power station activity. Some public utilities already use such systems, integrating cogeneration plants, wind farms, photovoltaic systems and other power plants. The virtual power station can also link consumers into the management process.

"it is important to optimise the energy system as a whole through intelligent management by both producers and consumers..."

references

7 'RENEWABLE ENERGIES - INNOVATIONS FOR THE FUTURE', GERMAN MINISTRY FOR THE ENVIRONMENT, NATURE CONSERVATION AND NUCLEAR SAFETY (BMU), 2006

image TEST WINDMILL N90 2500, BUILT BY THE GERMAN COMPANY NORDEX, IN THE HARBOUR OF ROSTOCK. THIS WINDMILL PRODUCES 2,5 MEGA WATT AND IS TESTED UNDER OFFSHORE CONDITIONS. TWO TECHNICIANS WORKING INSIDE THE TURBINE.



future power grids

The **power grid network** must also change in order to realise decentralised structures with a high share of renewable energy. Today's grids are designed to transport power from a few centralised power stations out to the passive consumers. A future system must enable an active integration of consumers and decentralised power generators and thus realise real time two-way power and information flows. Large power stations will feed electricity into the high voltage grid but small decentralised systems such as solar, cogeneration and wind plants will deliver their power into the low or medium voltage grid. In order to transport electricity from renewable generation such as offshore wind farms in remote areas (see box), a limited number of new high voltage transmission lines will need to be constructed. These power lines will also be available for cross-border power trade. Within the Energy [R]evolution Scenario, the share of variable renewable energy sources is expected to reach about 10% of total electricity generation by 2020 and about 35% by 2050.

case 1: a north sea electricity grid

A new Greenpeace report shows how a regionally integrated approach to the large-scale development of offshore wind in the North Sea could deliver reliable clean energy for millions of homes. The 'North Sea Electricity Grid [R]evolution' report (September 2008) calls for the creation of an offshore network to enable the smooth flow of electricity generated from renewable energy sources into the power systems of seven different countries - the United Kingdom, France, Germany, Belgium, The Netherlands, Denmark and Norway – at the same time enabling significant emissions savings. The cost of developing the grid is expected to be between €15 and €20 billion. This investment would not only allow the broad integration of renewable energy but also unlock unprecedented power trading opportunities and cost efficiency. In a recent example, a new 600 kilometre-long power line between Norway and the Netherlands cost €600 million to build, but is already generating a daily cross-border trade valued at €800,000.

The grid would enable the efficient integration of renewable energy into the power system across the whole North Sea region. By aggregating power generation from wind farms spread across the whole area, periods of very low or very high power flows would be reduced to a negligible amount. A dip in wind power generation in one area would be 'balanced' by higher production in another area, even hundreds of kilometres away. Over a year, an installed offshore wind power capacity of 68.4 GW in the North Sea would be able to generate an estimated 247 TWh of electricity.

An offshore grid in the North Sea would also allow, for example, the import of electricity from hydro power generation in Norway to the British and UCTE (Central European) network. This could replace thermal baseload plants and increase flexibility within a portfolio. In addition, increased liquidity and trading facilities on the European power markets will allow for a more efficient portfolio management. The value of such an offshore therefore lies in its contribution to increased security of supply, its function in aggregating the dispatch of power from offshore wind farms and its role as a facilitator for power exchange and trade between regions and power systems.

"a future system must enable an active integration of consumers and decentralised power generators..."

figure 1.3: offshore grid topology proposal and offshore wind power installed capacity scenario

* MAP IS INDICATIVE. NO ENVIRONMENTAL IMPACT ASSESSMENT OF LOCATIONS AND SITING OF WINDFARMS AND CABLES HAS BEEN DONE.

Wind energy is booming in the EU. In 2007 alone, no less than 8550MW of wind turbines were installed in the EU, which is 40% of all newly-installed capacity. By 2020–2030, offshore wind energy in the North Sea could grow to 68,000MW and supply 13% of all current electricity production of seven North Sea countries. In order to integrate the electricity from the offshore wind farms, an offshore grid will be required. Greenpeace demands that the governments of these seven countries and the European Commission cooperate to make this happen.

INSTALLED AND PLANNED CAPACITY [MW]

	[MW]	[TWh]
BELGIUM	3,850	13.1
DENMARK	1,580	5.6
FRANCE	1,000	3.4
GERMANY	26,420	97.5
UNITED KINGDOM	22,240	80.8
NETHERLANDS	12,040	41.7
NORWAY	1,290	4.9
TOTAL	68,420	247

LEGEND

- **GRID:** PROPOSED OR DISCUSSED IN THE PUBLIC DOMAIN
- **GRID:** IN OPERATION OR PLANNING
- PRINCIPLE HVDC SUBSTATIONS
- **WIND FARMS:** INSTALLED PLANNED CAPACITY < 1000 MW
- **WIND FARMS:** INSTALLED PLANNED CAPACITY > 1000 MW

image OFFSHORE WINDFARM, MIDDELGRUNDEN, COPENHAGEN, DENMARK.

image CONSTRUCTION OF WIND TURBINES.

rural electrification[8]

Energy is central to reducing poverty, providing major benefits in the areas of health, literacy and equity. More than a quarter of the world's population has no access to modern energy services. In sub-Saharan Africa, 80% of people have no electricity supply. For cooking and heating, they depend almost exclusively on burning biomass – wood, charcoal and dung.

Poor people spend up to a third of their income on energy, mostly to cook food. Women in particular devote a considerable amount of time to collecting, processing and using traditional fuel for cooking. In India, two to seven hours each day can be devoted to the collection of cooking fuel. This is time that could be spent on child care, education or income generation. The World Health Organisation estimates that 2.5 million women and young children in developing countries die prematurely each year from breathing the fumes from indoor biomass stoves.

The Millennium Development Goal of halving global poverty by 2015 will not be reached without adequate energy to increase production, income and education, create jobs and reduce the daily grind involved in having to just survive. Halving hunger will not come about without energy for more productive growing, harvesting, processing and marketing of food.

Improving health and reducing death rates will not happen without energy for the refrigeration needed for clinics, hospitals and vaccination campaigns. The world's greatest child killer, acute respiratory infection, will not be tackled without dealing with smoke from cooking fires in the home. Children will not study at night without light in their homes. Clean water will not be pumped or treated without energy.

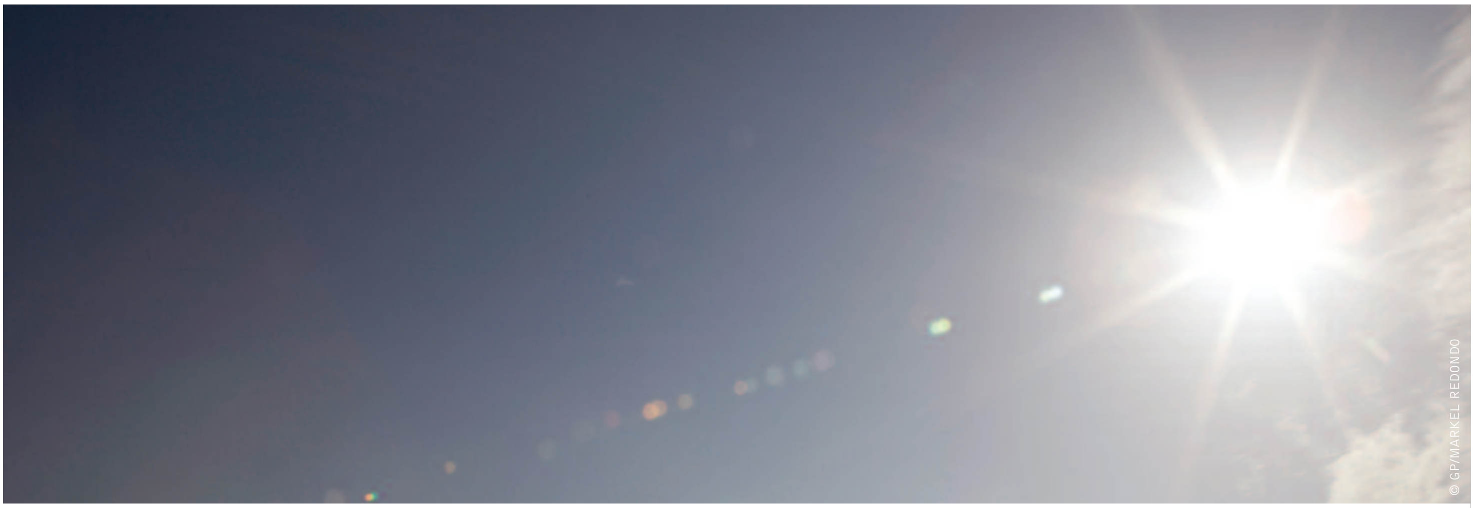
The UN Commission on Sustainable Development argues that "to implement the goal accepted by the international community of halving the proportion of people living on less than $1 per day by 2015, access to affordable energy services is a prerequisite".

the role of sustainable, clean renewable energy

Achieving the dramatic emissions cuts needed to avoid climate change - at least 30% by 2020 and more than 80% by 2050 - will require a massive uptake of renewable energy. The targets for renewable energy must be greatly expanded in industrialised countries both to substitute for fossil fuel and nuclear generation and to create the necessary economies of scale necessary for global expansion. Within the Energy [R]evolution Scenario we assume that modern renewable energy sources, such as solar collectors, solar cookers and modern forms of bio energy, will replace inefficient, traditional biomass use.

references

8 'SUSTAINABLE ENERGY FOR POVERTY REDUCTION: AN ACTION PLAN', IT POWER/GREENPEACE INTERNATIONAL, 2002



scenario principles in a nutshell

- Smart consumption, generation and distribution
- Energy production moves closer to the consumer
- Maximum use of locally available, environmentally friendly fuels

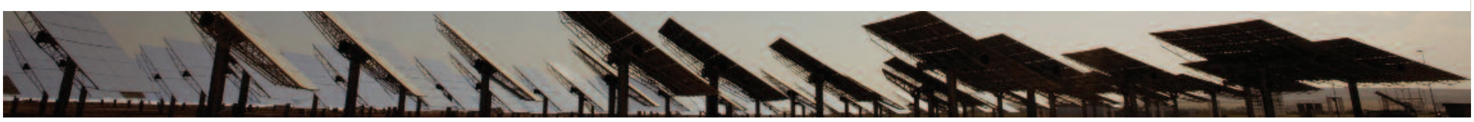


image THE PS10 CONCENTRATING SOLAR TOWER PLANT USES 624 LARGE MOVABLE MIRRORS CALLED HELIOSTATS. THE MIRRORS CONCENTRATE THE SUN'S RAYS TO THE TOP OF A 115 METER (377 FOOT) HIGH TOWER WHERE A SOLAR RECEIVER AND A STEAM TURBINE ARE LOCATED. THE TURBINE DRIVES A GENERATOR, PRODUCING ELECTRICITY, SEVILLA, SPAIN.

energy resources & security of supply

2

"the price of oil, the greenhouse gas emissions produced by oil and the exhaustion of fossil resources in the long term have turned renewable energies into the sole alternative to substitute the traditional energy sources."

JOSÉ LUIS RODRÍGUEZ ZAPATERO
PRESIDENT OF THE GOVERNMENT OF SPAIN

The issue of security of supply is now at the top of the energy policy agenda. Concern is focused both on price security and the security of physical supply. At present around 80% of global energy demand is met by fossil fuels. The unrelenting increase in energy demand is matched by the finite nature of these sources. The regional distribution of oil and gas resources, on the other hand, does not match the distribution of demand. Some countries have to rely almost entirely on fossil fuel imports. The maps on the following pages provide an overview of the availability of different fuels and their regional distribution. Information in this chapter is based partly on the report 'Plugging the Gap'[9].

oil

Oil is the lifeblood of the modern global economy, as the effects of the supply disruptions of the 1970s made clear. It is the number one source of energy, providing 36% of the world's needs and the fuel employed almost exclusively for essential uses such as transportation. However, a passionate debate has developed over the ability of supply to meet increasing consumption, a debate obscured by poor information and stirred by recent soaring prices.

the reserves chaos

Public data about oil and gas reserves is strikingly inconsistent, and potentially unreliable for legal, commercial, historical and sometimes political reasons. The most widely available and quoted figures, those from the industry journals Oil & Gas Journal and World Oil, have limited value as they report the reserve figures provided by companies and governments without analysis or verification. Moreover, as there is no agreed definition of reserves or standard reporting practice, these figures usually stand for different physical and conceptual magnitudes. Confusing terminology ('proved', 'probable', 'possible', 'recoverable', 'reasonable certainty') only adds to the problem.

Historically, private oil companies have consistently underestimated their reserves to comply with conservative stock exchange rules and through natural commercial caution. Whenever a discovery was made, only a portion of the geologist's estimate of recoverable resources was reported; subsequent revisions would then increase the reserves from that same oil field over time. National oil companies, mostly represented by OPEC (Organisation of Petroleum Exporting Countries), are not subject to any sort of accountability, so their reporting practices are even less clear. In the late 1980s, OPEC countries blatantly overstated their reserves while competing for production quotas, which were allocated as a proportion of the reserves. Although some revision was needed after the companies were nationalised, between 1985 and 1990, OPEC countries increased their joint reserves by 82%. Not only were these dubious revisions never corrected, but many of these countries have reported untouched reserves for years, even if no sizeable discoveries were made and production continued at the same pace. Additionally, the Former Soviet Union's oil and gas reserves have been overestimated by about 30% because the original assessments were later misinterpreted.

Whilst private companies are now becoming more realistic about the extent of their resources, the OPEC countries hold by far the majority of the reported reserves, and information on their resources is as unsatisfactory as ever. In brief, these information sources should be treated with considerable caution. To fairly estimate the world's oil resources a regional assessment of the mean backdated (i.e. 'technical') discoveries would need to be performed.

gas

Natural gas has been the fastest growing fossil energy source in the last two decades, boosted by its increasing share in the electricity generation mix. Gas is generally regarded as an abundant resource and public concerns about depletion are limited to oil, even though few in-depth studies address the subject. Gas resources are more concentrated, and a few massive fields make up most of the reserves: the largest gas field in the world holds 15% of the 'Ultimate Recoverable Resources' (URR), compared to 6% for oil. Unfortunately, information about gas resources suffers from the same bad practices as oil data because gas mostly comes from the same geological formations, and the same stakeholders are involved.

Most reserves are initially understated and then gradually revised upwards, giving an optimistic impression of growth. By contrast, Russia's reserves, the largest in the world, are considered to have been overestimated by about 30%. Owing to geological similarities, gas follows the same depletion dynamic as oil, and thus the same discovery and production cycles. In fact, existing data for gas is of worse quality than for oil, with ambiguities arising over the amount produced partly because flared and vented gas is not always accounted for. As opposed to published reserves, the technical ones have been almost constant since 1980 because discoveries have roughly matched production.

references

9 'PLUGGING THE GAP - A SURVEY OF WORLD FUEL RESOURCES AND THEIR IMPACT ON THE DEVELOPMENT OF WIND ENERGY', GLOBAL WIND ENERGY COUNCIL/RENEWABLE ENERGY SYSTEMS, 2006

image PLATFORM/OIL RIG DUNLIN IN THE NORTH SEA SHOWING OIL POLLUTION.

image HIGH MARNHAM COAL-FIRED POWER STATION ON THE RIVER TRENT IN NOTTINGHAMSHIRE, UK.


© GP/LANGER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coal

Coal was the world's largest source of primary energy until it was overtaken by oil in the 1960s. Today, coal supplies almost one quarter of the world's energy. Despite being the most abundant of fossil fuels, coal's development is currently threatened by environmental concerns; hence its future will unfold in the context of both energy security and global warming.

Coal is abundant and more equally distributed throughout the world than oil and gas. Global recoverable reserves are the largest of all fossil fuels, and most countries have at least some. Moreover, existing and prospective big energy consumers like the US, China and India are self-sufficient in coal and will be for the foreseeable future. Coal has been exploited on a large scale for two centuries, so both the product and the available resources are well known; no substantial new deposits are expected to be discovered. Extrapolating the demand forecast forward, the world will consume 20% of its current reserves by 2030 and 40% by 2050. Hence, if current trends are maintained, coal would still last several hundred years.

nuclear

Uranium, the fuel used in nuclear power plants, is a finite resource whose economically available reserves are limited. Its distribution is almost as concentrated as oil and does not match regional consumption. Five countries - Canada, Australia, Kazakhstan, Russia and Niger - control three quarters of the world's supply. As a significant user of uranium, however, Russia's reserves will be exhausted within ten years.

Secondary sources, such as old deposits, currently make up nearly half of worldwide uranium reserves. However, those will soon be used up. Mining capacities will have to be nearly doubled in the next few years to meet current needs.

A joint report by the OECD Nuclear Energy Agency[10] and the International Atomic Energy Agency estimates that all existing nuclear power plants will have used up their nuclear fuel, employing current technology, within less than 70 years. Given the range of scenarios for the worldwide development of nuclear power, it is likely that uranium supplies will be exhausted sometime between 2026 and 2070. This forecast includes the use of mixed oxide fuel (MOX), a mixture of uranium and plutonium.

references
10 'URANIUM 2003: RESOURCES, PRODUCTION AND DEMAND'

table 2.1: overview of fossil fuel reserves and resources

RESERVES, RESOURCES AND ADDITIONAL OCCURRENCES OF FOSSIL ENERGY CARRIERS ACCORDING TO DIFFERENT AUTHORS. **C** CONVENTIONAL (PETROLEUM WITH A CERTAIN DENSITY, FREE NATURAL GAS, PETROLEUM GAS, **NC** NON-CONVENTIONAL) HEAVY FUEL OIL, VERY HEAVY OILS, TAR SANDS AND OIL SHALE, GAS IN COAL SEAMS, AQUIFER GAS, NATURAL GAS IN TIGHT FORMATIONS, GAS HYDRATES). THE PRESENCE OF ADDITIONAL OCCURRENCES IS ASSUMED BASED ON GEOLOGICAL CONDITIONS, BUT THEIR POTENTIAL FOR ECONOMIC RECOVERY IS CURRENTLY VERY UNCERTAIN. IN COMPARISON: IN 1998, THE GLOBAL PRIMARY ENERGY DEMAND WAS 402EJ (UNDP ET AL., 2000).

ENERGY CARRIER		BROWN, 2002 EJ	IEA, 2002c EJ	IPCC, 2001a	EJ	NAKICENOVIC ET AL., 2000	EJ	UNDP ET AL., 2000	EJ	BGR, 1998	EJ
Gas	reserves	5,600	6,200	c	5,400	c	5,900	c	5,500	c	5,300
				nc	8,000	nc	8,000	nc	9,400	nc	100
	resources	9,400	11,100	c	11,700	c	11,700	c	11,100	c	7,800
				nc	10,800	nc	10,800	nc	23,800	nc[a)]	111,900
	additional occurrences				796,000		799,700		930,000		
Oil	reserves	5,800	5,700	c	5,900	c	6,300	c	6,000	c	6,700
				nc	6,600	nc	8,100	nc	5,100	nc	5,900
	resources	10,200	13,400	c	7,500	c	6,100	c	6,100	c	3,300
				nc	15,500	nc	13,900	nc	15,200	nc	25,200
	additional occurrences				61,000		79,500		45,000		
Coal	reserves	23,600	22,500		42,000		25,400		20,700		16,300
	resources	26,000	165,000		100,000		117,000		179,000		179,000
	additional occurrences				121,000		125,600				
Total	resource (reserves + resources)	**180,600**	**223,900**		**212,200**		**213,200**		**281,900**		**361,500**
Total	occurrence				**1,204,200**		**1,218,000**		**1,256,000**		

source SEE TABLE [a)] INCLUDING GAS HYDRATES

renewable energy

Nature offers a variety of freely available options for producing energy. Their exploitation is mainly a question of how to convert sunlight, wind, biomass or water into electricity, heat or power as efficiently, sustainably and cost-effectively as possible.

On average, the energy in the sunshine that reaches the Earth is about one kilowatt per square metre worldwide. According to the Research Association for Solar Power, power is gushing from renewable energy sources at a rate of 2,850 times more energy than is needed in the world. In one day, the sunlight which reaches the Earth produces enough energy to satisfy the world's current power requirements for eight years. Even though only a percentage of that potential is technically accessible, this is still enough to provide just under six times more power than the world currently requires.

definition of types of energy resource potential[11]

theoretical potential The theoretical potential identifies the physical upper limit of the energy available from a certain source. For solar energy, for example, this would be the total solar radiation falling on a particular surface.

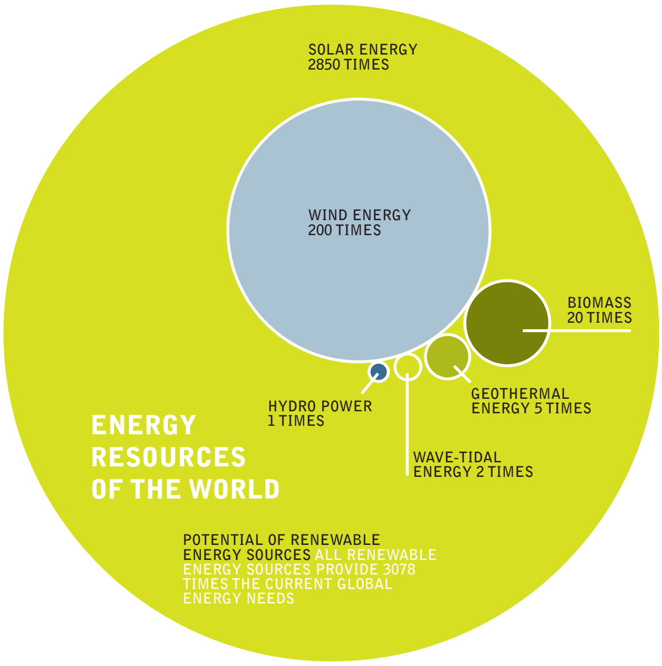
conversion potential This is derived from the annual efficiency of the respective conversion technology. It is therefore not a strictly defined value, since the efficiency of a particular technology depends on technological progress.

technical potential This takes into account additional restrictions regarding the area that is realistically available for energy generation. Technological, structural and ecological restrictions, as well as legislative requirements, are accounted for.

economic potential The proportion of the technical potential that can be utilised economically. For biomass, for example, those quantities are included that can be exploited economically in competition with other products and land uses.

sustainable potential This limits the potential of an energy source based on evaluation of ecological and socio-economic factors.

figure 2.1: energy resources of the world



source WBGU

table 2.2: technically accessible today

THE AMOUNT OF ENERGY THAT CAN BE ACCESSED WITH CURRENT TECHNOLOGIES SUPPLIES A TOTAL OF 5.9 TIMES THE GLOBAL DEMAND FOR ENERGY

Sun	3.8 times
Geothermal heat	1 time
Wind	0.5 times
Biomass	0.4 times
Hydrodynamic power	0.15 times
Ocean power	0.05 times

source DR. JOACHIM NITSCH

references
11 WBGU (GERMAN ADVISORY COUNCIL ON GLOBAL CHANGE)'

image SOLON AG PHOTOVOLTAICS FACILITY IN ARNSTEIN OPERATING 1,500 HORIZONTAL AND VERTICAL SOLAR "MOVERS". LARGEST TRACKING SOLAR FACILITY IN THE WORLD. EACH "MOVER" CAN BE BOUGHT AS A PRIVATE INVESTMENT FROM THE S.A.G. SOLARSTROM AG, BAYERN, GERMANY.

image WIND ENERGY PARK NEAR DAHME. WIND TURBINE IN THE SNOW OPERATED BY VESTAS.

renewable energy potential by region and technology

Based on the report 'Renewable Energy Potentials' from REN 21, a global policy network[12], we can provide a more detailed overview of renewable energy prospects by world region and technology. The table below focuses on large economies, which consume 80% of the world's primary energy and produce a similar share of the world's greenhouse gas emissions.

Solar photovoltaic (PV) technology can be harnessed almost everywhere, and its technical potential is estimated at over 1,500 EJ/year, closely followed by concentrating solar thermal power (CSP). These two cannot simply be added together, however, because they would require much of the same land resources. The onshore wind potential is equally vast, with almost 400 EJ/year available beyond the order of magnitude of future electricity consumption. The estimate for offshore wind potential (22 EJ/year) is cautious, as only wind intensive areas on ocean shelf areas, with a relatively shallow water depth, and outside shipping lines and protected areas, are included. The various ocean or marine energy potentials also reach a similar magnitude, most of it from ocean waves. Cautious estimates reach a figure of around 50 EJ/year. The estimates for hydro and geothermal resources are well established, each having a technical potential of around 50 EJ/year. Those figures should be seen in the context of a current global energy demand of around 500 EJ.

In terms of heating and cooling, apart from using biomass, there is the option of using direct geothermal energy. The potential is extremely large and could cover 20 times the current world energy demand for heat. The potential for solar heating, including passive solar building design, is virtually limitless. However, heat is costly to transport and one should only consider geothermal heat and solar water heating potentials which are sufficiently close to the point of consumption. Passive solar technology, which contributes enormously to the provision of heating services, is not considered as a (renewable energy) supply source in this analysis but as an efficiency factor to be taken into account in the demand forecasts.

table 2.3: technical renewable energy potential by region

EXCL. BIO ENERGY

	SOLAR CSP	SOLAR PV	HYDRO POWER	WIND ON-SHORE	WIND OFF-SHORE	OCEAN POWER	GEO-THERMAL ELECTRIC	GEO-THERMAL DIRECT USES	SOLAR WATER HEATING	TOTAL
	ELECTRICITY [EJ/YEAR]							HEATING [EJ/YEAR]		
OECD North America	21	72	4	156	2	68	5	626	23	976
Latin America	59	131	13	40	5	32	11	836	12	1,139
OECD Europe	1	13	2	16	5	20	2	203	23	284
Non OCED Europe & Transition Economies	25	120	5	67	4	27	6	667	6	926
Africa & Middle East	679	863	9	33	1	19	5	1,217	12	2,838
East & South Asia	22	254	14	10	3	103	12	1,080	45	1,543
Oceania	187	239	1	57	3	51	4	328	2	872
World	**992**	**1,693**	**47**	**379**	**22**	**321**	**45**	**4,955**	**123**	**8,578**

source REN21

references

12 'RENEWABLE ENERGY POTENTIALS: OPPORTUNITIES FOR THE RAPID DEPLOYMENT OF RENEWABLE ENERGY IN LARGE ENERGY ECONOMIES', REN 21, 2007

the global potential for sustainable biomass

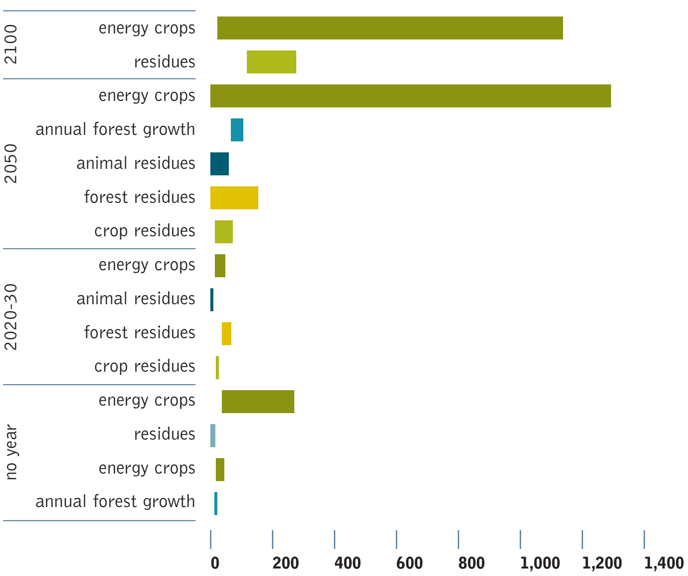
As part of background research for the Energy [R]evolution Scenario, Greenpeace commissioned the German Biomass Research Centre, the former Institute for Energy and Environment, to investigate the worldwide potential for energy crops in different scenarios up to 2050. In addition, information has been compiled from scientific studies of the worldwide potential and from data derived from state of the art remote sensing techniques such as satellite images. A summary of the report's findings is given below; references can be found in the full report.

assessment of biomass potential studies

Various studies have looked historically at the potential for bio energy and come up with widely differing results. A comparison between them is difficult because they use different definitions of the various biomass resource fractions. This problem is particularly significant in relation to forest derived biomass. Most research has focused almost exclusively on energy crops, as their development is considered to be more significant for satisfying the demand for bio energy. The result is that the potential for using forest residues (wood left over after harvesting) is often underestimated.

Data from 18 studies has been examined, with a concentration on those studies which report the potential for biomass residues. Among these there were ten comprehensive assessments with more or less detailed documentation of the methodology. The majority focus on the long-term potential for 2050 and 2100. Little information is available for 2020 and 2030. Most of the studies were published within the last ten years. Figure 2.2 shows the variations in potential by biomass type from the different studies.

figure 2.2: ranges of potentials for different resource categories



source GERMAN BIOMASS RESEARCH CENTRE (DBFZ)

Looking at the contribution of individual resources to the total biomass potential, the majority of studies agree that the most promising resource is energy crops from dedicated plantations. Only six give a regional breakdown, however, and only a few quantify all types of residues separately. Quantifying the potential of minor fractions, such as animal residues and organic wastes, is difficult as the data is relatively poor.

figure 2.3: bio energy potential analysis from different authors

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)

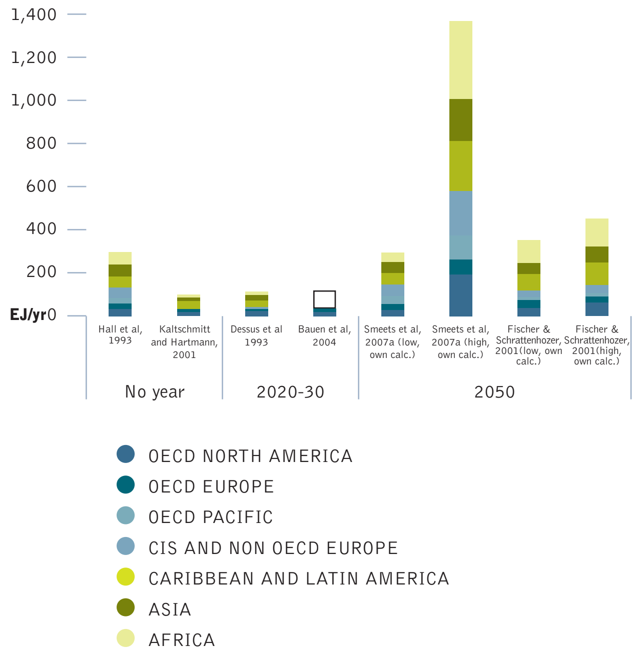


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image THE BIOENERGY VILLAGE OF JUEHNDE WHICH WAS THE FIRST COMMUNITY IN GERMANY TO PRODUCE ALL ITS ENERGY NEEDED FOR HEATING AND ELECTRICITY, WITH CO_2 NEUTRAL BIOMASS.

image A NEWLY DEFORESTED AREA WHICH HAS BEEN CLEARED FOR AGRICULTURAL EXPANSION IN THE AMAZON, BRAZIL.

potential of energy crops

Apart from the utilisation of biomass from residues, the cultivation of energy crops in agricultural production systems is of greatest significance. The technical potential for growing energy crops has been calculated on the assumption that demand for food takes priority. As a first step the demand for arable and grassland for food production has been calculated for each of 133 countries in different scenarios. These scenarios are:

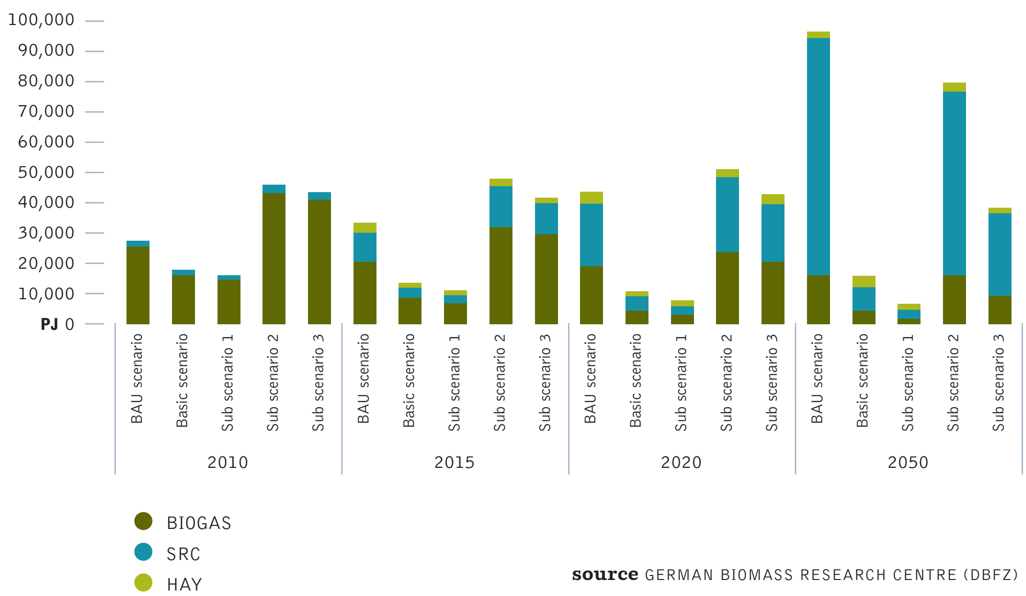
- Business as usual (BAU) scenario: Present agricultural activity continues for the foreseeable future
- Basic scenario: No forest clearing; reduced use of fallow areas for agriculture
- Sub-scenario 1: Basic scenario plus expanded ecological protection areas and reduced crop yields
- Sub-scenario 2: Basic scenario plus food consumption reduced in industrialised countries
- Sub-scenario 3: Combination of sub-scenarios 1 and 2

In a next step the surpluses of agricultural areas were classified either as arable land or grassland. On grassland, hay and grass silage are produced, on arable land fodder silage and Short Rotation Coppice (such as fast-growing willow or poplar) are cultivated. Silage of green fodder and grass are assumed to be used for biogas production, wood from SRC and hay from grasslands for the production of heat, electricity and synthetic fuels. Country specific yield variations were taken into consideration.

The result is that the global biomass potential from energy crops in 2050 falls within a range from 6 EJ in Sub-scenario 1 up to 97 EJ in the BAU scenario.

The best example of a country which would see a very different future under these scenarios in 2050 is Brazil. Under the BAU scenario large agricultural areas would be released by deforestation, whereas in the Basic and Sub 1 scenarios this would be forbidden, and no agricultural areas would be available for energy crops. By contrast a high potential would be available under Sub-scenario 2 as a consequence of reduced meat consumption. Because of their high populations and relatively small agricultural areas, no surplus land is available for energy crop production in Central America, Asia and Africa. The EU, North America and Australia, however, have relatively stable potentials.

figure 2.4: world wide energy crop potentials in different scenarios



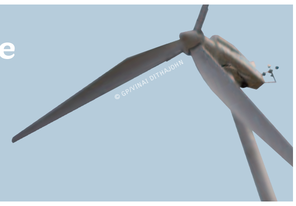
source GERMAN BIOMASS RESEARCH CENTRE (DBFZ)

The results of this exercise show that the availability of biomass resources is not only driven by the effect on global food supply but the conservation of natural forests and other biospheres. So the assessment of future biomass potential is only the starting point of a discussion about the integration of bioenergy into a renewable energy system.

The total global biomass potential (energy crops and residues) therefore ranges in 2020 from 66 EJ (Sub-scenario 1) up to 110 EJ (Sub-scenario 2) and in 2050 from 94 EJ (Sub-scenario 1) to 184 EJ (BAU scenario). These numbers are conservative and include a level of uncertainty, especially for 2050. The reasons for this uncertainty are the potential effects of climate change, possible changes in the worldwide political and economic situation, a higher yield as a result of changed agricultural techniques and/or faster development in plant breeding.

scenarios for a future energy supply

> "our climate change commitments and the insecurity of future and current fossil fuel supplies require us to make a quantum change in our energy policy."
>
> **EAMON RYAN**
> MINISTER OF COMMUNICATIONS, ENERGY AND NATURAL RESOURCES, IRELAND



1. fossil fuel and biomass price projections

The recent dramatic increase in global oil prices has resulted in much higher forward price projections for fossil fuels. Under the 2004 'high oil and gas price' scenario from the European Commission, for example, an oil price of just $34 per barrel was assumed in 2030. More recent projections of oil prices in 2030 range from the IEA's $$_{2006}$62/bbl ($$_{2005}$60/bbl) (WEO 2007) up to $$_{2006}$119/bbl ($$_{2005}$115/bbl) in the 'high price' scenario of the US Energy Information Administration's Annual Energy Outlook 2008.

Since the last Energy [R]evolution study was published, however, the price of oil has moved over $100/bbl for the first time (at the end of 2007), and in July 2008 reached a record high of more than $140/bbl. Although oil prices fell back to $100/bbl in September 2008, the above projections might still be considered too conservative. Considering the growing global demand for oil and gas we have assumed a price development path for fossil fuels in which the price of oil reaches $120/bbl by 2030 and $140/bbl in 2050.

As the supply of natural gas is limited by the availability of pipeline infrastructure, there is no world market price for natural gas. In most regions of the world the gas price is directly tied to the price of oil. Gas prices are assumed to increase to $20-25/GJ by 2050.

2. cost of CO_2 emissions

Assuming that a CO_2 emissions trading system is established in all world regions in the long term, the cost of CO_2 allowances needs to be included in the calculation of electricity generation costs. Projections of emissions costs are even more uncertain than energy prices, and available studies span a broad range of future CO_2 cost estimates. As in the previous Energy [R]evolution study we assume CO_2 costs of €8/tCO_2 in 2010, rising to €40/tCO_2 in 2050. Additional CO_2 costs are applied in Kyoto Protocol Non-Annex B (developing) countries only after 2020.

table 3.2: assumptions on fuel price development

	2005	2006	2007	2010	2015	2020	2030	2040	2050
Crude oil import prices in € 2005 per barrel	42	48	57						
IEA WEO 2007 ETP 2008				46	44		48		50
US EIA 2008 'Reference'				57		46	54		
US EIA 2008 'High Price'				61		79	92		
Energy [R]evolution 2008				80	84	88	96	104	112
Gas import prices in € 2005 per GJ	2000	2005	2006						
IEA WEO 2007/ ETP 2008									
US imports	3.7		5.9	6.0	6.0		6.4		6.5
European imports	2.7		6.0	5.4	5.4		6.0		6.1
Japan imports	4.5		5.7	6.0	6.0		6.4		6.5
Energy [R]evolution 2008									
US imports		4.5		9.2	10.1	11.7	14.7	17.5	19.6
European imports		4.6		8.0	9.1	10.6	13.7	16.4	18.3
Asia imports		4.5		9.2	10.0	11.7	14.6	17.5	19.6
Hard coal import prices in € 2005 per tonne	2000	2005	2006						
IEA WEO 2007/ ETP 2008	30		49	43	44		47	0	47
Energy [R]evolution 2008				114	133	155	200	248	286
Biomass (solid) prices in € 2005 per GJ	2005								
Energy [R]evolution 2008									
OECD Europe	6.0			6.3	6.8	7.5	8.2	8.4	8.6
OECD Pacific, NA	2.4			2.6	2.8	3.0	3.4	3.7	4.1
Other regions	2.0			2.2	2.5	2.8	3.2	3.7	3.9

image GROUP OF YOUNG PEOPLE TOUCHING SOLAR PANELS IN BRAZIL.

table 3.3: assumptions on CO_2 emissions cost development

(€/tCO_2)

COUNTRIES	2010	2020	2030	2040	2050
Kyoto Annex B countries	8	15.9	23.9	31.9	**39.8**
Non-Annex B countries		15.9	23.9	31.9	**39.8**

3. power plant investment costs

fossil fuel technologies and carbon capture and storage (CCS)

While the fossil fuel power technologies in use today for coal, gas, lignite and oil are established and at an advanced stage of market development, further cost reduction potentials are assumed. The potential for cost reductions is limited, however, and will be achieved mainly through an increase in efficiency, bringing down investment costs[13].

There is much speculation about the potential for carbon capture and storage (CCS) technology to mitigate the effect of fossil fuel consumption on climate change, even though the technology is still under development.

CCS is a means of trapping CO_2 from fossil fuels, either before or after they are burned, and 'storing' (effectively disposing of) it in the sea or beneath the surface of the Earth. There are currently three different methods of capturing CO_2: 'pre-combustion', 'post-combustion' and 'oxyfuel combustion'. However, development is at a very early stage and CCS will not be implemented - in the best case - before 2020 and will probably not become commercially viable as a possible effective mitigation option until 2030.

Cost estimates for CCS vary considerably, depending on factors such as power station configuration, technology, fuel costs, size of project and location. One thing is certain, however, CCS is expensive. It requires significant funds to construct the power stations and the necessary infrastructure to transport and store carbon. The IPCC assesses costs at €12-60 per ton of captured CO_2[14], while a recent US Department of Energy report found installing carbon capture systems to most modern plants resulted in a near doubling of costs[15]. These costs are estimated to increase the price of electricity in a range from 21-91%[16].

Pipeline networks will also need to be constructed to move CO_2 to storage sites. This is likely to require a considerable outlay of capital[17]. Costs will vary depending on a number of factors, including pipeline length, diameter and manufacture from corrosion-resistant steel, as well as the volume of CO_2 to be transported. Pipelines built near population centres or on difficult terrain, such as marshy or rocky ground, are more expensive[18].

The IPCC estimates a cost range for pipelines of €1-6/ton of CO_2 transported. A United States Congressional Research Services report calculated capital costs for an 11 mile pipeline in the Midwestern region of the US at approximately €5 million. The same report estimates that a dedicated interstate pipeline network in North Carolina would cost upwards of €4 billion due to the limited geological sequestration potential in that part of the country[19]. Storage and subsequent monitoring and verification costs are estimated by the IPCC to range from €0.4-6/tCO_2 injected and €0.1-0.2/tCO_2 injected, respectively. The overall cost of CCS could therefore serve as a major barrier to its deployment[20].

For the above reasons, CCS power plants are not included in our financial analysis. Table 3.4 summarises our assumptions on the technical and economic parameters of future fossil-fuelled power plant technologies. In spite of growing raw material prices, we assume that further technical innovation will result in a moderate reduction of future investment costs as well as improved power plant efficiencies. These improvements are, however, outweighed by the expected increase in fossil fuel prices, resulting in a significant rise in electricity generation costs.

table 3.4: development of efficiency and investment costs for selected power plant technologies

		2005	2010	2020	2030	2040	2050
Coal-fired condensing power plant	Efficiency (%)	45	46	48	50	52	**53**
	Investment costs (€/kW)	1,052	980	948	924	900	**876**
	Electricity generation costs including CO_2 emission costs (€cents/kWh)	5.3	7.2	8.6	10.0	11.3	**12.5**
	CO_2 emissions [a](g/kWh)	744	728	697	670	644	**632**
Lignite-fired condensing power plant	Efficiency (%)	41	43	44	44.5	45	**45**
	Investment costs (€/kW)	1,251	1,147	1,100	1,076	1,052	**1,028**
	Electricity generation costs including CO_2 emission costs (€cents/kWh)	4.7	5.2	6.0	6.7	7.4	**8.2**
	CO_2 emissions [a](g/kWh)	975	929	908	898	888	**888**
Natural gas combined cycle	Efficiency (%)	57	59	61	62	63	**64**
	Investment costs (€/kW)	550	538	514	486	462	**438**
	Electricity generation costs including CO_2 emission costs (€cents/kWh)	6.0	8.4	10.1	12.2	13.9	**15.1**
	CO_2 emissions [a](g/kWh)	354	342	330	325	320	**315**

source DLR, 2008 [a] CO_2 EMISSIONS REFER TO POWER STATION OUTPUTS ONLY; LIFE-CYCLE EMISSIONS ARE NOT CONSIDERED.

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4. cost projections for renewable energy technologies

The range of renewable energy technologies available today display marked differences in terms of their technical maturity, costs and development potential. Whereas hydro power has been widely used for decades, other technologies, such as the gasification of biomass, have yet to find their way to market maturity. Some renewable sources by their very nature, including wind and solar power, provide a variable supply, requiring a revised coordination with the grid network. But although in many cases these are 'distributed' technologies - their output being generated and used locally to the consumer - the future will also see large-scale applications in the form of offshore wind parks, photovoltaic power plants or concentrating solar power stations.

By using the individual advantages of the different technologies, and linking them with each other, a wide spectrum of available options can be developed to market maturity and integrated step by step into the existing supply structures. This will eventually provide a complementary portfolio of environmentally friendly technologies for heat and power supply and the provision of transport fuels.

Many of the renewable technologies employed today are at a relatively early stage of market development. As a result, the costs of electricity, heat and fuel production are generally higher than those of competing conventional systems - a reminder that the external (environmental and social) costs of conventional power production are not included in the market prices. It is expected, however, that compared with conventional technologies large cost reductions can be achieved through technical advances, manufacturing improvements and large-scale production. Especially when developing long-term scenarios spanning periods of several decades, the dynamic trend of cost developments over time plays a crucial role in identifying economically sensible expansion strategies.

To identify long-term cost developments, learning curves have been applied which reflect the correlation between cumulative production volumes of a particular technology and a reduction in its costs. For many technologies, the learning factor (or progress ratio) falls in the range between 0.75 for less mature systems to 0.95 and higher for well-established technologies. A learning factor of 0.9 means that costs are expected to fall by 10% every time the cumulative output from the technology doubles. Empirical data shows, for example, that the learning factor for PV solar modules has been fairly constant at 0.8 over 30 years whilst that for wind energy varies from 0.75 in the UK to 0.94 in the more advanced German market.

Assumptions on future costs for renewable electricity technologies in the Energy [R]evolution Scenario are derived from a review of learning curve studies, for example by Lena Neij and others[21], from the analysis of recent technology foresight and road mapping studies, including the European Commission funded NEEDS (New Energy Externalities Developments for Sustainability)[22] project or the IEA Energy Technology Perspectives 2008, and a discussion with experts from the renewable energy industry.

"large cost reductions can be achieved through technical advances, manufacturing improvements and large-scale production."

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22 WWW.NEEDS-PROJECT.ORG

image TRANSPORT POLLUTION.

photovoltaics (pv)

The worldwide photovoltaics (PV) market has been growing at over 35% per annum in recent years and the contribution it can make to electricity generation is starting to become significant. Development work is focused on improving existing modules and system components by increasing their energy efficiency and reducing material usage. Technologies like PV thin film (using alternative semiconductor materials) or dye sensitive solar cells are developing quickly and present a huge potential for cost reduction. The mature technology crystalline silicon, with a proven lifetime of 30 years, is continually increasing its cell and module efficiency (by 0.5% annually), whereas the cell thickness is rapidly decreasing (from 230 to 180 microns over the last five years). Commercial module efficiency varies from 14 to 21% depending on silicon quality and fabrication process.

The learning factor for PV modules has been fairly constant over the last 30 years, with a cost reduction of 20% each time the installed capacity doubles, indicating a high rate of technical learning. Assuming a globally installed capacity of 1,600 GW by between 2030 and 2040, and with an electricity output of 2,600 TWh, we can expect that generation costs of around 5-10 cents/kWh (depending on the region) will be achieved. During the following five to ten years, PV will become competitive with retail electricity prices in many parts of the world and competitive with fossil fuel costs by 2050. The importance of photovoltaics comes from its decentralised/centralised character, its flexibility for use in an urban environment and huge potential for cost reduction.

concentrating solar power (csp)

Solar thermal 'concentrating' power stations (CSP) can only use direct sunlight and are therefore dependent on high irradiation locations. North Africa, for example, has a technical potential which far exceeds local demand. The various solar thermal technologies (parabolic trough, power towers and parabolic dish concentrators) offer good prospects for further development and cost reductions. Because of their more simple design, 'Fresnel' collectors are considered as an option for additional cost reduction. The efficiency of central receiver systems can be increased by producing compressed air at a temperature of up to 1,000°C, which is then used to run a combined gas and steam turbine.

Thermal storage systems are a key component for reducing CSP electricity generation costs. The Spanish Andasol 1 plant, for example, is equipped with molten salt storage with a capacity of 7.5 hours. A higher level of full load operation can be realised by using a thermal storage system and a large collector field. Although this leads to higher investment costs, it reduces the cost of electricity generation.

Depending on the level of irradiation and mode of operation, it is expected that long term future electricity generation costs of 6-10 cents/kWh can be achieved. This presupposes rapid market introduction in the next few years.

table 3.5: photovoltaics (pv)

	2005	2010	2020	2030	2040	**2050**
Global installed capacity (GW)	5.2	21	269	921	1,799	**2,911**
Investment costs (€/kW)	5,259	2,996	1,323	1,020	908	**861**
Operation & maintenance costs (€/kWa)	53	30	13	10	9	**8**

table 3.6: concentrating solar power (csp)

	2005	2010	2020	2030	2040	**2050**
Global installed capacity (GW)	0.53	5	83	199	468	**801**
Investment costs (€/kW)	6,000	5,052	4,175	3,530	3,474	**3,442**
Operation & maintenance costs (€/kWa)	239	199	167	143	127	**124**

wind power

Within a short period of time, the dynamic development of wind power has resulted in the establishment of a flourishing global market. The world's largest wind turbines, several of which have been installed in Germany, have a capacity of 6 MW. While favourable policy incentives have made Europe the main driver for the global wind market, in 2007 more than half of the annual market was outside Europe. This trend is likely to continue. The boom in demand for wind power technology has nonetheless led to supply constraints. As a consequence, the cost of new systems has stagnated or even increased. Because of the continuous expansion of production capacities, the industry expects to resolve the bottlenecks in the supply chain over the next few years. Taking into account market development projections, learning curve analysis and industry expectations, we assume that investment costs for wind turbines will reduce by 30% for onshore and 50% for offshore installations up to 2050.

biomass

The crucial factor for the economics of biomass utilisation is the cost of the feedstock, which today ranges from a negative cost for waste wood (based on credit for waste disposal costs avoided) through inexpensive residual materials to the more expensive energy crops. The resulting spectrum of energy generation costs is correspondingly broad. One of the most economic options is the use of waste wood in steam turbine combined heat and power (CHP) plants. Gasification of solid biomass, on the other hand, which opens up a wide range of applications, is still relatively expensive. In the long term it is expected that favourable electricity production costs will be achieved by using wood gas both in micro CHP units (engines and fuel cells) and in gas-and-steam power plants. Great potential for the utilisation of solid biomass also exists for heat generation in both small and large heating centres linked to local heating networks. Converting crops into ethanol and 'bio diesel' made from rapeseed methyl ester (RME) has become increasingly important in recent years, for example in Brazil, the USA and Europe. Processes for obtaining synthetic fuels from biogenic synthesis gases will also play a larger role.

A large potential for exploiting modern technologies exists in Latin and North America, Europe and the Transition Economies, either in stationary appliances or the transport sector. In the long term Europe and the Transition Economies will realise 20-50% of the potential for biomass from energy crops, whilst biomass use in all the other regions will have to rely on forest residues, industrial wood waste and straw. In Latin America, North America and Africa in particular, an increasing residue potential will be available.

In other regions, such as the Middle East and all Asian regions, the additional use of biomass is restricted, either due to a generally low availability or already high traditional use. For the latter, using modern, more efficient technologies will improve the sustainability of current usage and have positive side effects, such as reducing indoor pollution and the heavy workloads currently associated with traditional biomass use.

table 3.7: wind power

	2005	2010	2020	2030	2040	**2050**
Installed capacity (on+offshore)	59	164	893	1,622	2,220	**2,733**
Wind onshore						
Global installed capacity (GW)	59	162	866	1,508	1,887	**2,186**
Investment costs (€/kW)	1,203	1,092	940	884	869	**869**
O&M costs (€/kWa)	46	41	36	34	33	**33**
Wind offshore						
Global installed capacity (GW)	0,3	1,6	27	114	333	**547**
Investment costs (€/kW)	2,996	2,773	2,072	1,753	1,586	**1,506**
O&M costs (€/kWa)	132	122	91	77	70	**66**

table 3.8: biomass

	2005	2010	2020	2030	2040	**2050**
Biomass (electricity only)						
Global installed capacity (GW)	21	35	56	65	81	**99**
Investment costs (€/kW)	2,422	2,191	2,016	1,968	1,944	**1,924**
O&M costs (€/kWa)	146	132	121	118	117	**116**
Biomass (CHP)						
Global installed capacity (GW)	32	60	177	275	411	**521**
Investment costs (€/kW)	4,598	3,960	3,076	2,693	2,478	**2,351**
O&M costs (€/kWa)	322	277	216	188	174	**165**

image THE PS10 SOLAR TOWER PLANT AT SAN LUCAR LA MAYOR OUTSIDE SEVILLE, SPAIN, APRIL 29, 2008.

geothermal

Geothermal energy has long been used worldwide for supplying heat, and since the beginning of the last century for electricity generation as well. Geothermally generated electricity was previously limited to sites with specific geological conditions, but further intensive research and development work has enabled the potential areas to be widened. In particular the creation of large underground heat exchange surfaces (Enhanced Geothermal Systems - EGS) and the improvement of low temperature power conversion, for example with the Organic Rankine Cycle, open up the possibility of producing geothermal electricity anyywhere. Advanced heat and power cogeneration plants will also improve the economics of geothermal electricity.

As a large part of the costs for a geothermal power plant come from deep underground drilling, further development of innovative drilling technology is expected. Assuming a global average market growth for geothermal power capacity of 9% per year up to 2020, adjusting to 4% beyond 2030, the result would be a cost reduction potential of 50% by 2050:

- for conventional geothermal power, from 6 €cents/kWh to about 2 €cents/kWh.
- for EGS, despite the presently high figures (about 16 €cents/kWh), electricity production costs - depending on the payments for heat supply - are expected to come down to around 4 €cents/kWh in the long term.

Because of its non-fluctuating supply and a grid load operating almost 100% of the time, geothermal energy is considered to be a key element in a future supply structure based on renewable sources. Until now we have just used a marginal part of the geothermal heating and cooling potential. Shallow geothermal drilling makes possible the delivery of heating and cooling at any time anywhere, and can be used for thermal energy storage.

ocean energy

Ocean energy, particularly offshore wave energy, is a significant resource, and has the potential to satisfy an important percentage of electricity supply worldwide. Globally, the potential of ocean energy has been estimated at around 90,000 TWh/year. The most significant advantages are the vast availability and high predictability of the resource and a technology with very low visual impact and no CO_2 emissions. Many different concepts and devices have been developed, including taking energy from the tides, waves, currents and both thermal and saline gradient resources. Many of them are in an advanced phase of R&D, large scale prototypes have been deployed in real sea conditions and some have reached pre-market deployment. There are a few grid connected, fully operational commercial wave and tidal generating plants.

The cost of energy from initial tidal and wave energy farms has been estimated to be in the range of 12-44 €cents/kWh, and for initial tidal stream farms in the range of 9-18 €cents/kWh. Generation costs of 8-20 €cents/kWh are expected by 2020. Key areas for development will include concept design, optimisation of the device configuration, reduction of capital costs by exploring the use of alternative structural materials, economies of scale and learning from operation. According to the latest research findings, the learning factor is estimated to be 10-15% for offshore wave and 5-10% for tidal stream. In the medium term, ocean energy has the potential to become one of the most competitive and cost effective forms of generation. In the next few years a dynamic market penetration is expected, following a similar curve to wind energy.

Because of the early development stage any future cost estimates for ocean energy systems are uncertain, and no learning curve data is available. Present cost estimates are based on analysis from the European NEEDS project[23].

table 3.9: geothermal

	2005	2010	2020	2030	2040	**2050**
Geothermal (electricity only)						
Global installed capacity (GW)	8.7	12	33	71	120	**152**
Investment costs (€/kW)	13,896	11,984	9,211	8,088	7,562	**7,155**
O&M costs (€/kWa)	514	444	341	299	280	**265**
Geothermal (CHP)						
Global installed capacity (GW)	0.24	1.7	13	38	82	**124**
Investment costs (€/kW)	13,944	10,398	7,578	6,335	5,522	**5,028**
O&M costs (€/kWa)	516	385	280	234	204	**186**

table 3.10: ocean energy

	2005	2010	2020	2030	2040	**2050**
Global installed capacity (GW)	0.27	0.9	17	44	98	**194**
Investment costs (€/kW)	7,203	4,120	2,319	1,785	1,490	**1,331**
Operation & maintenance costs (€/kWa)	287	165	93	71	60	**53**

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23 WWW.NEEDS-PROJECT.ORG

hydro power

Hydro power is a mature technology with a significant part of its potential already exploited. There is still, however, some potential left both for new schemes (especially small scale run-of-river projects with little or no reservoir impoundment) and for repowering of existing sites. The significance of hydro power is also likely to be encouraged by the increasing need for flood control and maintenance of water supply during dry periods. The future is in sustainable hydro power which makes an effort to integrate plants with river ecosystems while reconciling ecology with economically attractive power generation.

table 3.11: hydro

	2005	2010	2020	2030	2040	**2050**
Global installed capacity (GW)	878	978	1,178	1,300	1,443	**1,565**
Investment costs (€/kW)	2,199	2,295	2,446	2,550	2,645	**2,725**
Operation & maintenance costs (€/kWa)	88	92	98	102	106	**109**

summary of renewable energy cost development

Figure 3.3 summarises the cost trends for renewable energy technologies as derived from the respective learning curves. It should be emphasised that the expected cost reduction is basically not a function of time, but of cumulative capacity, so dynamic market development is required. Most of the technologies will be able to reduce their specific investment costs to between 30% and 70% of current levels by 2020, and to between 20% and 60% once they have achieved full development (after 2040).

Reduced investment costs for renewable energy technologies lead directly to reduced heat and electricity generation costs, as shown in Figure 3.4. Generation costs today are around 8 to 25 €cents/kWh (10-25 $cents/kWh) for the most important technologies, with the exception of photovoltaics. In the long term, costs are expected to converge at around 4 to 10 €cents/kWh (5-12 $cents/kWh). These estimates depend on site-specific conditions such as the local wind regime or solar irradiation, the availability of biomass at reasonable prices or the credit granted for heat supply in the case of combined heat and power generation.

figure 3.3: future development of investment costs
(NORMALISED TO CURRENT COST LEVELS) FOR RENEWABLE ENERGY TECHNOLOGIES

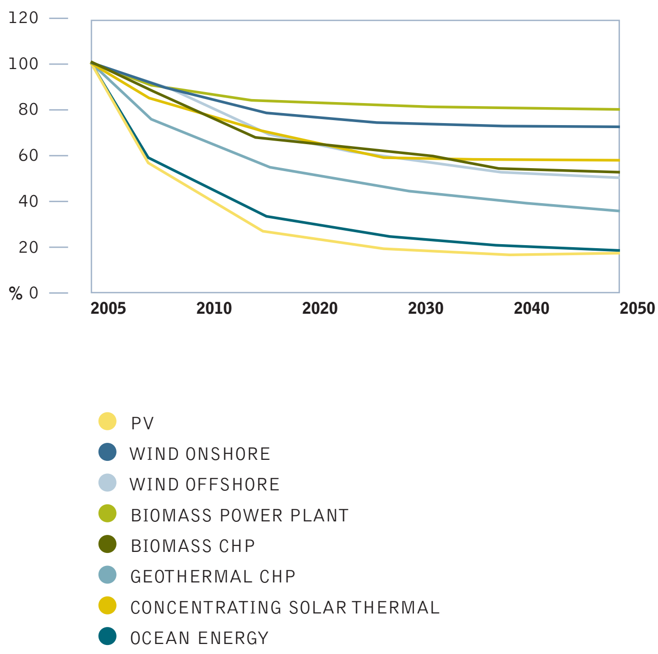
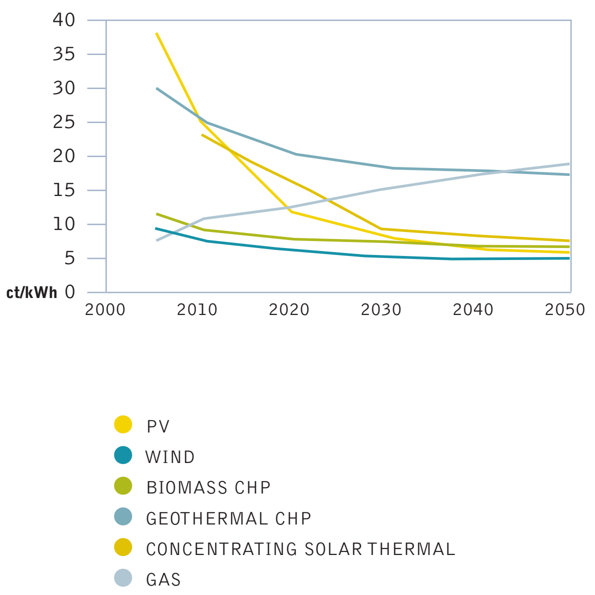


figure 3.4: expected development of electricity generation costs from fossil fuel and renewable options
EXAMPLE FOR EU-27

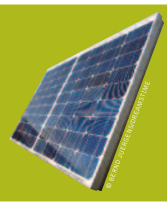


key results of the italian energy [r]evolution scenario

4

"this is an interesting vision, which should be possible to implement if there is sufficient political will behind it."

MARTIN BURSIK,
GOVERNMENT VICE-CHAIRMAN AND ENVIRONMENT MINISTER OF THE CZECH REPUBLIC
ON THE FIRST EDITION OF THE ENERGY [R]EVOLUTION SCENARIO



The development of future global energy demand is determined by three key factors:

- Population development: the number of people consuming energy or using energy services.
- Economic development, for which Gross Domestic Product (GDP) is the most commonly used indicator. In general, an increase in GDP triggers an increase in energy demand.
- Energy intensity: how much energy is required to produce a unit of GDP.

Both the Reference and Energy [R]evolution Scenarios are based on the same projections of population and economic development. The future development of energy intensity, however, differs between the two, taking into account the measures to increase energy efficiency under the Energy [R]evolution Scenario.

projection of energy intensity

An increase in economic activity and a growing population does not necessarily have to result in an equivalent increase in energy demand. There is still a large potential for exploiting energy efficiency measures. Under the Reference Scenario, we assume that energy intensity will be reduced by 1,35% on average per year, leading to a reduction in final energy demand per unit of GDP of about 56% between 2005 and 2050. Under the Energy [R]evolution Scenario, it is assumed that active policy and technical support for energy efficiency measures will lead to an even higher reduction in energy intensity of almost 60%.

figure 4.1: italy: population development projection

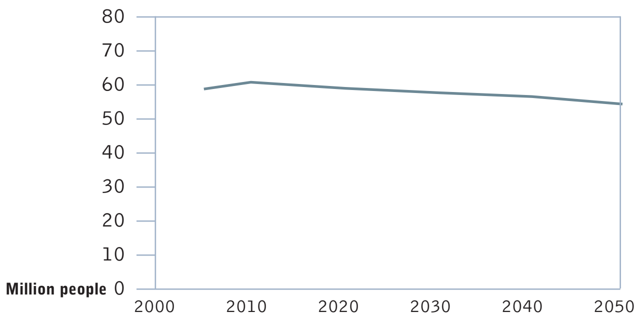
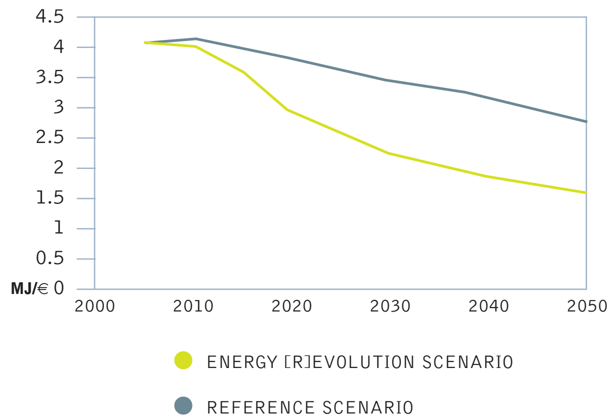


figure 4.2: italy: projection of average energy intensity under the reference and energy [r]evolution scenarios



italy: energy demand by sector

Pathways for Italy's energy demand are shown in Figure 4.3 for both the Reference and the Energy [R]evolution Scenarios. Under the Reference Scenario, total energy demand increase by more than 20% the current 7,884 PJ/a to 9,726 PJ/a in 2050. In the Energy [R]evolution Scenario, the energy demand decreases by 32% compared to current consumption and is expected by 2050 to reaching 5,366 PJ/a.

The accelerated increase of energy efficiency, which is a crucial prerequisite for achieving a sufficiently large share of renewable energy sources for our energy supply, is beneficial not only for the environment, but also from an economic point of view. Taking into account the full service life, in most cases the implementation of energy efficiency measures saves costs compared to the additional energy supply. The mobilisation of cost-effective energy saving potentials leads directly to the reduction of costs. A dedicated energy efficiency strategy thus also helps to compensate in part for the additional costs required during the market introduction phase of renewable energy sources.

figure 4.3: italy: projection of total final energy demand by sector for the two scenarios

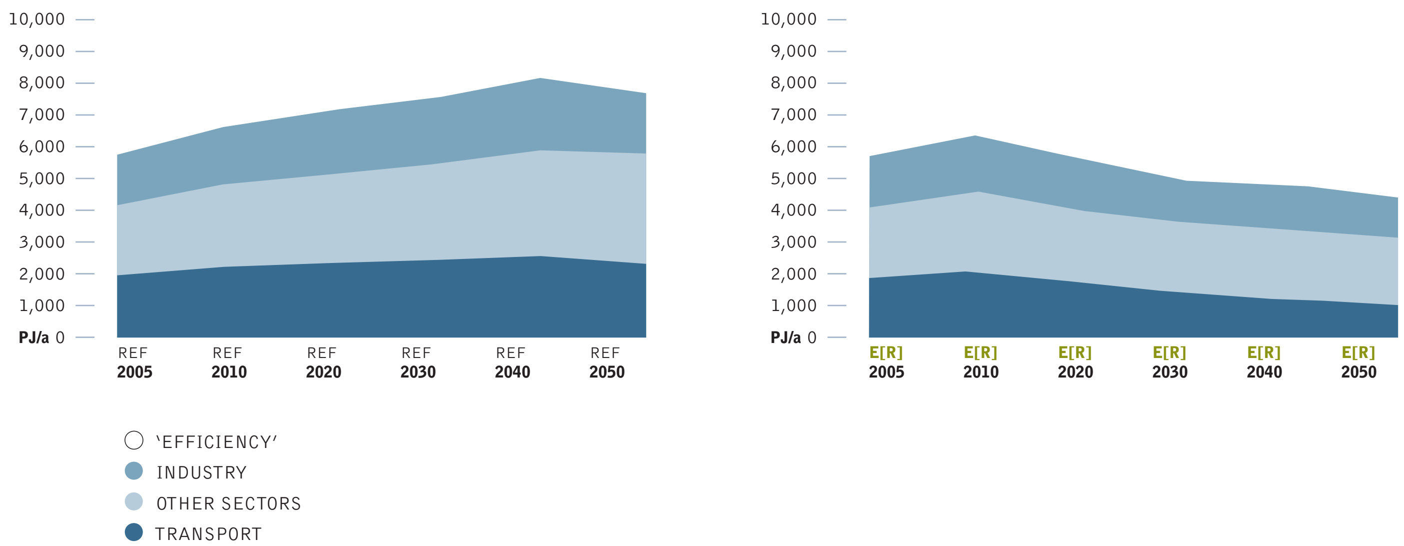


image image PHOTOVOLTAIC PANELS NEAR A CITY IN ITALY.

image GEOTHERMAL POWER PLANT IN LARDERELLO, ITALY.

Under the Energy [R]evolution Scenario, electricity demand is expected to decrease disproportionately, with households and services the main source of reduced consumption. With the exploitation of efficiency measures, but with an increase use of electric vehicles, an increase can not be avoided, leading to electricity demand of around 445 TWh/a in the year 2050. Compared to the Reference Scenario, efficiency measures avoid the generation of about 119 TWh/a. This reduction in energy demand can be achieved in particular by introducing highly efficient electronic devices using the best available technology in all demand sectors. Employment of solar architecture in both residential and commercial buildings will help to curb the growing demand for active air-conditioning.

Efficiency gains in the heat supply sector are even larger. Under the Energy [R]evolution Scenario, final demand for heat supply can even be reduced (see Figure 4.5). Compared to the Reference Scenario, consumption equivalent to 861 PJ/a is avoided through efficiency gains by 2050. As a result of energy-related renovation of the existing stock of residential buildings, as well as the introduction of low energy standards and 'passive houses' for new buildings, enjoyment of the same comfort and energy services will be accompanied by a much lower future energy demand.

In the transport sector, it is assumed under the Energy [R]evolution Scenario that energy demand will decrease by almost half to 1,008 PJ/a by 2050, saving 67% compared to the Reference Scenario. This reduction can be achieved by the introduction of highly efficient vehicles, by shifting the transport of goods from road to rail and by changes in mobility-related behaviour patterns.

figure 4.4: italy: development of electricity demand by sector

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO; OTHER SECTORS = SERVICES, HOUSEHOLDS)

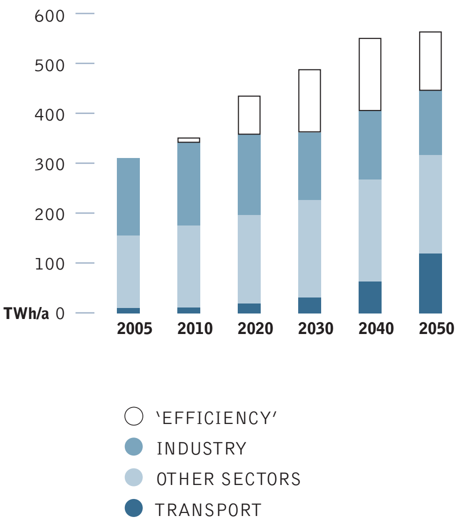
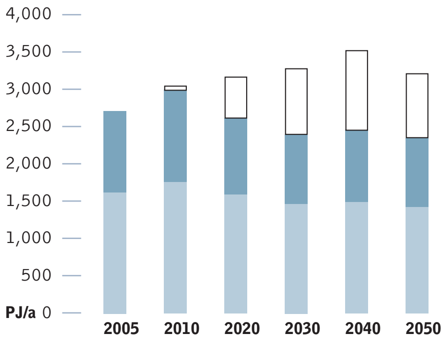


figure 4.5: italy: development of heat demand by sector

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)



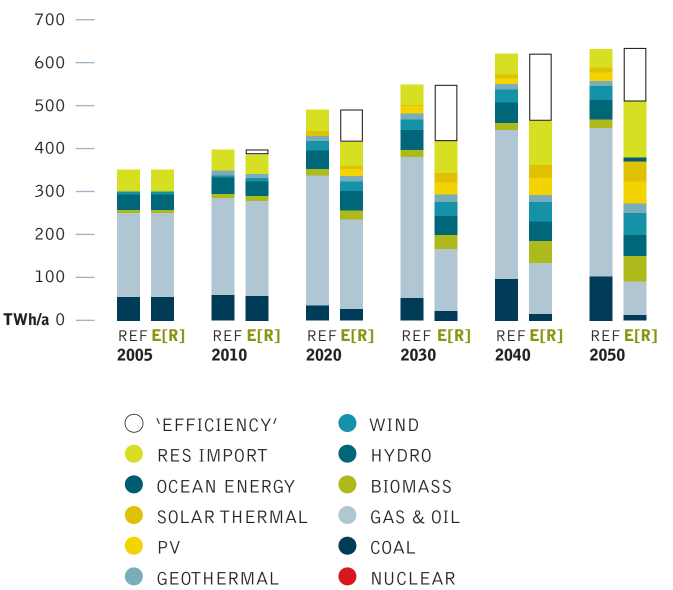
italy: electricity generation

The development of the electricity supply sector is characterised by a dynamically growing renewable energy market and an increasing share of renewable electricity. This will compensate for the phasing out of oil power plants and reduce the number of fossil fuel-fired power plants required for grid stabilisation. By 2050, 76% of the electricity produced in Italy will come from renewable energy sources. 'New' renewables – mainly wind, solar thermal energy, PV and geothermal – will contribute 54% of electricity generation. The following strategy paves the way for a future renewable energy supply:

- The phasing out of oil power plants and rising electricity demand will be met initially by bringing into operation new highly efficient gas-fired combined-heat and power plants, plus an increasing capacity of wind turbines, concentrated solar power plants and photovoltaic. In the long term, wind will be the most important single source of electricity generation, followed by solar photovoltaic.
- Solar energy, hydro and biomass will make substantial contributions to electricity generation. In particular, as non-fluctuating renewable energy sources, hydro, biomass and solar thermal, combined with efficient heat storage, are important elements in the overall generation mix.
- The installed capacity of renewable energy technologies will grow from the current 18 GW to 104 GW in 2050. Increasing renewable capacity by a factor of 5.7 within the next 40 years requires political support and well-designed policy instruments, however. There will be a considerable demand for investment in new production capacity over the next 20 years. As investment cycles in the power sector are long, decisions on restructuring the world's energy supply system need to be taken now.

figure 4.6: italy: development of electricity generation structure under the two scenarios

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)



To achieve an economically attractive growth in renewable energy sources, a balanced and timely mobilisation of all technologies is of great importance. This mobilisation depends on technical potentials, cost reduction and technological maturity. Figure 4.7 shows the comparative evolution of the different renewable technologies over time. Up to 2020, hydro-power, wind and biomass will remain the main contributors to the growing market share. After 2020, the continuing growth of wind will be complemented by electricity photovoltaic and concentrated solar power stations (CSP).

In the Reference Scenario, Italy´s electricity demand increases untill 2050. New or replacement capacity for fossil fuel power plants in the Reference Scenario are based on the cost assumptions given on page 23, table 3.4. Therefore the overall installed capacity for coal power plants increases and decreases according to these assumptions.

None of these numbers describe a maximum feasibility, but a possible balanced approach. With the right policy development, thesolar industry believes that a much further uptake could happen, and also the Italian Wind Industry is confident that by 2030 already 24 GW could be installed in Italy. Therefore the figures shown in the alternative scenario should be considered conservative.

table 4.1: italy: projection of renewable electricity generation capacity under the energy [r]evolution scenario

IN GW

	2005	2010	2020	2030	2040	2050
Hydro	14	15	18	19	20	21
Wind	2	4	11	13	15	18
PV	0	2	12	22	28	36
Biomass	1	2	4	7	9	11
Geothermal	1	1	2	2	3	3
Solarthermal	0	0	1.2	5	9	13
Ocean energy	0	0	1	1	1	2
Total	**18**	**23**	**49**	**69**	**86**	**104**

figure 4.7: italy: growth of renewable electricity generation capacity under the energy [r]evolution scenario

BY INDIVIDUAL SOURCE

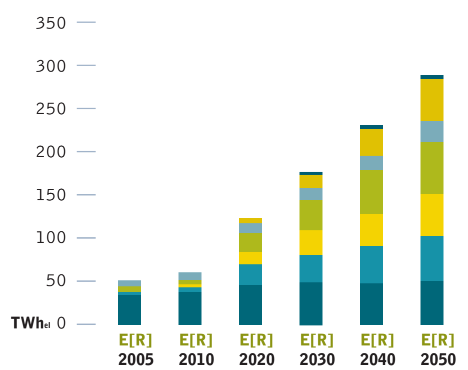


image WIND FARM IN ITALY.

image RAPESEED FIELD IN ITALY.

italy: future costs of electricity generation

Figure 4.8 shows that the introduction of renewable technologies under the Energy [R]evolution Scenario slightly increases the costs of electricity generation compared to the Reference Scenario. This difference will be less than 0.5 cents/kWh up to 2015. Note that any increase in fossil fuel prices beyond the projection given in Table 3.2, page 22 will reduce the gap between the two scenarios. Because of the lower CO_2 intensity of electricity generation, by 2020 electricity generation costs will become economically favourable under the Energy [R]evolution Scenario, and by 2050 generation costs will be more than 4 cents/kWh below those in the Reference Scenario.

Due to growing demand, we face a significant increase in society's expenditure on electricity supply. Under the Reference Scenario, the unchecked growth in demand, the increase in fossil fuel prices and the cost of CO_2 emissions result in total electricity supply costs rising from today's €28 billion per year to more than € 79 bn in 2050. Figure 28 shows that the Energy [R]evolution Scenario not only complies with Italy's CO_2 reduction targets but also helps to stabilise energy costs and relieve the economic pressure on society. Increasing energy efficiency and shifting energy supply to renewables leads to long term costs for electricity supply that are one third lower than in the Reference Scenario. It becomes clear that pursuing stringent environmental targets in the energy sector also pays off in terms of economics.

The overall costs for power generation in 2005 have been calculated on the fuel cost assumption on page 23, table 3.4. However the real costs for oil and gas have been higher in the year 2008, up to 160 $/barrel. Therefore Italy`s power generation costs in 2008 have been significantly higher than 28 billion.

figure 4.8: italy: development of specific electricity generation costs under the two scenarios

(CO₂ EMISSION COSTS IMPOSED FROM 2010, WITH AN INCREASE FROM 15 €/T_{CO_2} IN 2010 TO 50 €/T_{CO_2} IN 2050)

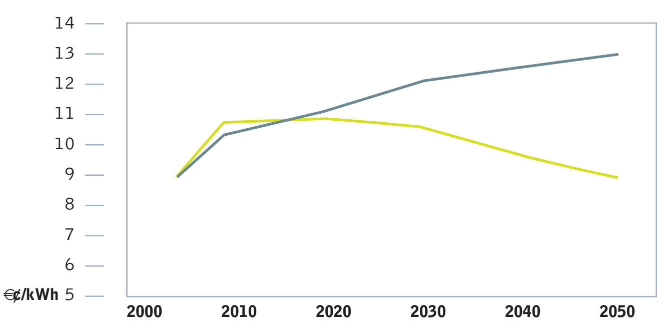
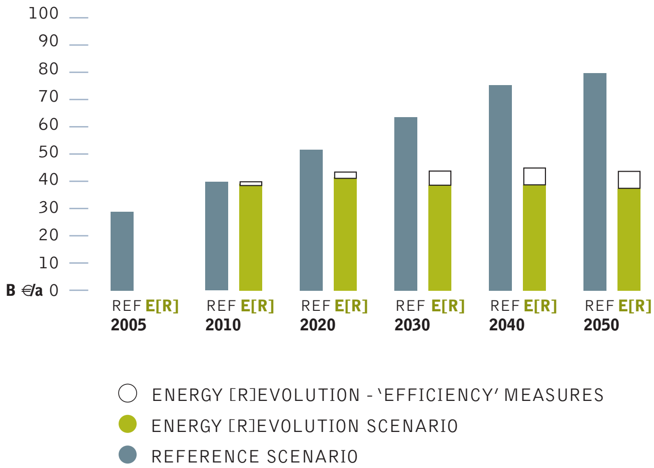


figure 4.9: italy: development of total electricity supply costs



italy: heat and cooling supply

Development of renewables in the heat supply sector raises different issues. Today, renewables provide 2.7% of Italy's primary energy demand for heat supply, the main contribution coming from the use of biomass. The lack of district heating networks is a severe structural barrier to the large scale utilisation of geothermal and solar thermal energy. Past experience shows that it is easier to implement effective support instruments in the grid-connected electricity sector than in the heat market, with its multitude of different actors. Dedicated support instruments are required to ensure a dynamic development.

In the Energy [R]evolution scenario, renewables provide 64% of Italy's total heating and cooling demand in 2050.

- Energy efficiency measures can decrease the current demand for heat supply by 13% in 2050, in spite of improving living standards.
- For direct heating, solar collectors, biomass/biogas as well as geothermal energy are increasingly substituting for fossil fuel-fired systems.
- A shift from coal and oil to natural gas in the remaining conventional applications will lead to a further reduction of CO_2 emissions.

italy: transport

In the transport sector, it is assumed under the Energy [R]evolution Scenario that energy demand will decrease by almost half to 1,008 PJ/a by 2050, saving 57% compared to the Reference Scenario. This reduction can be achieved by the introduction of highly efficient vehicles, by shifting the transport of goods from road to rail and by changes in mobility-related behaviour patterns. Implementing attractive alternatives to individual cars, the light-duty vehicles (LDV) stock is growing slower than in the Reference Scenario. A shift towards smaller cars triggered by economic incentives together with a significant shift in propulsion technology towards electrified power trains and a reduction of vehicle kilometres travelled by 0.25% per year leads to a 60% final energy savings.

figure 4.10: italy: development of heat supply structure under the two scenarios

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)

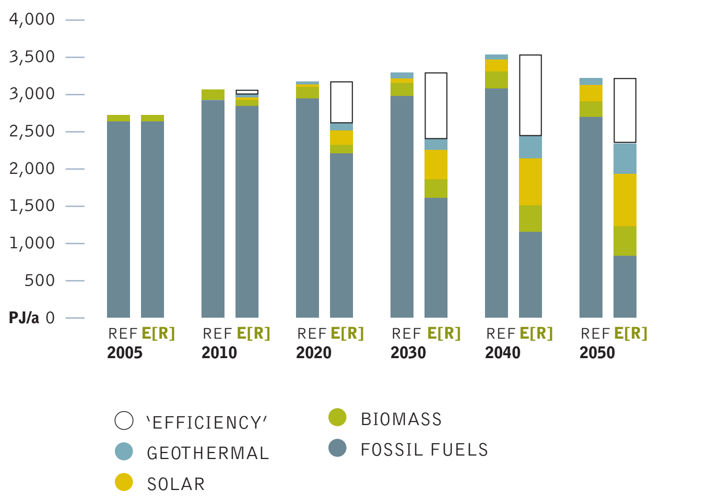


figure 4.11: italy: transport under the two scenarios

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)

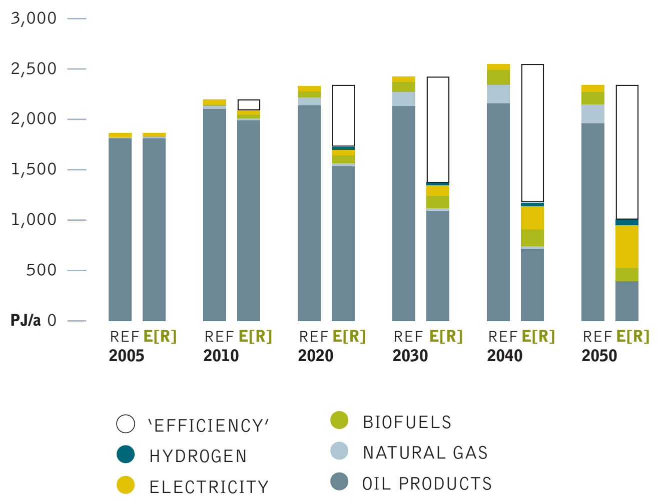


image PHOTOVOLTAIC PANELS IN SAN SABINO, OSIMO, ANCONA, ITALY.

image FUEL EFFICIENT CARS PRESENTED AT ONE OF THE LARGEST CAR SHOWS IN THE WORLD, IN BOLOGNA, ITALY.

italy: development of CO_2 emissions

Whilst Italy's emissions of CO_2 will increase by 18% under the Reference Scenario, under the Energy [R]evolution Scenario they will decrease by 71% from 444 million tons in 2005 to 112 Mt in 2050. Annual per capita emissions will drop from 7.6 t to 2.1 t. In spite of increasing electricity demand, CO_2 emissions will decrease in the electricity sector. In the long run efficiency gains and the increased use of renewable electricity and sustainable bio fuels in vehicles will even reduce CO_2 emissions in the transport sector. With a share of 25% of total CO_2 in 2050, both the power and transport sector will remain the largest source of emissions.

italy: primary energy consumption

Taking into account the assumptions discussed above, the resulting primary energy consumption under the Energy [R]evolution Scenario is shown in Figure 4.13. Compared to the Reference Scenario, overall energy demand will be reduced by almost 45% in 2050. Around 61% of the remaining demand will be covered by renewable energy sources. Note that because of the 'efficiency method' used for the calculation of primary energy consumption, which postulates that the amount of electricity generation from hydro, wind, solar and geothermal energy equals the primary energy consumption, the share of renewables seems to be lower than their actual importance as energy suppliers.

figure 4.12: italy: development of CO_2 emissions by sector under the energy [r]evolution scenario

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)

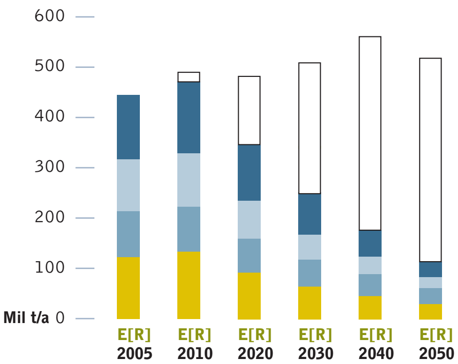


figure 4.13: italy: development of primary energy consumption under the two scenarios

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)

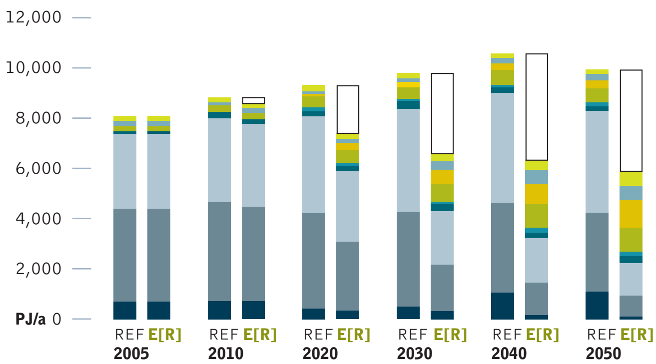


table 4.2: italy: development of final energy demand under the energy [r]evolution scenario in PJ/a

	2005	2010	2020	2030	2040	2050
Transport	1,870	2,092	1,726	1,384	1,183	1,008
Industry	1,581	1,791	1,546	1,341	1,345	1,273
Other	2,289	2,525	2,332	2,254	2,267	2,141
Total	**5,740**	**6,408**	**5,603**	**4,978**	**4,795**	**4,422**

climate & energy policy

5

"we need to take the scientific research seriously. the time we have left to respond is getting shorter every day."

HANS-GERT PÖTTERING
PRESIDENT OF THE EUROPEAN PARLIAMENT

climate policy

The Intergovernmental Panel on Climate Change (IPCC) projects global temperature increases over the next hundred years of up to 5.8°C, depending on action taken to mitigate greenhouse gas emissions. This is much faster than anything experienced in human history and does not include the very strong likelihood of "positive feedbacks" being triggered, which result in additional warming.

We are already experiencing impacts of climate change. From the Inuit in the far north to residents of low-lying atolls and river delta regions, people are already struggling with climate impacts, and millions are threatened with an increased risk of hunger, malaria, flooding and water shortages. Never before has humanity been forced to grapple with such an immense environmental crisis. Italy is one of the most threatened countries in Europe due to the simple fact that its territory lies in the middle of the Mediterranean Sea, an area which will strongly be affected by water scarcity and desertification. Already now southern regions, like Sardinia, Sicily and Apulia, are expected to lose 30% of land to desertification. Italy also has thousands of kilometres of coasts which will be affected by sea level increase and coastal erosion. Last but not least, the country hosts one of the most fragile and unique ecosystems in Europe, the Alps glaciers. Recently the European Environmental Agency warned that "European glaciers are melting rapidly: those in the Alps have lost two thirds of their volume since 1850. There is the risk that all Alps glaciers will be lost by 2080. This will have a tremendous impact on many economic sectors which rely on the water coming from glaciers: reduced supply of drinking water; weakened irrigation for agriculture, reduced generation of hydropower, loss of seasonal tourism. Climate change will also dramatically affect biodiversity loss and risk of extinction for many species living in our seas and mountains.

If immediate political action to stop climate change does not occur and overall temperatures rise to more than 2°C beyond preindustrial levels, the damage will become catastrophic. Warming from greenhouse gas emissions may trigger the irreversible meltdown of the Greenland ice sheet, adding up to seven metres of sea level rise. New evidence also shows that the rate of ice discharge from parts of the Antarctic mean it is also at risk of meltdown. Large releases of methane from melting permafrost and from the oceans will lead to rapid increases of the gas in the atmosphere and consequent warming. There is clearly an imperative to reduce emissions as much and as quickly as we can. The final goal should be to keep the global mean temperature rise to as far below 2°C above pre-industrial levels as possible: greenhouse gases emissions have to be stabilised in 2015 and reduced as close to ZERO as possible by 2050.

Each country has its own responsibility in reducing CO_2 emissions to respect European and International agreements, such as the Kyoto Protocol, which obliges Italy to cut its emissions by 6,5% in 2008-2012 period, compared to 1990 levels. Up to now Italian CO_2 emissions have registered a net increase, almost +10% since 1990. It's now time for Italy to exploit its huge potential in renewables resources and improve its actual policies on energy efficiency to reduce emissions up to 71% by 2050. The Italian Energy [R]evolution demonstrates that this target is entirely feasible and achievable, and it needs to happen fast. Actually the lack of political commitment is still the greatest barrier to a clean, stable and secure energy future.

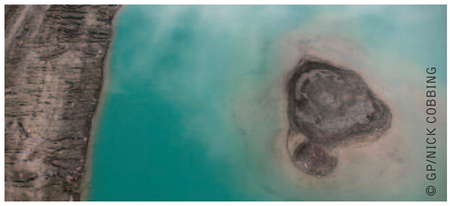
italian energy policy

Europe has often claimed to be a leader on climate change, but Italy has never played a leading role at European level on this issue. To drive the energy revolution that is required in this fight against global warming, Italy should instead lead by example through a shift towards a clean and sustainable energy system. This would not only deliver the substantial emission reductions required, but it would also contribute to sustainable economic growth, high quality jobs, technology development, global competitiveness and industrial and research leadership.

At present, a wide range of energy-market failures still discourage the significant investments in renewable energy and energy efficiency that are needed. An ambitious approach is required to remove these barriers so as to replace Italy's addiction on fossil fuels with clean and abundant renewable energy sources. Italy energy sector is strongly dependant on fossil fuels arriving from abroad – such as oil, gas and coal. To support the development of clean energy sources will result in stopping the huge amount of money spent abroad and enhancing national economy: over 300 thousands green new jobs could be created in Italy by 2020[24], only if the EU targets of the "Climate and Energy" package will be met.

image OFF SHORE WINDFARM, MIDDELGRUNDEN, COPENHAGEN, DENMARK.

image A MELT POOL NEAR SERMALIK FJORD, EAST GREENLAND, MADE BY THE HELHEIM GLACIER WHICH HAS RECEDED AND MELTED AWAY. THE LINES IN THE EARTH BANK ARE SCULPTED BY THE MOVEMENT OF THE GLACIER'S RETREAT.



Greenpeace proposes six main measures that the Italian government should implement to realise the energy [r]evolution:

1. Support scientific emission reduction targets in line with the 2°Celsius global warming limit
2. Phase out all subsidies for fossil fuel and nuclear power
3. Stop opening new coal power plants, and stop nuclear renaissance
4. Set stringent and ever-improving standards for energy efficiency
5. Provide stable support for renewable energy and fix regional burden sharing for renewables
6. Remove barriers to renewable energy development and reform the electricity market

six political steps for the energy [r]evolution

1. **support scientific emission reduction targets in line with the 2°Celsius global warming limit** The European Union has already committed to the objective of keeping global mean temperature increase below 2°C compared to pre-industrial levels, and has also indicated a target of 20% emission reduction in 2020 within the European "Climate and Energy" package. Greenpeace believes that this target is not in line with actual scientific indications and asks all European countries to support an unilateral European commitment to reduce its domestic greenhouse gas emissions by at least 40% compared to 1990 levels.

Italy, which chairs the G8 meetings, should support this target during international negotiations while working for an ambitious agreement on the second commitment period (2013-2017) of the Kyoto Protocol. Negotiations will have their highest moment at the UN Conference on Climate Change in Copenhagen, and the Italian Prime Minister should personally attend this meeting to assure that a concrete decision is reached.

At the same time, Italy should also commit to sustain the European process to provide substantial additional finance to help developing countries in mitigating climate change and to enhance adaptation and climate protection measures.

2. **phase out all subsidies for fossil fuel and nuclear power** In August 2008, the UN Environmental Programme reported that each year globally around €240 billion or 0.7 per cent of global GDP is being spent on energy subsidies. The lion's share is being used to artificially lower the real price of fossil fuels or nuclear energy. These subsidies make energy efficiency less attractive, keep renewable energy out of the market place and prop up non-competitive and non-efficient technologies and fuels.

In Italy the founding of fossil fuels and other unsustainable technologies like urban waste incineration has been supported directly diverting money from real renewable sources through the introduction of energy sources "assimilated to renewables", which in reality are sub-products of oil refineries and wastes. In 2007 more that 80% of total subsidies to renewables has been given to "assimilated to renewables" energy sources, equal to 4.4 billion euro. Solar, wind and other clean energy source received 0.9 billion euro.

Italy is facing an infringement procedure by the European Commission for this reason, and Greenpeace believes this scandal cannot be perpetuated any further. This is a clear case of how wrong strategic decision on energy issues can result in unnecessary economic costs for society. Public money has been once more diverted from clean and safe solutions.

In recent years, several countries have also increased research and development funding for fossil technologies, in the hope to promote carbon capture and storage (CCS). This is already happening also in Italy, where research funds are used to keep alive frozen institutions with the excuse of new research on CCS. Even assuming that at some stage carbon capture becomes technically feasible, commercially viable, capable of long term storage and environmentally safe, it would still only have a limited impact on emission reductions and would come at a high cost. Redirect taxpayers money towards investments in energy efficiency and renewable energy would bring consistency to government policies and would allow the inclusion of social and environmental costs in prices. Greenpeace is therefore opposed to CCS public financing.

In addition, fossil and nuclear energy currently benefit from a range of indirect subsidies, given that the market is not incorporating the external costs of these fuels: the real cost of energy production by conventional energy sources should include expenses borne by society, such as those related to health impacts and local and regional environmental degradation ranging from mercury pollution to acid rain. These external costs should be factored into energy pricing to move the energy sector towards a fairer energy system. Italy should therefore strictly apply the 'polluter-pays principle', introducing polluter-pays taxation for dirty energy sources, and excluding renewable energy from environment related taxation.

references
24 BOCCONI-GSE REPORT, MAY 2009; POLYTECHNIC OF MILAN REPORT FOR GREENPEACE ITALY, FEBRUARY 2008.

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3. stop opening new coal power plants, and stop nuclear renaissance The greatest threat to renewables expansion in Italy comes from the recent decision of the Italian government to reintroduce nuclear power, which was banned in 1987, and also to support the unveiled plans of the major national energy company, Enel SpA, to double its coal capacity. Enel is controlled by the Italian government, which is the biggest shareholder with roughly 30%. Increasing coal capacity will allow Enel to strengthen its market dominant position, granting easiest profits for all shareholders. This policy will nevertheless undermine the possibility to respect commitments on GHGs reduction which Italy has undertaken both ratifying the Kyoto Protocol and signing the European "Energy and Climate" package.

Enel has recently converted an old oil-fired power plant into a new coal one in Civitavecchia, near Rome, and there are other four projects on the pipeline. New coal installations are going to add new 30 million tonnes CO_2 to the emissions Italy should reduce to respect the Kyoto Protocol, which are nearly 100 million.

The expansion of coal capacity will also undermine the possibility to reach the renewables target under EU "Energy and Climate" package: increasing fossil fuel capacity will indeed make much more difficult to reach 17% share of final consumption in primary energy, starting from actual 7%.The present plans for restarting the nuclear industry in Italy had a first step with the French-Italian "memorandum of understanding" signed on February 2009. Even though the agreement does not contain any formal commitment, the "memorandum of understanding" is about a possible collaboration for building 4 EPRs in Italy, producing some 45-50 TWh. In various statements the government declared, as target for the future fuel mix in the power sector, the following share: nuclear energy 25%, renewables 25% and 50% of fossil. For reaching this share – even if it is not clear by when – 15 GW of new nuclear plants are needed at least.

While these nuclear goals are pushed by the government's energy policy communications, reality is that natural gas infrastructure's growth – strengthening existing pipelines and building new LNG terminals – are going to double the import capacity of Italy. There is the serious chance to have a total capacity of natural gas importation around 180 billion cubic meters in 2020 with an internal consumption of less than 90, under a scenario where 20-20-20 EU targets are met.

Present government policies toward new coal and nuclear power plants, with the ongoing natural gas investments, are clearly undermining the development of renewables and efficiency.

The additional electricity to be produced by renewables to reach the European goals by 2020 is some 50-54 TWh while efficiency in the electricity end uses can give almost the double of that figure by the same timeframe. So far, renewables and efficiency have the potential to provide about three times more energy compared to the "nuclear memorandum", and can generate some 300 thousand jobs. Present policies are disrupting the chances to exploit this potential.

For all these reasons Greenpeace believes that the present energy strategy is against European and International agreements ratified by Italy, and strongly asks to neglect coal and nuclear expansion plans. We are still in time to change direction and starting a clean energy revolution forward EU 2020 targets.

4. set stringent and ever-improving standards for energy efficiency Determined policies to improve energy efficiency are vital to set Italy on a clean energy pathway. According to this report, efficiency measures for the electricity end-uses can save 83 TWh in 2020 implementing existing technologies of energy efficiency in end-use products. This is a conservative estimation, cause another report developed by Greenpeace and Polytechnic of Milan in 2008 clearly shows that this potential is even bigger, around 100 Twh in 2020. Energy efficiency is therefore the first cost-effective energy source to support in order to stabilise final energy consumption and kick-start the energy revolution.

Italy should foster the European Union to introduce mandatory efficiency standards for all energy appliances, and should already proceed in phasing out at national level the most inefficient appliances, such as energy intensive fridges and washing machines, incandescent lighting, all standby technologies, electric boilers, energy intensive televisions and others. These standards should improve over time and adapt to technological innovation.

Italy needs also to expand and strengthen actual fiscal mechanisms, such as the possibility to apply 55% de-taxation on building efficiency and renewable use, and the incentives for energy efficiency in the industrial sector under the programme "Industria 2015".

A huge energy saving potential is finally to be exploited in the buildings sector, which remains in Italy one of the most reluctant to respect energy efficiency standards. Strict building codes to define maximum levels for the annual energy consumption of buildings – as required by the European law – have been adopted. The government has now to ensure high performance levels in both new and existing buildings are effectively implemented. Green public procurement and green mandatory criteria for the renovation of public building stock can play an important role too, the same as creating a fund for energy efficiency loans at low rate interest in order to sustain the efficiency and renewables market for the existing building stock.

Italy should oblige planners and architects to always consider renewable energy technologies, district heating networks and efficient energy management in the planning, construction and renovation of industrial and residential areas. The Italian government should also invest in the further creation of energy auditors in order to assist professionals and consumers in identifying opportunities for improving and upgrading the energy efficiency of their buildings, as well as the use of renewable energy technologies for heat or electricity generation. At the same time, the energy consumption of buildings should be made clear and available through "energy labels" to house owners, as well as tenants. Energy labels should serve as bases for implementing incentives, tax reductions and other supporting programmes, and Italy has to re-introduce the obligation for the energy certification of household, as required by EU legislation.

Italy has also to present and submit the national Action Plan on Energy Efficiency, to clearly show which are the measures to fulfil European targets in 2020, and to share efficiency targets among regions.

image COMPACT FLUORESCENT LAMP LIGHT BULB.

image WASHING MACHINE.

5. provide stable support for renewable energy and fix regional burden sharing for renewables EU leaders have already adopted a binding target of 20% for the share of renewable energy in total energy use by 2020, which is an important element for securing investor confidence. In order to secure the realisation of the 20% target, the Italian government should further support policies to help maturing renewable energy technologies to achieve their full economic potential in the short term, removing licensing barriers and compensating for market failures.

In the electricity sector, two types of incentives can be identified as the main instruments to promote the deployment of renewable electricity. These are fixed price systems, where the government defines the electricity price paid to the producer from renewables (so-called feed-in systems), and renewable quota systems or tradable green certificate systems, where the government dictates the quantity of renewable electricity an electricity company has to provide and leaves it to the market to determine the price.

Both systems aim to provide incentives for technology improvements and cost reductions, leading to cheaper renewables that can compete with conventional sources in the future. Experience shows that feed-in systems, if designed well, have been the most successful and cost effective instruments to promote the broad uptake of renewable power technologies.

Actually in Italy exists a mixed system which uses both feed-in and tradable green certificate mechanisms. The Italian mixed system has been proved by the European Commission to be less cost effective, and Italian government should increase the effectiveness of the subsidies, in order to finance with less money more electricity production from renewables. Part of this problem rely also on the complex framework of the Italian legislation in the energy sector, which divides competences between the national government and regional authorities. Complex licensing procedures and bureaucratic hurdles constitute one of the most difficult obstacles. Italy should optimise the national legal framework, introducing common and standard guidelines to secure simple and transparent authorisation and licensing procedures in all different regions.

At the same time Greenpeace strongly sustain the definition of a "burden sharing" agreement among the Italian regions to share the national renewable target at 2020, taking into account the renewable potential of each region.

To further foster clean energy production, both in the electricity and in the heat sector, Italy should also introduce at national level the obligation to use renewable sources in new buildings. In the heat sector Greenpeace recognise the need to increase the incentives, in order to reduce the gap with the levels of incentives in the electricity generation sector.

6. remove barriers to renewable energy development and reform the electricity market Substantial reforms of the Italian energy sector are necessary to integrate new renewable energy technologies on a larger scale. Favourable access conditions to infrastructure, electricity grids, district heating networks and gas networks should be defined to reduce bottlenecks. This includes priority connection, priority access and priority dispatch of electricity from renewable energy sources. But more fundamental changes of the energy market are required: the entire energy system has been developed to suit centralised fossil production structures, and decentralised renewable energy technologies have now to break into unfavourable market conditions.

As an important step to facilitate the reform of the energy market, the Italian government should reduce dominant position of its controlled companies in the energy sector, such as Enel SpA and Eni SpA, which perpetuate conditions of major state-monopoly, in opposition to a real competitive and liberalized energy market. To fulfil this objective the government should secure the full ownership unbundling of transmission network operation from production and supply activities. This is the only effective way to provide fair market access and overcome existing discriminatory practices against new market entrants, such as renewable energy producers. In Italy these practices currently include extensive administrative requirements, delaying tactics for grid access, excessive costs of grid connection and unjustified operational charges.

Both the European and Italian regulators should be sufficiently powerful and independent to foster the development of a flexible and interconnected European market and to secure the necessary network extension for the integration of small-scale and large-scale renewable energy production. These should also introduce smart meters for households to facilitate an active demand-side management and the further diffusion of "smart grids".

Furthermore, Italy should promote the development of combined heat and power generation. District heating networks are a fundamental precondition for the efficient use of several renewable, as well as fossil, energy sources. Targeted policies and financial incentives should strongly encourage investments in combined heat and power generation and the development of district heating networks.

"never before has humanity been forced to grapple with such an immense environmental crisis."

GREENPEACE INTERNATIONAL
CLIMATE CAMPAIGN

glossary & appendix

6

"the sooner we act, the more effective and cost efficient efforts at controlling climate change will be."

PROFESSOR JACQUELINE MCGLADE
EXECUTIVE DIRECTOR OF THE EUROPEAN ENVIRONMENT AGENCY

glossary of commonly used terms and abbreviations

CHP Combined Heat and Power
CO_2 Carbon dioxide, the main greenhouse gas
GDP Gross Domestic Product (means of assessing a country's wealth)
PPP Purchasing Power Parity (adjustment to GDP assessment to reflect comparable standard of living)
IEA International Energy Agency

J Joule, a measure of energy:
kJ = 1,000 Joules,
MJ = 1 million Joules,
GJ = 1 billion Joules,
PJ = 10^{15} Joules,
EJ = 10^{18} Joules

W Watt, measure of electrical capacity:
kW = 1,000 watts,
MW = 1 million watts,
GW = 1 billion watts

kWh Kilowatt-hour, measure of electrical output: TWh = 10^{12} watt-hours
t/Gt Tonnes, measure of weight: Gt = 1 billion tonnes

conversion factors - fossil fuels

FUEL				
Coal	23.03	GJ/t	1 cubic	0.0283 m^3
Lignite	8.45	GJ/t	1 barrel	159 liter
Oil	6.12	GJ/barrel	1 US gallon	3.785 liter
Gas	38000.00	kJ/m^3	1 UK gallon	4.546 liter

conversion factors - different energy units

FROM / TO: MULTIPLY BY	TJ	Gcal	Mtoe	Mbtu	GWh
TJ	1	238.8	2.388×10^{-5}	947.8	0.2778
Gcal	4.1868×10^{-3}	1	$10^{(-7)}$	3.968	1.163×10^{-3}
Mtoe	4.1868×10^{4}	10^{7}	1	3968×10^{7}	11630
Mbtu	1.0551×10^{-3}	0.252	2.52×10^{-8}	1	2.931×10^{-4}
GWh	3.6	860	8.6×10^{-5}	3412	1

definition of sectors

The definition of different sectors is analog to the sectorial break down of the IEA World Energy Outlook series.

All definitions below are from the IEA Key World Energy Statistics

Industry sector: Consumption in the industry sector includes the following subsectors (energy used for transport by industry is not included -> see under "Transport")

- Iron and steel industry
- Chemical industry
- Non-metallic mineral products e.g. glass, ceramic, cement etc.
- Transport equipment
- Machinery
- Mining
- Food and tobacco
- Paper, pulp and print
- Wood and wood products (other than pulp and paper)
- Construction
- Textile and Leather

Transport sector: The Transport sector includes all fuels from transport such as road, railway, aviation, domestic and navigation. Fuel used for ocean, costal and inland fishing is included in "Other Sectors".

Other sectors: 'Other sectors' covers agriculture, forestry, fishing, residential, commercial and public services.

Non-energy use: This category covers use of other petroleum products such as paraffin waxes, lubricants, bitumen etc.

image NEXT EXIT 'SUNSHINE', CANADA.

image PHOTOVOLTAIC PANELS IN A FIELD IN ITALY.
Francesco is pleased to dedicate this photo to Claudia.

appendix: italy reference scenario

table 6.1: italy: electricity generation

TWh/a	2005	2010	2020	2030	2040	2050
Power plants	**264**	**308**	**391**	**446**	**513**	**521**
Coal	54	59	34	51	94	97
Lignite	0	0	0	0	0	0
Gas	122	155	227	253	273	275
Oil	36	35	29	26	22	17
Diesel	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Biomass	6	7	11	13	13	13
Hydro	35	37	44	46	47	48
Wind	2	5	23	26	29	31
PV	0	2	11	15	17	19
Geothermal	7	8	10	11	12	12
Solar thermal power plants	0	0	2	4	5	6
Ocean energy	0	0	1	2	2	2
Combined heat & power production	**39**	**42**	**51**	**56**	**61**	**66**
Coal	0	0	1	2	3	5
Lignite	0	0	0	0	0	0
Gas	28	30	35	37	39	42
Oil	10	10	12	13	13	13
Biomass	1	2	4	5	6	6
Geothermal	0	0	0	0	0	0
CHP by producer						
Main acitivity producers	22	23	26	28	29	31
Autoproducers	17	19	25	28	32	35
Total generation	**303**	**350**	**442**	**502**	**574**	**587**
Fossil	251	289	337	381	444	449
Coal	54	59	34	52	97	102
Lignite	0	0	0	0	0	0
Gas	150	185	262	290	312	317
Oil	47	45	41	39	35	30
Diesel	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Renewables	**52**	**61**	**105**	**121**	**130**	**138**
Hydro	35	37	44	46	47	48
Wind	2.3	5.0	23	26	29	31
PV	0.031	2.0	11	15	17	19
Biomass	6.9	8.8	15	17	19	19
Geothermal	7.4	8.4	10	11	12	12
Solar thermal	0.0	0.0	2	4	5	6
Ocean energy	0.0	0.0	1	2	2	2
Import	50	50	50	50	50	50
Import RES	8	11	15	16	16	16
Export	1	1	1	1	1	1
Distribution losses	21	22	26	29	32	33
Own consumption electricity	22	24	30	34	38	39
Electricity for hydrogen production	0	0	0	0	0	0
Final energy consumption (electricity)	**310**	**353**	**435**	**489**	**553**	**564**
Fluctuating RES (PV, Wind, Ocean)	2	7	35	43	48	52
Share of fluctuating RES	0.8%	2.0%	7.9%	8.5%	8.4%	8.9%
RES share	**17.2%**	**17.5%**	**23.8%**	**24.1%**	**22.7%**	**23.5%**

table 6.2: italy: heat supply

PJ/A	2005	2010	2020	2030	2040	2050
District heating plants	**0**	**2**	**2**	**2**	**1**	**0**
Fossil fuels	0	2	1	1	1	0
Biomass	0	1	0	0	0	0
Solar collectors	0	0	0	0	0	0
Geothermal	0	0	0	0	0	0
Heat from CHP	**189**	**182**	**217**	**234**	**227**	**236**
Fossil fuels	185	172	199	215	210	217
Biomass	3	9	17	18	17	18
Geothermal	0	1	1	1	1	1
Direct heating[1]	**2,513**	**2,860**	**2,939**	**3,037**	**3,283**	**2,965**
Fossil fuels	2,443	2,740	2,713	2,731	2,861	2,464
Biomass	60	94	147	164	195	197
Solar collectors	1	13	45	92	158	218
Geothermal	9	13	34	49	69	86
Total heat supply[1]	**2,701**	**3,045**	**3,157**	**3,273**	**3,512**	**3,202**
Fossil fuels	2,628	2,914	2,913	2,948	3,071	2,681
Biomass	63	103	165	183	212	215
Solar collectors	1	13	45	92	158	218
Geothermal	9	14	34	50	70	86
RES share (including RES electricity)	**2.7%**	**4.3%**	**7.7%**	**9.9%**	**12.5%**	**16.2%**

1) heat from electricity (direct and from electric heat pumps) not included; covered in the model under 'electric appliances'

table 6.3: italy: CO_2 emissions

MILL t/a	2005	2010	2020	2030	2040	2050
Condensation power plants	**114**	**126**	**123**	**140**	**173**	**168**
Coal	41.9	45.2	25.5	37.6	67.5	67.9
Lignite	0.0	0.0	0.0	0.0	0.0	0.0
Gas	45.5	56.2	77.6	85.0	91.0	89.4
Oil	25.9	24.5	19.6	17.1	14.5	11.2
Diesel	0.4	0.3	0.1	0.0	0.0	0.0
Combined heat & power production	**35**	**27**	**24**	**28**	**29**	**31**
Coal	0	0	0	2	3	4
Lignite	0	0	0	0	0	0
Gas	15	15	17	18	19	19
Oil	20	11	7	8	8	7
CO_2 emissions electricity & steam generation	**149**	**153**	**147**	**168**	**202**	**200**
Coal	42	45	26	39	71	72
Lignite	0	0	0	0	0	0
Gas	61	71	94	103	109	109
Oil & diesel	46	36	26	25	22	19
CO_2 emissions by sector	**444**	**487**	**481**	**507**	**558**	**514**
% of 1990 emissions	115%	126%	124%	131%	144%	133%
Industry	87	92	97	103	111	89
Other sectors	105	111	98	94	99	94
Transport	126	148	153	156	161	147
Electricity & steam generation	125	136	133	154	188	185
District heating	0	0	0	0	0	0
Population (Mill.)	58	61	59	58	57	55
CO_2 emissions per capita (t/capita)	**7.6**	**8.0**	**8.1**	**8.8**	**9.8**	**9.4**

table 6.4: italy: installed capacity

GW	2005	2010	2020	2030	2040	2050
Power plants	**73**	**88**	**119**	**130**	**129**	**125**
Coal	10	11	6	8	14	15
Lignite	0	0	0	0	0	0
Gas	32	40	58	63	55	50
Oil	13	15	14	13	11	9
Diesel	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Biomass	1.0	1.1	1.7	1.8	1.8	1.7
Hydro	14	15	18	19	20	21
Wind	1.6	3.3	10.5	10.0	10.2	10.5
PV	0.0	1.8	9.1	12.0	13.1	14.1
Geothermal	1.0	1.1	1.3	1.4	1.5	1.6
Solar thermal power plants	0.0	0.0	0.5	1.3	1.4	1.5
Ocean energy	0.0	0.0	0.5	0.7	1.0	1.1
Combined heat & power production	**12**	**12**	**14**	**15**	**15**	**16**
Coal	0	0	0	1	1	2
Lignite	0	0	0	0	0	0
Gas	7	7	8	9	9	9
Oil	5	4	5	5	4	4
Biomass	0	1	1	1	1	1
Geothermal	0	0	0	0	0	0
CHP by producer						
Main activity producers	8	8	9	9	9	9
Autoproducers	4	4	6	6	6	7
Total generation	**85**	**100**	**133**	**145**	**144**	**141**
Fossil	68	78	91	98	94	89
Coal	10	11	6	8	16	17
Lignite	0	0	0	0	0	0
Gas	40	48	66	72	63	59
Oil	18	19	18	18	15	13
Diesel	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Renewables	**18**	**22**	**42**	**47**	**50**	**53**
Hydro	14	15	18	19	20	21
Wind	1.6	3	10	10	10	11
PV	0.0	2	9	12	13	14
Biomass	1.3	1.7	2.7	2.9	2.9	2.9
Geothermal	1.0	1.1	1.3	1.4	1.5	1.6
Solar thermal	0.0	0.0	0.5	1.3	1.4	1.5
Ocean energy	0.0	0.0	0.5	0.7	1.0	1.1
Fluctuating RES (PV, Wind, Ocean)	**1.6**	**5.1**	**20.0**	**22.7**	**24.2**	**25.7**
Share of fluctuating RES	1.9%	5.1%	15.1%	15.6%	16.8%	18.2%
RES share	**20.6%**	**22.3%**	**31.8%**	**32.6%**	**34.7%**	**37.3%**

table 6.5: italy: primary energy demand

PJ/A	2005	2010	2020	2030	2040	2050
Total	**7,884**	**8,615**	**9,083**	**9,576**	**10,357**	**9,726**
Fossil	**7,348**	**8,072**	**8,140**	**8,437**	**9,025**	**8,303**
Hard coal	702	717	435	607	1,059	1,016
Lignite	0	0	0	0	0	0
Natural gas	2,967	3,448	3,979	4,201	4,388	4,115
Crude oil	3,679	3,906	3,726	3,630	3,579	3,172
Nuclear	**0**	**0**	**0**	**0**	**0**	**0**
Renewables	**536**	**543**	**943**	**1,139**	**1,332**	**1,423**
Hydro	127	133	158	166	169	173
Wind	8	18	83	94	104	112
Solar	1	21	90	162	237	308
Biomass	195	253	461	546	622	607
Geothermal	205	118	151	171	198	223
Ocean Energy	0	0	4	5	7	8
RES share	**6.7%**	**6.4%**	**10.5%**	**12.0%**	**12.9%**	**14.6%**

table 6.6: italy: final energy demand

PJ/A	2005	2010	2020	2030	2040	2050
Total (incl. non-energy use)	**6,162**	**7,033**	**7,582**	**7,980**	**8,587**	**8,073**
Total (energy use)	**5,740**	**6,611**	**7,160**	**7,558**	**8,165**	**7,652**
Transport	**1,870**	**2,200**	**2,351**	**2,438**	**2,560**	**2,350**
Oil products	1,811	2,116	2,148	2,128	2,163	1,955
Natural gas	16	26	76	137	185	193
Biofuels	7	15	80	123	159	154
Electricity	36	43	47	49	52	49
RES electricity	6	7	11	12	12	11
Hydrogen	0	0	0	0	0	0
RES share Transport	**0.7%**	**1.0%**	**3.9%**	**5.5%**	**6.7%**	**7.0%**
Industry	**1,581**	**1,815**	**1,995**	**2,105**	**2,247**	**1,884**
Electricity	563	603	645	680	732	716
RES electricity	97	105	153	164	166	168
District heat	0	0	0	0	0	0
RES disrict heat	0	1	1	2	2	2
Coal	102	134	152	199	293	235
Oil products	245	269	282	281	279	214
Gas	660	793	885	909	894	668
Solar	0	1	1	1	1	2
Biomass and waste	12	16	28	33	42	38
Geothermal	0	0	2	3	6	10
RES share Industry	**6.9%**	**6.8%**	**9.3%**	**9.6%**	**9.6%**	**11.7%**
Other Sectors	**2,289**	**2,596**	**2,814**	**3,015**	**3,358**	**3,417**
Electricity	516	626	875	1,030	1,207	1,265
RES electricity	89	109	208	248	274	298
District heat	70	85	105	128	124	126
RES disrict heat	3	10	17	18	16	17
Coal	140	88	-4	-21	0	-2
Oil products	362	401	366	357	360	326
Gas	1,127	1,270	1,245	1,219	1,259	1,219
Solar	1	13	44	92	157	216
Biomass and waste	63	101	152	166	190	193
Geothermal	9	12	31	45	61	72
RES share Other Sectors	**7.2%**	**9.4%**	**16.1%**	**18.8%**	**20.8%**	**23.3%**
Total RES	**287**	**390**	**729**	**904**	**1,086**	**1,183**
RES share	**5.0%**	**5.9%**	**10.2%**	**12.0%**	**13.3%**	**15.5%**
Non energy use	**422**	**422**	**422**	**422**	**422**	**422**
Oil	374	374	374	374	374	374
Gas	42	42	42	42	42	42
Coal	7	7	7	7	7	7

appendix: italy energy [r]evolution scenario

table 6.7: italy: electricity generation

TWh/a	2005	2010	2020	2030	2040	2050
Power plants	**264**	**300**	**301**	**276**	**295**	**304**
Coal	54	55	24	20	15	9
Lignite	0	0	0	0	0	0
Gas	122	149	140	90	87	55
Oil	36	35	22	12	0	0
Diesel	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Biomass	6	7	14	16	18	19
Hydro	35	37	45	47	48	48
Wind	2	6	25	34	44	54
PV	0	2	15	28	37	49
Geothermal	7	8	11	12	13	15
Solar thermal power plants	0	0	4	16	31	51
Ocean energy	0	0	1	2	3	4
Combined heat & power production	**39**	**43**	**56**	**64**	**71**	**77**
Coal	0	0	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	28	30	41	41	34	27
Oil	10	11	8	2	0	0
Biomass	1	1	7	19	32	42
Geothermal	0	0	1	2	5	7
CHP by producer						
Main acitivity producers	22	23	28	30	32	35
Autoproducers	17	20	28	34	39	42
Total generation	**303**	**342**	**357**	**340**	**366**	**381**
Fossil	251	280	235	165	136	92
Coal	54	55	24	20	15	9
Lignite	0	0	0	0	0	0
Gas	150	179	181	131	121	82
Oil	47	46	30	14	0	0
Diesel	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Renewables	**52**	**62**	**121**	**175**	**230**	**290**
Hydro	35	37	45	47	48	48
Wind	2.3	6	25	34	44	54
PV	0.031	2	15	28	37	49
Biomass	6.9	8	21	35	50	61
Geothermal	7.4	8	12	14	18	22
Solar thermal	0.0	0	4	16	31	51
Ocean energy	0.0	0	1	2	3	4
Import	50	51	60	80	105	135
Import RES	8	12	23	48	103	134
Export	1	1	1	1	1	1
Distribution losses	21	23	25	23	25	27
Own consumption electricity	22	25	27	25	27	29
Electricity for hydrogen production	0	0	5	9	14	14
Final energy consumption (electricity)	**310**	**344**	**358**	**362**	**404**	**445**
Fluctuating RES (PV, Wind, Ocean)	2	8	41	64	84	107
Share of fluctuating RES	0.8%	2.4%	11.6%	18.7%	22.9%	28.1%
RES share	**17.2%**	**18.1%**	**34.1%**	**51.5%**	**62.9%**	**76.0%**
'Efficiency' savings (compared to Ref.)	**0**	**9**	**77**	**127**	**149**	**119**

table 6.8: italy: heat supply

PJ/A	2005	2010	2020	2030	2040	2050
District heating plants	**0**	**3**	**17**	**22**	**28**	**33**
Fossil fuels	0	0	0	0	0	0
Biomass	0	1	7	8	8	10
Solar collectors	0	1	7	10	14	17
Geothermal	0	0	3	4	6	7
Heat from CHP	**189**	**181**	**243**	**266**	**264**	**276**
Fossil fuels	185	173	208	180	124	93
Biomass	3	7	31	70	97	119
Geothermal	0	2	5	16	42	64
Direct heating[1)]	**2,513**	**2,813**	**2,342**	**2,106**	**2,152**	**2,032**
Fossil fuels	2,443	2,669	1,980	1,434	1,038	**742**
Biomass	60	82	115	173	245	**262**
Solar collectors	1	20	167	362	609	**700**
Geothermal	9	42	81	138	261	**328**
Total heat supply[1)]	**2,701**	**2,997**	**2,602**	**2,394**	**2,444**	**2,341**
Fossil fuels	2,628	2,842	2,188	1,614	1,162	835
Biomass	63	90	152	251	350	391
Solar collectors	1	21	174	372	623	717
Geothermal	9	44	88	158	309	398
RES share (including RES electricity)	**2.7%**	**5.2%**	**15.9%**	**32.6%**	**52.5%**	**64.3%**
'Efficiency' savings (compared to Ref.)		**48**	**555**	**879**	**1068**	**861**

1) heat from electricity (direct and from electric heat pumps) not included; covered in the model under 'electric appliances'

table 6.9: italy: CO_2 emissions

MILL t/a	2005	2010	2020	2030	2040	2050
Condensation power plants	**114**	**121**	**81**	**53**	**40**	**24**
Coal	41.9	42.5	18.4	14.5	10.5	6.4
Lignite	0.0	0.0	0.0	0.0	0.0	0.0
Gas	45.5	54.0	47.8	30.2	29.0	17.9
Oil	25.9	24.5	14.9	7.9	0.0	0.0
Diesel	0.4	0.3	0.1	0.1	0.0	0.0
Combined heat & power production	**35**	**27**	**24**	**21**	**15**	**12**
Coal	0	0	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	15	15	19	20	15	12
Oil	20	11	4	1	0	0
CO_2 emissions electricity & steam generation	**149**	**148**	**105**	**74**	**55**	**36**
Coal	42	43	19	15	11	6
Lignite	0	0	0	0	0	0
Gas	61	69	67	50	44	30
Oil & diesel	46	36	19	9	0	0
CO_2 emissions by sector	**444**	**470**	**345**	**245**	**175**	**112**
% of 1990 emissions	115%	121%	89%	63%	45%	29%
Industry	87	88	63	50	41	33
Other sectors	105	111	81	55	36	23
Transport	126	140	108	78	53	28
Electricity & steam generation	125	132	92	63	46	28
District heating	0	0	0	0	0	0
Population (Mill.)	58	61	59	58	57	55
CO_2 emissions per capita (t/capita)	**7.6**	**7.7**	**5.8**	**4.2**	**3.1**	**2.1**

table 6.10: italy: installed capacity

GW	2005	2010	2020	2030	2040	2050
Power plants	**73**	**87**	**97**	**96**	**98**	**106**
Coal	10	10	4	3	2	1
Lignite	0	0	0	0	0	0
Gas	32	39	36	23	17	10
Oil	13	15	10	6	0	0
Diesel	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Biomass	1.0	1	2	2	2	3
Hydro	14	15	18	19	20	21
Wind	1.6	4	11	13	15	18
PV	0.0	2	12	22	28	36
Geothermal	1.0	1.1	1.4	1.6	1.7	2.0
Solar thermal power plants	0.0	0.0	1.2	4.9	8.9	12.8
Ocean energy	0.0	0.0	0.6	0.9	1.3	1.9
Combined heat & power production	**12**	**13**	**15**	**15**	**15**	**15**
Coal	0	0	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	7	7	10	9	7	6
Oil	5	5	3	1	0	0
Biomass	0	0	2	4	6	8
Geothermal	0	0	0	0	1	1
		0	0	0	0	0
CHP by producer						
Main activity producers	8	8	8	7	7	7
Autoproducers	4	5	6	7	8	8
Total generation	**85**	**99**	**112**	**111**	**113**	**121**
Fossil	68	76	63	42	27	17
Coal	10	10	4	3	2	1
Lignite	0	0	0	0	0	0
Gas	40	46	45	32	25	16
Oil	18	20	13	7	0	0
Diesel	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Renewables	**18**	**23**	**49**	**69**	**86**	**104**
Hydro	14	15	18	19	20	21
Wind	1.6	4	11	13	15	18
PV	0.0	2	12	22	28	36
Biomass	1.3	2	4	7	9	11
Geothermal	1.0	1	2	2	3	3
Solar thermal	0.0	0	1.2	5	9	13
Ocean energy	0.0	0	1	1	1	2
Fluctuating RES (PV, Wind, Ocean)	1.6	6.0	24.3	36.3	45.2	56.5
Share of fluctuating RES	1.9%	6.0%	21.7%	32.8%	40.0%	46.5%
RES share	**20.6%**	**23.3%**	**43.6%**	**62.4%**	**76.0%**	**85.8%**

table 6.11: italy: primary energy demand

PJ/A	2005	2010	2020	2030	2040	2050
Total	**7,884**	**8,379**	**7,186**	**6,263**	**5,931**	**5,366**
Fossil	**7,348**	**7,782**	**5,954**	**4,368**	**3,269**	**2,268**
Hard coal	702	709	351	242	175	94
Lignite	0	0	0	0	0	0
Natural gas	2,967	3,326	2,953	2,294	1,869	1,347
Crude oil	3,679	3,747	2,650	1,832	1,226	827
Nuclear	**0**	**0**	**0**	**0**	**0**	**0**
Renewables	**536**	**597**	**1,232**	**1,896**	**2,662**	**3,099**
Hydro	127	133	160	169	171	173
Wind	8	22	90	122	158	194
Solar	1	29	241	530	868	1,077
Biomass	195	265	517	762	961	1,009
Geothermal	205	148	219	306	494	632
Ocean Energy	0	0	4	6	10	14
RES share	**6.7%**	**7.3%**	**17.2%**	**30.6%**	**48.0%**	**61.2%**
'Efficiency' savings (compared to Ref.)	**0**	**237**	**1,850**	**3,219**	**4,441**	**4,277**

table 6.12: italy: final energy demand

PJ/A	2005	2010	2020	2030	2040	2050
Total (incl. non-energy use)	**6,162**	**6,830**	**6,025**	**5,400**	**5,217**	**4,843**
Total (energy use)	**5,740**	**6,408**	**5,603**	**4,978**	**4,795**	**4,422**
Transport	**1,870**	**2,092**	**1,726**	**1,384**	**1,183**	**1,008**
Oil products	1,811	1,997	1,536	1,094	731	383
Natural gas	16	18	20	17	14	7
Biofuels	7	36	92	146	172	157
Electricity	36	41	64	106	231	423
RES electricity	6	7	22	54	145	322
Hydrogen	0	0	13	22	36	37
RES share Transport	**0.7%**	**2.1%**	**6.9%**	**15.3%**	**28.7%**	**50.3%**
Industry	**1,581**	**1,791**	**1,546**	**1,341**	**1,345**	**1,273**
Electricity	563	603	590	489	481	461
RES electricity	97	109	201	252	303	350
District heat	0	0	0	0	0	0
RES disrict heat	0	0	0	0	0	0
Coal	102	115	77	61	46	17
Oil products	245	248	100	38	19	9
Gas	660	782	671	577	492	437
Solar	0	6	27	57	125	142
Biomass and waste	12	14	45	69	100	112
Geothermal	0	23	35	50	82	95
RES share Industry	**6.9%**	**8.5%**	**20.0%**	**31.9%**	**45.3%**	**54.9%**
Other Sectors	**2,289**	**2,525**	**2,332**	**2,254**	**2,267**	**2,141**
Electricity	516	594	636	709	742	717
RES electricity	89	108	216	365	467	544
District heat	70	83	133	154	147	153
RES disrict heat	3	9	36	67	97	124
Coal	140	127	68	16	8	0
Oil products	362	394	241	133	72	52
Gas	1,127	1,209	983	736	509	316
Solar	1	14	140	305	484	558
Biomass and waste	63	88	96	140	192	197
Geothermal	9	15	35	60	113	148
RES share Other Sectors	**7.2%**	**9.3%**	**22.4%**	**41.6%**	**59.7%**	**73.4%**
Total RES	**287**	**431**	**950**	**1,577**	**2,303**	**2,777**
RES share	**5.0%**	**6.7%**	**17.0%**	**31.7%**	**48.0%**	**62.8%**
Non energy use	**422**	**422**	**422**	**422**	**422**	**422**
Oil	374	374	374	374	374	374
Gas	42	42	42	42	42	42
Coal	7	7	7	7	7	7

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Greenpeace has been campaigning against environmental degradation since 1971 when a small boat of volunteers and journalists sailed into Amchitka, an area west of Alaska, where the US Government was conducting underground nuclear tests. This tradition of 'bearing witness' in a non-violent manner continues today, and ships are an important part of all its campaign work.

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EREC

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Created on 13 April 2000, the European Renewable Energy Council (EREC) is the umbrella organisation of the European renewable energy industry, trade and research associations active in the sectors of bioenergy, geothermal, ocean, small hydro power, solar electricity, solar thermal and wind energy. EREC represents thus 40 billion € turnover and provides jobs to around 350,000 people!

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