

Crisis or not, renewable energy is hot*

To reap the rewards, governments and companies should act now

March 2009



Time for action

It is with great pleasure that we present PricewaterhouseCoopers' view on Europe's developing renewable energy market.

2009 brings us new and difficult challenges. But it also offers real opportunities to change the course of our economies and the impact of the environmental footprint we will leave behind. As the European Union's 2020 environmental targets—20% less CO₂, 20% more energy efficiency, and an overall energy mix comprising 20% renewables—loom nearer, data suggests we are not yet on course to meet these ambitious targets. Despite the economic downturn, now is the time for action. The investments required in renewables could contribute to reverse the economic downtrend.

To provide a sound basis for that action, we recently examined Europe's future renewable energy marketplace through the lens of progress towards the 2020 goals. Our study considers the market's potential, compares approaches in various countries, and puts forth some high-level recommendations for how governments and companies can reap the rewards.

Making renewable energy 20% of total energy consumption in the 27 countries of the EU will require an investment of €1.8 to €22 trillion over the next decade depending on the type of renewable technology. In practical terms, that will mean building more than a million windmills or installing enough solar panels to cover an area twice the size of Belgium.

A formidable challenge, no doubt. The opportunities, however, are proportionate to that challenge. The take-away from our study is really quite simple: The renewable market is set to become a major part of the energy sector—and the time to act is now.



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1 Highlights

The renewables market will flourish...

As conventional sources such as oil and gas wane, the marginal cost of producing them will rise. Over the longer term, this increase will enhance the competitive position of renewables and tip the balance in favour of these new technologies.

At the same time, technological progress is driving down the initial investment costs of renewable technologies and increasing their efficiency.

Stakeholder pressure is acting as both carrot and stick, spurring investment in renewable sources and decreasing Europe's energy dependence.

...despite current economic turmoil

Renewable energy investments will suffer in the current economic crisis. However, increasing or speeded investment could decrease our environmental footprint and boost our economies.

There is room for improvement...

The current share of renewable energy in the primary energy mix is just 7%—far from the 20% target for 2020.

Extrapolating, the historic growth rate suggests we will not reach this ambitious target. A step-change is necessary, and the time for action is now.

...but the sums are staggering...

Meeting the 20% primary energy target through savings in the electricity sector (now about 20% of total energy consumption) will require €1.8 to €22 trillion of investment in the next decade alone depending on the type of renewable technology.

That outlay equates to €3,600 to €43,900 per capita. The 20% target can be met by implementing:

- 1.2 million windmills
- 565 million m³ of biomass wood
- 58,153 km² of solar panels
- 1,454 times the Hoover Dam's hydropower
- 2,237 times Iceland's geothermal capacity
- 21,414 km² of tidal installation.

...and the situation requires government action

To help realise the potential of the renewables market, governments will have to:

- **create stability and predictability:** Policies should be clearly formulated with stated timelines, and they should be consistent with other policies. They should not be subject to political decision-making.
- **use carrots and sticks:** Policies should strike a balance between requiring companies to source and invest in renewables, and providing financial incentives to realise investments.
- **simplify planning and permitting:** Policies should focus explicitly on eliminating delays and on smoothing planning and permitting procedures.
- **leverage comparative advantage:** Policies should exploit a country's comparative advantages.
- **foster communities:** Policies should encourage communities or networks of investors and technology developers.
- **share information:** Policies should be based on lessons from other countries and should aim to be best practice.

Adopt a European—not a national—mindset: Policies should aim to meet the larger European targets, not just national targets.

2 Crisis or not, renewable energy is hot

Crisis or not...

As 2009 unfolds—despite the economic downturn taking hold around the world, and conservation efforts aside—global demand for energy continues to grow.

It is true in emerging markets like Brazil, Russia, India and China, where huge construction projects and growing manufacturing have been pushing up demand. But it is also true in the more mature markets of Europe and the United States. All over the world, energy demand has grown steadily over the past year.

While the economic downturn may temporarily suppress demand, the eventual turnaround—now thought likely to occur in late 2009 or early 2010—will bring continued growth in the fundamental demand for energy.

...demand for renewables is heating up

The heat is on to meet the EU's 2020 environmental targets, but the chill of the economic downturn adds to the complexity of renewable energy projects. The credit crunch has shut down some sources of financing. The sharp fall in oil prices challenges the economics of clean energy. Uncertain economic times bring even greater energy price volatility. Nonetheless, the imperative to grow sustainable energy production to bolster energy security, decarbonise energy supply and meet environmental targets remains paramount.

Energy and utility companies are expanding their renewable portfolios either organically via project development or through mergers and acquisitions. Each route has advantages, depending on market conditions and timing. The backdrop of turbulent financial and energy markets provides opportunities for some companies, but increases challenges facing others as they strive to meet renewable energy targets.

As we tap more of the earth's finite supply of fossil fuels, renewable sources of energy are becoming increasingly important. Over time, renewables will have to fill the gap left by depleted conventional fuels. Ultimately, they must supply a larger and larger share of the world's energy needs.

On top of growing demand for energy, society's increasing environmental awareness is fostering investment in more sustainable, eco-friendly energy

sources. This trend is causing governments to exert pressure for more use of renewables. The 2020 targets are a prime example.

With the inauguration of US President Barack Obama, the market for renewable energy got a boost. Part of Obama's plan to revive the US economy is to invest US\$150 billion over 10 years to catalyse private efforts for a cleaner energy future. Another aspect of the plan is to put one million plug-in hybrid cars—built in the US—on the roads by 2015.

These plans aim to stimulate both the economy and renewable energy, moving towards Obama's goal to reduce US greenhouse gas emissions by 80% by 2050 and to ensure that 10% of electricity comes from renewable sources by 2012, and 25% by 2025.

The growing focus on renewable energy is viewed by many countries as a way to reduce reliance on imported energy, thus increasing indigenous energy provision.

These developments point to one conclusion: Renewables will become the energy marketplace of the future—and that translates into exciting investment opportunities today.

Governments and business can benefit

Renewables offer private investors potential for attractive returns, and those who act quickly have a shot at gaining a front-runner position. For public investors—national and local governments—renewables offer a means to drive innovation, foster positive economic spin-offs and create new jobs locally, regionally and nationally.

Because the renewables marketplace transcends national borders, governments will have to compete to attract and realise renewable investment in their countries. To distinguish their markets from those of other nations, they will have to adopt legislation and regulations that eliminate delays, create a stable investment climate, and encourage innovation.

At the same time, they will need to transcend their own national and cultural borders and work with other governments to create an environment conducive to global cooperation. The scale of the challenge is simply too big to remain nationally focussed.

Credit crunch no obstacle in long term

As is true for most industries, the current economic downturn could present a setback for the development of renewables. With less available capital and more stringent and expensive financing conditions, capital is likely to flow to more conventional investments that seem more certain. Despite this obstacle, the downturn could actually present opportunities.

Investing in renewables now could create positive economic spin-off effects, spur innovation and set economies on a better course towards sustainable energy systems. So in addition to helping reduce the adverse environmental effects of growing energy consumption, investing in renewables could help mitigate the economic malaise and contribute to a quicker recovery.

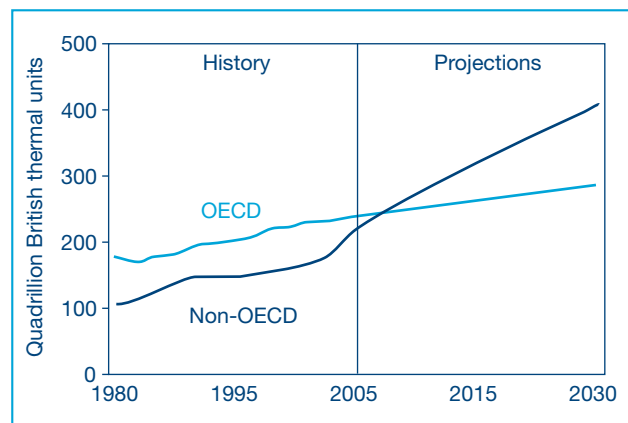
In any case, renewables will remain an attractive investment for the long term. For smart investors, the message is clear: Renewables are hot, they are here to stay and the time to act is now.

All around the world, people are using more energy

Global energy demand is expected to continue on its upward trajectory. As figure 1 shows, some projections indicate that by 2030, total energy consumption could reach almost twice its 1980 level.

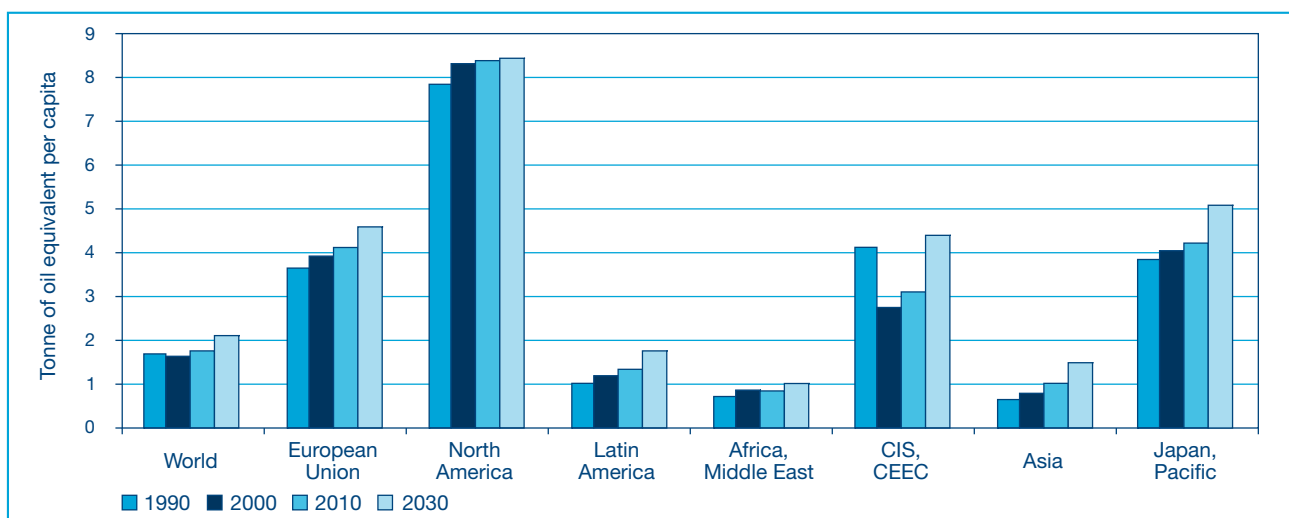
This growth is being driven predominantly by non-OECD countries, most notably rapidly developing economies such as Brazil, Russia, India and China. Although part of the growth can be attributed to population increases, the primary factor behind it is rising per-capita energy consumption. As individuals' wealth increases, so does their energy use.

Figure 1: Energy consumption 1980-2030 OECD versus non-OECD



Source: Energy Information Agency (2005, 2008)

Figure 2: Energy consumption per capita 1990-2030



Source: European Commission (2003), World energy, technology and climate policy outlook

Conventional energy sources are available...

Studies of oil and gas reserves suggest there is no direct shortage of these conventional fuels—but rather, plenty of reserves still to be found (see figures 3 and 4).

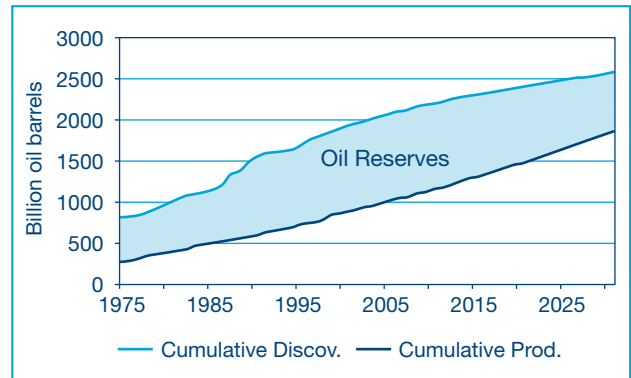
These remaining sources, however, are likely to be in more difficult to reach areas such as deep seas or tar sands.

...but at increasing cost

Tapping these supplies is more costly than using conventional methods, and the higher costs will, over time, drive up the intrinsic price of the energy. The price increase is already reflected in the oil price projections shown in figure 5.

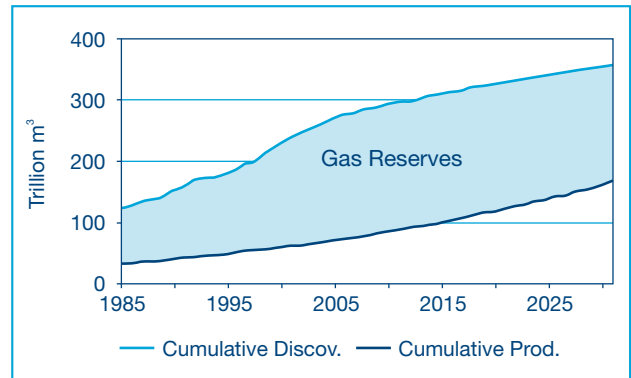
This situation is good news for renewables. In the longer term, the increasing marginal cost of conventional fuel production will drive up prices, thereby increasing the relative attractiveness of renewables.

Figure 3: Oil reserves 1975-2030



Source: European Commission (2003), World energy, technology and climate policy outlook

Figure 4: Gas reserves 1985-2030



Source: European Commission (2003), World energy, technology and climate policy outlook

Figure 5: Historic oil price development (WTI) and forward projections (1981-2029)

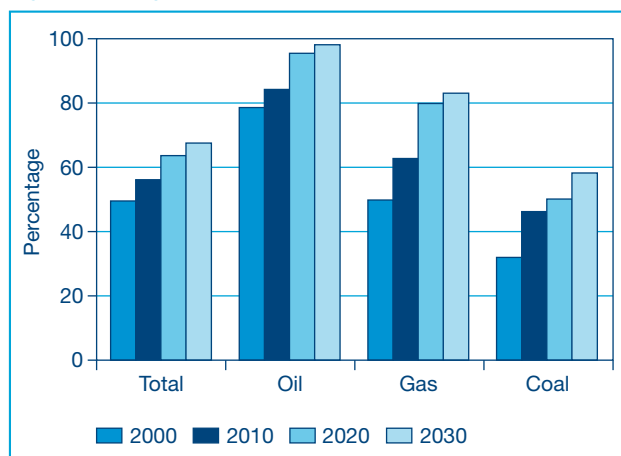


Source: Bloomberg, Annual Energy Outlook (EIA, 2008), PwC analysis

Security of supply: Increase of fuel independence

Another major driver behind renewables is increasing security of supply, in both the short term and the long term. The EU's dependency on foreign supply of fossil fuels is likely to increase over time, as shown in figure 6.

Figure 6: Energy import dependence EU27 2000-2030



Source: European Commission, 2007

Increasing the share of renewables in the energy mix will help reduce this dependency in the long term.

The short-term consequences of increasing shares of renewables are mixed. On one hand, the consequences of temporary interruption of fossil fuels—played out in the recent dispute between Russia and Ukraine—can be reduced by increasing shares of renewables. On the other hand, dependency on other factors such as weather conditions may reduce the reliability and stability of the system.

Stakeholders want more renewables

Where once was a debate about whether climate change was actually occurring, there is today a broadly accepted acknowledgement that the earth's ecosystems are being adversely affected by human action, particularly our use of fuels that emit CO₂.

As evidence of climate change mounts and its impact seems more dire, people around the world are demanding environmental accountability from both the

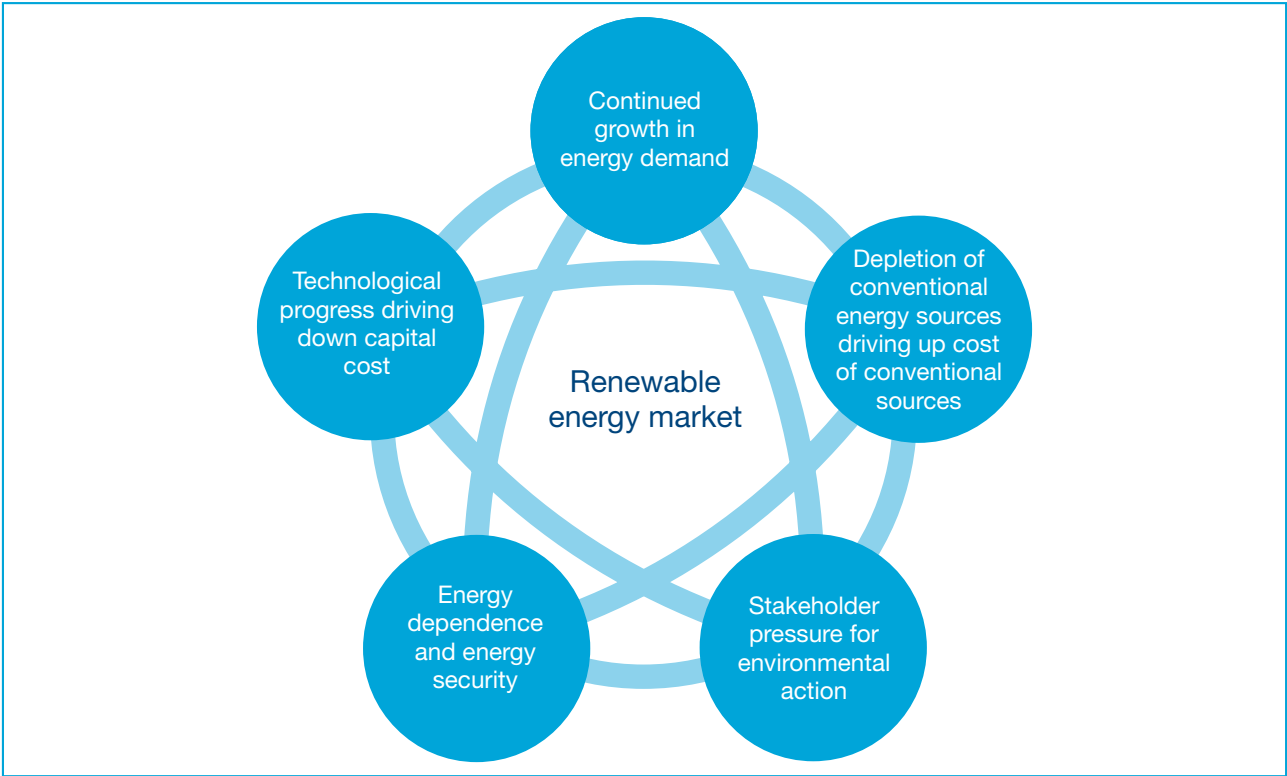
companies they do business with and their governments. Increasingly, consumers, companies and governments are demanding a fundamental shift in energy use. This trend can be seen in recent actions including:

- The EU has set ambitious 2020 targets. By that year, CO₂ emissions should be reduced by 20%, energy efficiency should be increased by 20%, and renewable sources should comprise 20% of the overall energy mix.
- The United Kingdom recently announced ambitions for a five-year carbon budget.
- The new US president has made public his intention to put renewable energy high on his country's national agenda.
- Global mail and express company TNT recently launched its Planet Me initiative to mitigate climate change. The company has also stated the need to do even more in the future to manage emissions from its ground and air fleets.
- At the Local Renewables 2007 event in Freiburg, Germany, city and business leaders from 34 countries called for renewable energy to be the basis of a decentralised and secure energy supply.
- Former US President Bill Clinton launched the Clinton Climate Initiative (CCI) in 2006 to help reverse climate change in practical, measurable and significant ways. As part of the programme, 40 large cities around the world pledged to accelerate their efforts to reduce greenhouse gas emissions.

"Today I challenge our nation to commit to producing 100% of our electricity from renewable energy and truly clean carbon-free sources within 10 years."
Former US Vice President Al Gore, 17 July 2008.

"This bill will enable us to double renewable energy production in three years and help transform how we use energy."
US President Barack Obama, 17 February 2009, announcing the country's US\$ 787.2 billion economic stimulus bill aimed at benefiting renewable energy and other sectors.

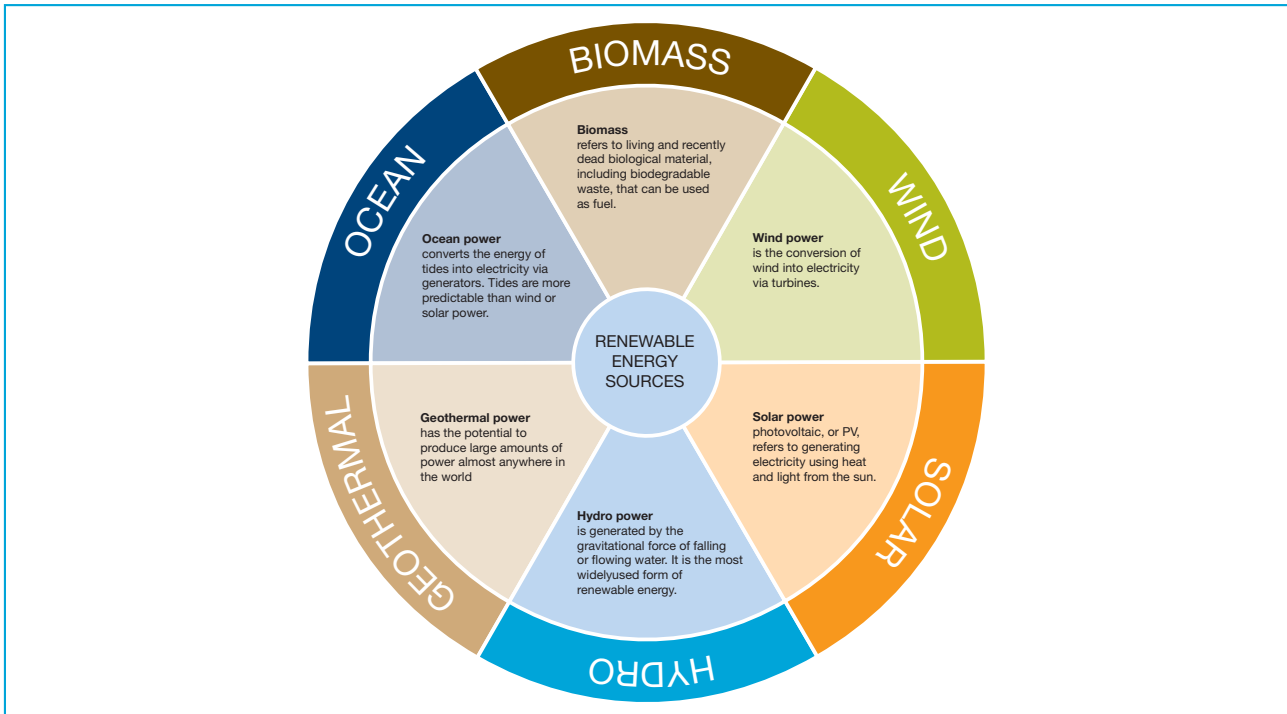
Figure 7: Forces driving development of the renewable market



Source: PwC analysis

3 The facts and figures

Figure 8: Overview of main renewable sources



Source: IEA, 2008, PwC analysis

Biomass

- Largest renewable energy contributor
- Traditional use—cooking and space heating—is inefficient
- Future supply levels are highly uncertain agricultural and forestry systems
- Applications for electricity, heating and transportation
- Economically attractive application is combined heat and power (CHP) projects
- Gasification technologies promising, 20-25% cost reductions

Wind

- Rapid growth since 1990, capacity in 2007 was 50 times that in 1990
- Robust technology, double-digit growth, great technological development
- No fuel requirement and CO₂ emission, quick installation from technical point of view (permitting process dominant aspect)
- Turbine output varies with wind resources
- Onshore already commercial at sites with good wind climate
- Five countries—US, Spain, Germany, India and China—represent 74% of global capacity
- Offshore is area of development

Solar

- Today PV is only profitable in remote off-grid areas
- Costs are decreasing rapidly in subsidised markets
- Fast-growing market, grid connected and building integrated systems
- Significant potential in both developed and developing countries
- Key technological developments: Increase efficiency and reduce material intensity and costs, increase lifespan of film modules

Hydro

- Hydro accounts for 90% of all renewable power production today
- Realistic potential is 2.5-3 times the current production (Asia, Africa and South America)
- Pumped storage capacity about 1,000 GW (10 times current capacity)
- Future power production may be affected by climate change
- Main challenge is competition with scarce water/land resources

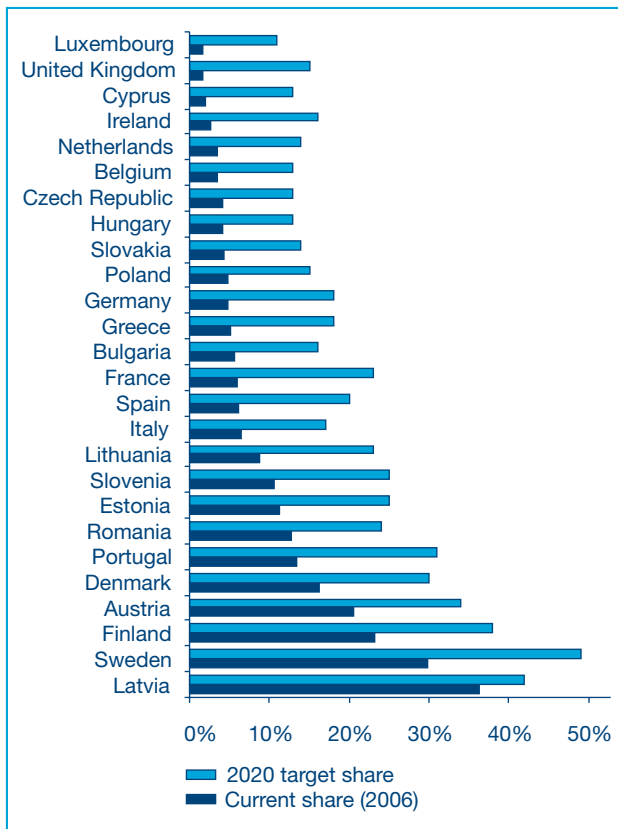
Geothermal

- Geothermal has large potential: high-quality resources are already economically viable
- The current capacity installed worldwide is 10 GW
- Enhanced geothermal systems (EGS) have the potential to produce large amounts of power almost anywhere in the world. Several pilot projects are being conducted in the US, Australia and Europe
- Costs need to decrease by 80% to make geothermal economically viable. To improve the viability of EGS more cost-effective deep drilling and construction are required as are more cost-effective reservoir fracturing and stimulation techniques, and tailored surface-conversion technologies

Ocean

- Prospects for expansion of ocean energy is limited
- Wave energy is still limited (4 GW)
- Costs need to come down to a third or a quarter of their current levels

Figure 9: Current share of renewables in primary energy and 2020 target



Source: Eurostat

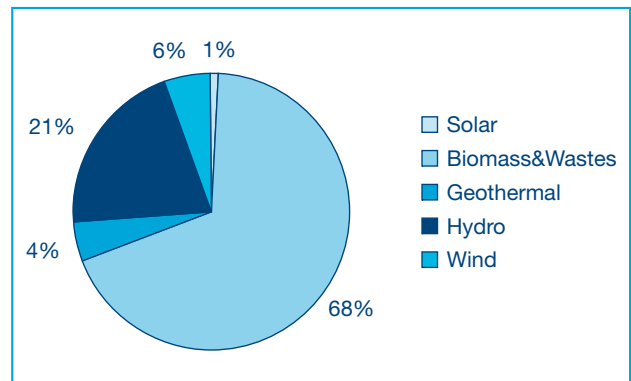
Renewables share in EU27 energy production

The 27 countries that form the European Union have set ambitious renewables targets.

As of the year 2020, 20% of all energy consumed in the EU should come from renewable sources. To achieve this target, massive shifts in investment must take place. The current share of renewable energy is approximately 7% — a long way from the 20% target (see figure 11).

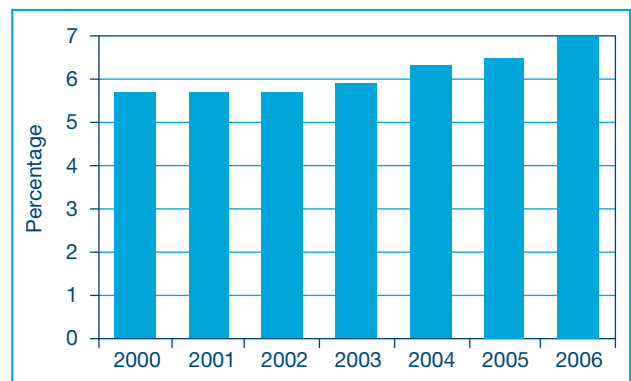
The current mix of renewable sources in Europe (highlighted in figure 10) is dominated by biomass and wastes (68%). Hydropower makes up 21%; wind accounts for 6%; geothermal, 4%; and solar contributes 1%.

Figure 10: Share of renewable sources in EU27 primary energy 2006



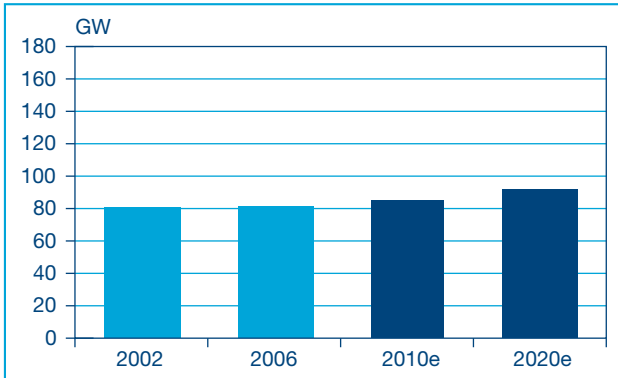
Source: Eurostat

Figure 11: Growth of renewables share in EU27 primary energy



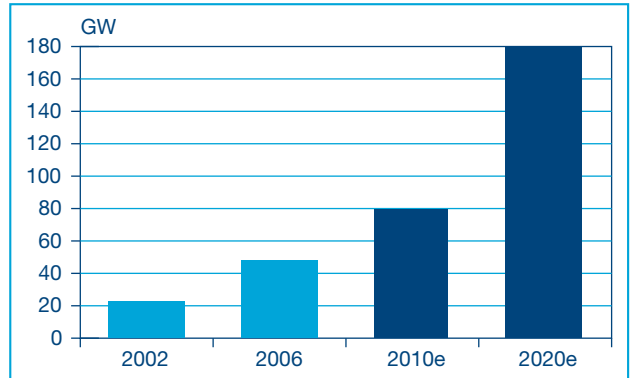
Source: Eurostat

Figure 12: Current hydro capacity and EU27 2020 projections



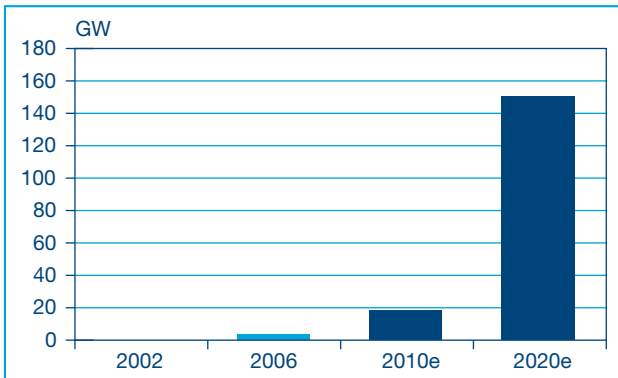
Source: European Renewable Energy Council

Figure 13: Current wind capacity and EU27 2020 projections



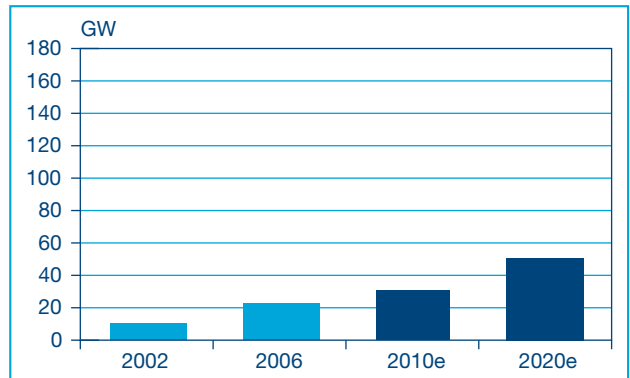
Source: European Renewable Energy Council

Figure 14: Current solar capacity and EU27 2020 projections



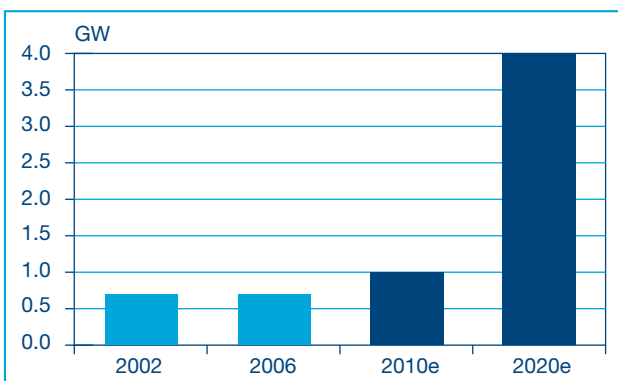
Source: European Renewable Energy Council

Figure 15: Current biomass capacity and EU27 2020 projections



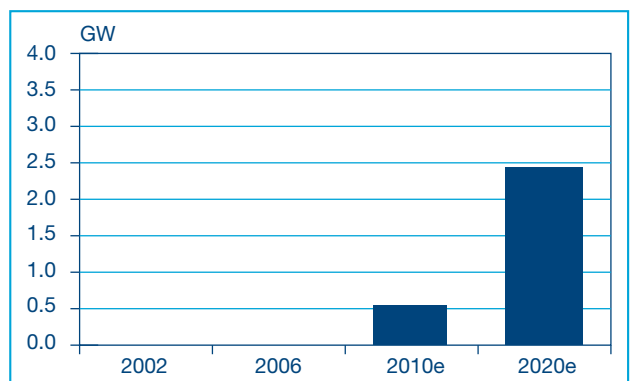
Source: European Renewable Energy Council

Figure 16: Current geothermal capacity and EU27 2020 projections



Source: European Renewable Energy Council

Figure 17: Current ocean capacity and EU27 2020 projections



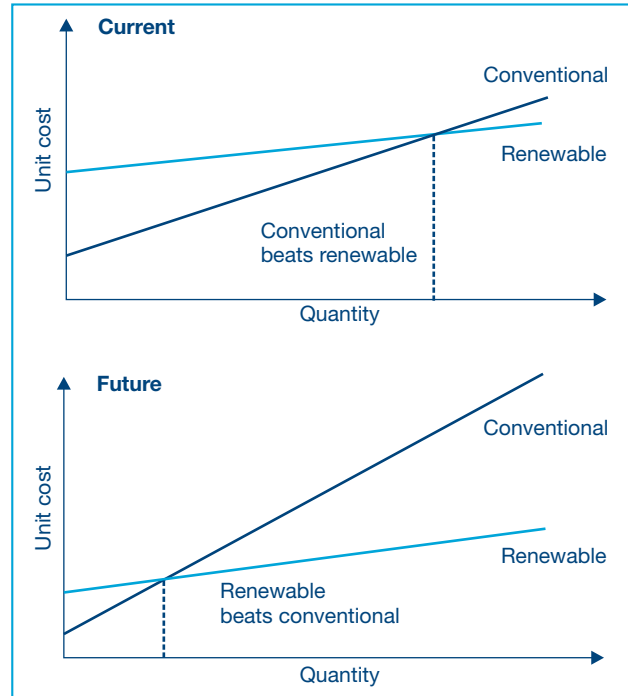
Source: European Renewable Energy Council

Technology advances are driving down the price of investing in renewables

As with the proliferation of all technology, ongoing development of renewable energy know-how is lowering investment thresholds. As these technologies become more widespread, the effects of learning and the economies of scale are driving down costs. Figure 18 shows the rapid decrease in unit cost per technology as total installed capacity has increased.

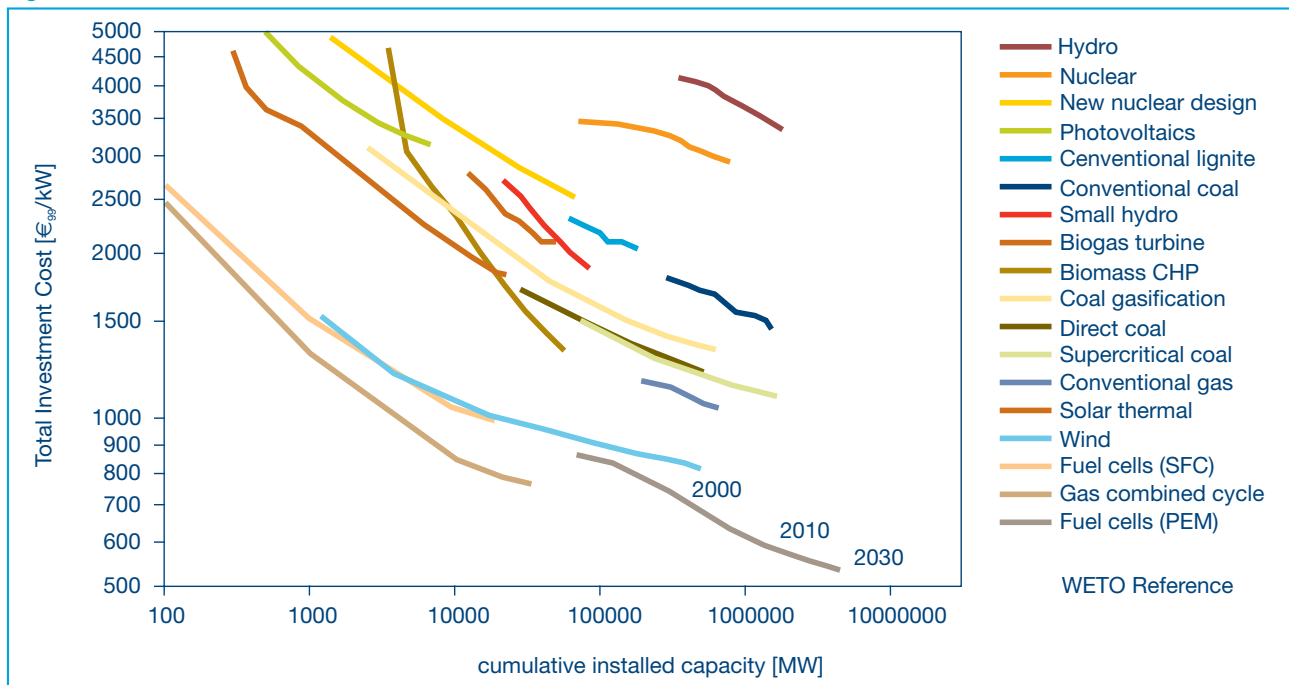
In the current marketplace, the fixed costs of renewable technologies is higher than those of conventional technologies—even though the marginal costs are likely to be lower (e.g. the “fuel” for wind is free). As technology progresses and more investment takes place, the fixed costs of renewable technologies are likely to decrease. This development is depicted in figure 19. At the same time, fixed costs of conventional technologies are likely to decrease further. In addition, because the remaining sources of conventional fuels are more expensive to retrieve, the marginal costs are likely to rise. This trend will ultimately lead to renewables “beating” conventional technologies earlier than in current market conditions.

Figure 19: Tipping point between renewable and conventional sources



Source: PwC analysis

Figure 18: Total investment costs over time



Source: European Commission (2003), World energy, technology and climate policy outlook

Size of the EU's potential renewables market

The target for renewables to comprise 20% of the overall energy mix is a dynamic one; as total energy demand continues to grow, the absolute required amount will increase. Assuming a 2.5% annual growth in total energy demand, 2020 would see a renewables market for approximately 6,000 TWh of electricity equivalent. Figure 20 shows an estimate of the size of the market.

We have calculated what will be required from each form of renewable energy if the target is to be met through electricity production alone. (Electricity now comprises about 20% of total primary energy.)

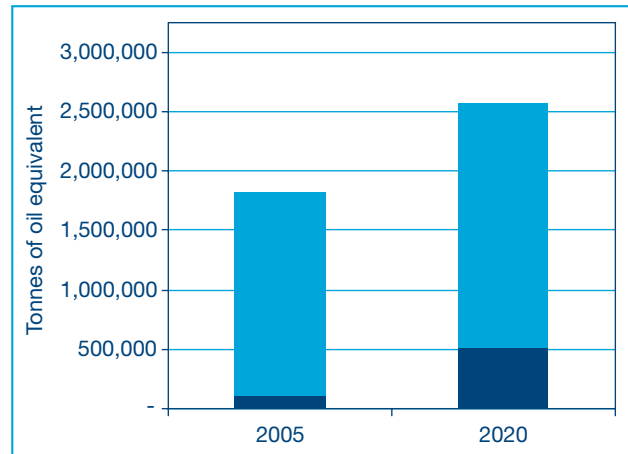
Our analysis, summarised in figure 21, suggests that by 2020 we will need either:

- 1.2 million windmills
- 565 million m³ of biomass wood
- 58,153 km² of solar panels
- 1,454 times the Hoover Dam's hydropower
- 2,237 times Iceland's geothermal capacity
- 21,414 km² of tidal installation.

We also estimated the financial investment required. Our calculations suggest renewable sources contributing 20% to the overall energy mix would require € 1.8 to 22 trillion, depending on the renewable source.

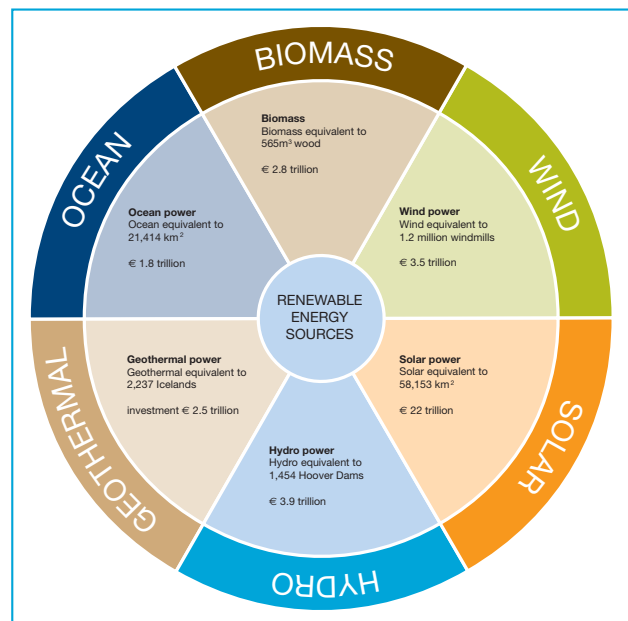
Obviously, electricity is not the only energy carrier to fulfill the target. Other sectors that contribute to the primary energy consumption—notably the transport sector—must also contribute to meet the 20% target.

Figure 20: Estimated size of renewables market



Source: Eurostat, PwC analysis

Figure 21: Investment requirement per renewable source



Source: PwC analysis (see appendix for calculations)

Renewables share in energy production: Seven selected countries

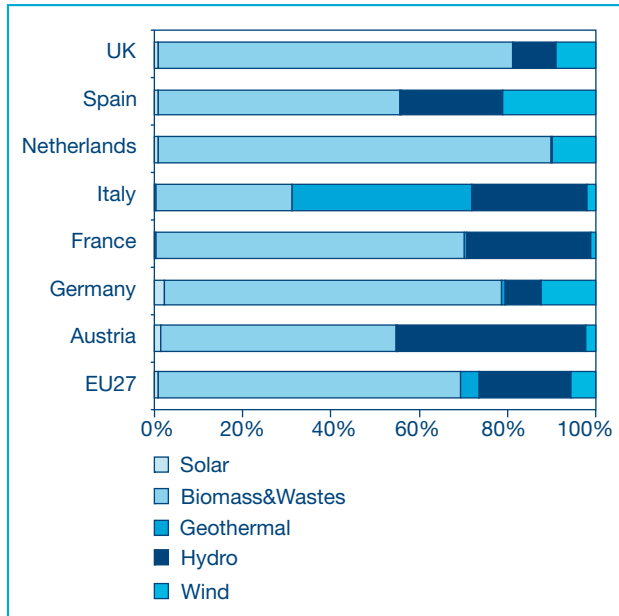
In this report we take a closer look at Germany, France, the Netherlands, the UK, Italy, Spain and Austria. The relative shares of renewable sources in each country are depicted in figure 22.

Figure 23 presents an overview of the historic development and 2020 targets for the seven countries.

Figure 24 shows the relative historic growth as an index starting in 1995.

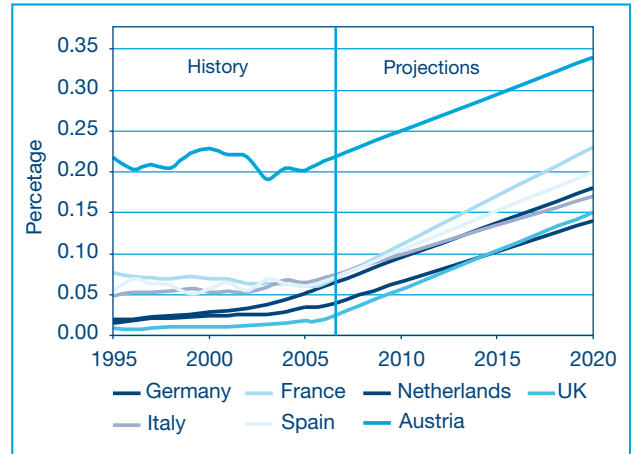
In relative terms, Germany appears to be most successful in promoting renewable energy. The backbone of the country's renewable energy policy is the Renewable Energy Sources Act (EEG). The act introduced a fundamental change in energy supply: Every citizen can now become an energy producer. The grid system operators are committed to accepting this electricity, and to paying fixed fees (feed-in tariffs) for it. The tariffs paid depend on the technology used, the year the installation began operation, and the size of the plant. The combination of attractive tariffs and a stable policy environment is regarded as the EEG's determining success factor.

Figure 22: Relative share of renewable sources in 7 countries



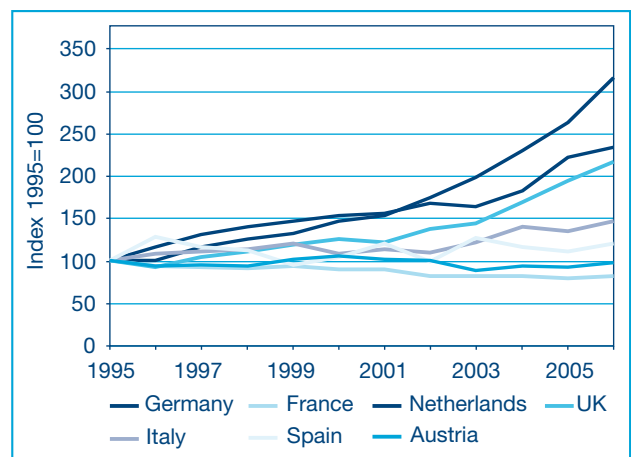
Source: Eurostat

Figure 23: Share of renewable energy 1995 - 2006, and projection to target in 2020



Source: Eurostat

Figure 24: Relative growth of renewable energy index 1995=100



Source: Eurostat



4 How governments can reap the rewards of renewables

Governments have installed various incentive schemes...

National governments have crafted and are using various schemes to encourage business investment in renewable energy. While each scheme varies, when viewed collectively, they show a fundamental choice between stimulation and obligations—in other words, between the carrot and the stick.

Often, a mix of incentives is used. Tools include subsidies, fiscal incentives, feed-in tariffs, regulation and information.

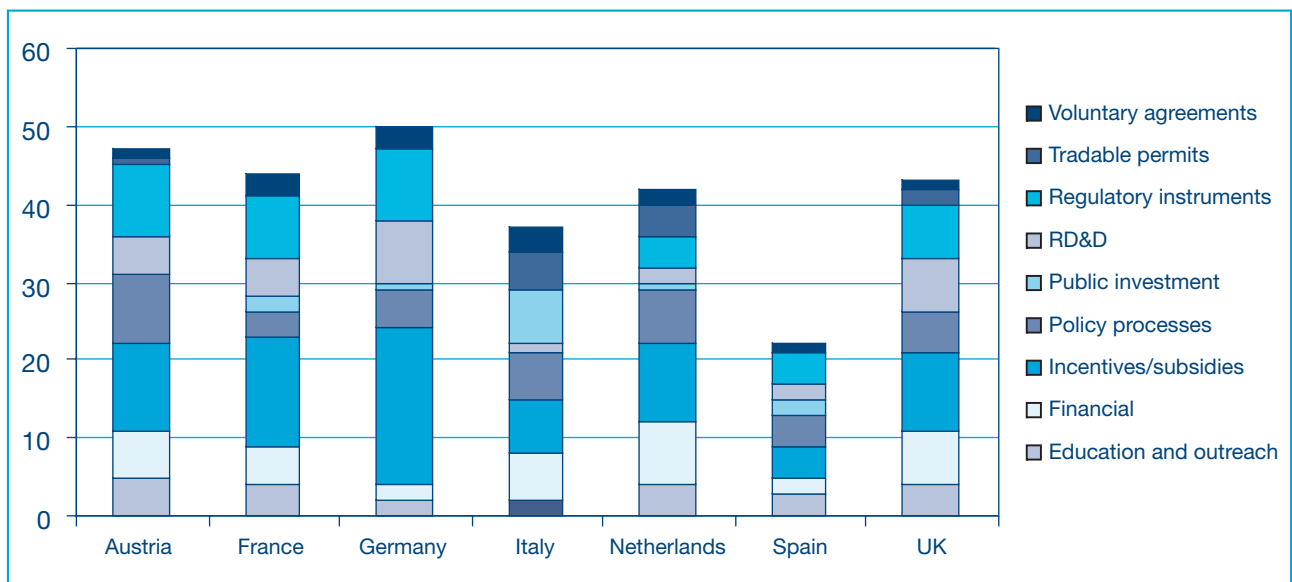
The incentive mix offers governments challenges and opportunities. Designing a coherent and best-practice suite of renewable policies will encourage innovation and investment. Finding the delicate balance between policies that are “effective” and those that are economically “efficient” is crucial. Figure 25 shows an overview of the kinds of policy instruments used in the countries examined. First, the chart shows the variety of instruments. Furthermore, it illustrates the relative extensive incentive scheme in Germany.

Table 1: Number of policy tools per country

Voluntary agreements	Agreements among governments and businesses/associations to promote/stimulate renewable energy
Tradable permits	Cap-and-trade systems in which participants exceeding their objectives (cap) can sell permits to those not meeting theirs
Regulatory instruments	Regulation regarding implementation of renewable energy, such as obligations for shares of renewable technologies
R&D	Stimulation of the research, development and demonstration of renewable technologies
Public investment	Government investments or participation in renewable energy projects
Policy processes	Special measures to facilitate renewable energy
Incentives/subsidies	Financial assistance for business or economic sectors to encourage investments in renewable energy
Financial	Financial facilities to make investments more attractive
Education and outreach	Information about renewable energy for target groups

Source: PwC analysis

Figure 25: Number of policy tools per country



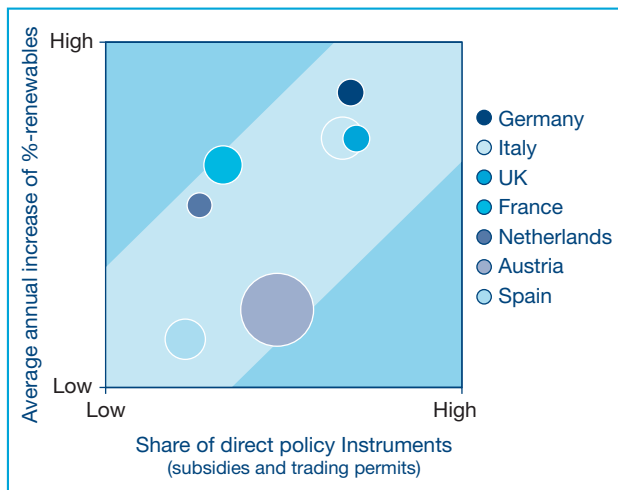
Source: International Energy Agency, PwC analysis

...with different degrees of success

Certain policies can be effective in realising investments, but may be viewed as economically inefficient. Economic efficiency is measured by examining the level of funds required to achieve a marginal investment, how the funds are raised, and how funds are distributed.

The matrix in figure 26 compares the share of direct policy instruments (such as subsidies and tradable permits) and the average annual growth of renewables. There seems to be a link between those countries with relatively high growth in renewables and the proportion of direct policy instruments.

Figure 26: Relationship between direct policy tools and renewables growth



Source: International Energy Agency, PwC analysis

Shift from facilitating to attracting investments

While efficiency of incentives is important, what the ambitious 2020 goals show is that effectiveness should now become a priority. Governments will likely begin shifting their focus from facilitating investments to attracting them. In other words, countries will begin competing for renewable energy investments.

Countries will want to attract investments to meet their own national targets, but must not overlook the fact that the EU goals reach across national boundaries—with a 20% overall European target.

Competition between renewables policies will encourage policy innovation and increase overall quality of policies. This development will increase policy efficiency, but may have negative consequences in the short term by reducing the level of renewable investment. In other words, it may be less effective to achieve the goals in 2020.

It is clear that a coordinated approach across Europe is required. Such an approach will help reward those investments best suited to meet the European targets, rather than simply meeting national goals. This European angle also mirrors the way investors approach the marketplace, and will reduce the “policy arbitrage” by investors who must decide where to invest in renewable energy.

Nevertheless, countries should focus on their comparative advantages. These could, for example, be in the form of technology development such as solar technology, or they could take the form of facilitating particular sources, such as offshore wind parks.

Create a robust renewable energy policy

A robust renewable energy policy requires a number of ingredients. The balance should be between policies that are effective and those that are efficient. Critical success factors are the stability and predictability of policy.

Renewable energy investments—like other capital-intensive investments—are long term and require policy stability to ensure economic viability.

PwC has identified several key elements necessary to a robust renewable energy policy:

- **stability and predictability**
Policies should be clearly formulated with stated timelines, and they should be coherent with other policies. They should be predictable and not subject to political decision-making. For example, Germany’s EEG is paid by all electricity consumers rather than through the central government.
- **carrots and sticks**
Policies should strike a balance between carrots and sticks. On one hand, requiring companies to source and invest in renewables (and passing costs on to consumers) and on the other hand, providing financial incentives to realise investments (indirectly passing

costs on to society through general taxation). The UK and Belgium, for example, both have renewable obligations.

- **planning and permitting**
Policies should focus explicitly on eliminating delays and smoothing planning and permitting for renewable energy.
- **comparative advantage**
Policies should leverage countries' comparative advantages, such as the greater capacity of countries in southern Europe to realise solar energy over those in the north.
- **communities of investors**
Policies should encourage development of communities or networks of investors and technology developers. Bringing expertise together fosters cooperation and innovation.
- **information-sharing and best practice**
Policies should be based on lessons from other countries and should aim to be best practice.
- **a European—not a national—mindset**
Policies should focus primarily on achieving European targets and how the country can contribute to that larger goal.

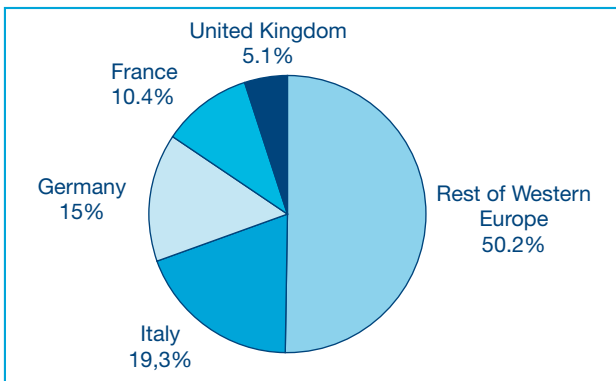
5 How companies can reap the rewards of renewables

Substantial revenues available

The renewable energy market is a fast-growing field. According to Datamonitor, the European renewable energy market generated revenues of US\$74 billion in 2007. The growth rate between 2003 and 2007 was a staggering 16% per year. Meeting the EU targets suggests projected 2020 revenues of around US\$225 billion.

The picture below shows the five leading countries, with Italy providing the highest turnover.

Figure 27: 2007 turnover in renewables



Source: Datamonitor

Further analysis by Datamonitor shows that the German renewable market grew 20.3% and the French market 10.4%, respectively, over the same period, to reach respective values of US\$11.1 billion and US\$7.7 billion in 2007.

Follow the leaders

The renewables market has seen new companies develop and grow into contenders. At the same time, many traditional companies have taken the opportunities to realise new growth and establish new profitable lines of business.

This section highlights a few companies that have developed unique or innovative business opportunities.

This listing is certainly not exhaustive—but the summaries give a flavour of the vast potential of the renewables marketplace.

The Green MEP from Luxembourg, who wrote parliament's report on a proposal to boost the share of renewables in final energy consumption to 20% by 2020, predicts that the wind turbine sector alone will overtake EU car manufacturers as the steel industry's biggest customers by 2013.

The market for European wind power capacity broke new records in 2006, according to the annual statistics issued by the European Wind Energy Association (EWEA). 7,588 MW of wind power capacity, worth some €9 billion, was installed last year in the EU, an increase of 23% compared to 2005.

Figure 28: The Guardian's CleanTech top 100 European companies

Company name	Sector	What they do	Based	Founded	Employees
Odersun	Solar power	Design and manufacture of thin-film flexible solar cells	Germany, Frankfurt	2002	90
Deep Stream Technologies	Distribution and management	'Embedded intelligence' circuits for power management	UK, Bangor	2003	52
CamSemi	Electricals	Low cost, low power standby mode technology	UK, Cambridge	2000	57
SIC Processing	Industry	Hydrocyclone technology to improve solar cell production	Germany, Hirschau	2000	Undisclosed
Marine Current Turbines	Marine power	Tidal turbines	UK, Bristol	1989	15
Sulfurcell Solartechnik	Solar power	Thin film solar technology	Germany, Berlin	2001	60
Pelamis Wave Power	Marine power	Wave energy technology	UK, Edinburgh	1998	70
Solarcentury	Solar power	Mass market solar technology	UK, London	1998	100
Nujira	Electricals	Low-power mobile-phone and radio transmission	UK, Cambridge	2002	47
Atraverda	Electricals	Conductive ceramics for power storage	UK, Abertilly	1991	8
Biogasol	Biofuels	Bioethanol based fuels from organics	Denmark, Kgs Lyngby	2005	15
Choren Industries	Biofuels	Turns biomass into tar-free synthetic gas	Germany, Freiburg	1997	230
KIOR	Biofuels	Converts biomass into bio-crude	Netherlands, Hoevelaken	2007	15
Green Biologics	Biofuels	Advanced microbial technologies to convert biomass	UK, Abingdon	2002	20
Inetec	Biofuels	Turns food waste into energy	UK, Brigend	1997	11
Orchid Environmental	Biofuels	Converts household waste into energy	UK, Lancashire	2003	Undisclosed
Regenastar	Biofuels	Biofuel conversion systems for diesel engines	UK, Oxford	2008	Undisclosed
TMO Renewables	Biofuels	Next generation biofuels using micro-organisms	UK, Guildford	2002	29
SweTree Technologies	Biofuels	Specialist breeding technologies for trees	Sweden, Umea	1999	11
Microtherm	Building technology	Innovative thermal insulation	Belgium, Sint-Niklaas	1970	60
ChromoGenics Sweden	Building technology	Electrochromism - control of light and heat	Sweden, Uppsala	2002	21
Integrated Environmental Solutions	Building technology	Simulation software for eco-buildings	UK, Glasgow	1994	93
Onzo	Building technology	Smart electricity meters	UK, London	2007	12
ClimateWell	Building technology	Solar-powered air conditioning	Sweden, Hägersten	2001	46
2K Manufacturing	Building technology	Eco-friendly construction materials	UK, London	2007	5
Econnect	Distribution and management	Connects renewables to the national grid	UK, Hexham	1994	54
Flexitricity	Distribution and management	Matches supply and demand	UK, Edinburgh	2004	Undisclosed
Rltec	Distribution and management	Dynamic demand technology	UK, London	1999	9
Moixa Energy	Distribution and management	Portable power technologies	UK, London	2005	8
Watteco	Distribution and management	Energy management including consumption limiters	France, La Garde	1998	14
Insensys	Distribution and management	Fibre optic strain measurement	UK, Southampton	2002	20
Camfridge	Electricals	Gas-free, magnetic refrigeration	UK, Cambridge	2003	6
Novalad	Electricals	Organic light emitting diodes	Germany, Dresden	2001	110
Ubidyne	Electricals	Low-power digital radio broadcasting	Germany, Ulm	2005	30
Pelikon	Electricals	Next generation liquid crystal displays	UK, Caerphilly	1999	50

Company name	Sector	What they do	Based	Founded	Employees
Plastic Lodge	Electricals	Plastic electronics	UK, Cambridge	2000	90
Metrolight	Electricals	Lighting control systems	Israel, Netanya	1996	30
Norstel	Electricals	Materials for low-power electricals	Sweden, Norrköping	2005	50
QuNano	Electricals	Nanoelectronics	Sweden, Lund	2005	Undisclosed
Nanotecture	Energy storage	Nanotechnology, including powders for batteries	UK, Southampton	2002	17
Enfucell	Energy storage	Paper thin batteries	Finland, Espoo	2002	20
Effpower	Energy storage	Hybrid vehicle batteries	Sweden, Hisings Backa	1999	30
High Power Lithium	Energy storage	Nano-structured metal oxides	Switzerland, Lausanne	2003	12
ReVolt Technology	Energy storage	Zinc-air batteries	Switzerland, Staefa	2004	50
Oxis Energy	Energy storage	Low-weight batteries	UK, Abingdon	2000	7
Ilika Technologies	Energy storage	Advanced materials	UK, Southampton	2004	17
Xipower	Energy storage	Battery-based energy storage	UK, Alloa	2003	Undisclosed
P21	Energy storage	Power for remote locations	Germany, Brunnthal	2001	35
EnStorage	Energy storage	Wind and power plant fuel cells	Israel, Zichron Yaacov	2007	5
Electro Power Systems	Energy storage	Fuel cells for business	Italy, Alpignano	2005	23
Acal Energy	Energy storage	Fuel cells for cars and homes	UK, Runcorn	2004	10
St Andrews Fuel Cells	Energy storage	Solid oxide fuel cells	UK, Fife	2005	6
Intelligent Energy	Energy storage	High density fuel cells	UK, Loughborough	2000	97
Bac2	Energy storage	Electrically conductive resin for fuel cells	UK, Southampton	2001	4
Metalysis	Industry	Low energy metal processing	UK, Rotherham	2001	40
RecovCo	Industry	Aluminium recycling	UK, London	2004	3
Perpetuum	Industry	Harnessing vibration energy for sensors	UK, Southampton	2004	10
AQUAporin	Industry	Biotech-based water purification	Denmark, Kgs Lyngby	2005	6
Fluxion	Industry	Silicon wafer membrane technology	Netherlands, Eindhoven	2003	17
LM Glasfiber	Industry	Blades for wind turbines	Denmark, Lunderskov	1940	4100
ScotAsh	Industry	Eco-friendly construction materials	UK, Alloa	1999	22
Neosens	Industry	Contaminant sensors	France, Labege Cedex	2001	14
Scotrenewables	Marine power	Free floating tidal energy systems	UK, Orkney	2002	19
HydroVenturi	Marine power	Small scale hydro and tidal power	UK, London	1999	8
OECOn	Marine power	Oscillating water column technology	UK, Derriford Plymouth	2008	Undisclosed
Lunar Energy	Marine power	Seabed tidal turbines	UK, Hessle	2001	Undisclosed
OpenHydro	Marine power	Tidal turbines with slow moving rotors	Ireland, Dublin	2004	27
4d-Technologie GmbH	Solar energy	Solar-thermal collector system	Germany, Leipzig	2005	Undisclosed
Concentrix Solar	Solar energy	Concentrators for photovoltaic cells	Germany, Freiburg	2005	Undisclosed
CSG Solar	Solar energy	Thin-film solar technology	Germany, Thalheim	2004	55
Solarion	Solar energy	Flexible thin film solar technology	Germany, Leipzig	2000	20
Solitem	Solar energy	Trough-shaped solar collectors for heating and cooling	Germany, Aachen	1999	50
Würth Solar GmbH & Co KG	Solar energy	Copper-indium-diselenide solar cells	Germany, Marbach	1999	183
Norsun	Solar energy	Thin crystalline silicone wafers	Norway, Oslo	2005	Undisclosed
QuantaSol	Solar energy	Nano-scale solar cell technology	UK, London	2006	5

Company name	Sector	What they do	Based	Founded	Employees
Whitfield Solar	Solar energy	Solar concentration systems	UK, Reading	2004	5
Heliatek	Solar energy	Organic solar cells	Germany, Dresden	2006	13
G24i	Solar energy	Advanced solar cells that mimic photosynthesis	UK, Cardiff	2006	60
EVO Electric	Transport	High-power, low-density electric motors	UK, Woking	2006	10
Loremo	Transport	Lightweight, fuel-efficient vehicles	Germany, Mari	2003	18
Think Global	Transport	Emission free electric vehicles	Norway, Aurskog	1999	Undisclosed
Modec	Transport	Commercial electric vehicles	UK, Coventry	2004	55
NexxtDrive	Transport	Next generation hybrid technology	UK, London	2000	5
Advanced Transport Systems	Transport	Personal-public urban transport	UK, Thornbury	1995	20
PML Flightlink	Transport	Compact electric motors for cars and scooters	UK, Hampshire	2001	90
Vestesen	Waste stream power	Wind-diesel systems	Denmark, Viby J	2002	Undisclosed
Environmental Energy Resources	Waste stream power	Eco-friendly waste disposal	Israel, Ramat Gan	2000	15
Freepower	Waste stream power	Electricity from waste heat	UK, Andover	2000	13
Juwi	Waste stream power	Finances and develops renewable energy	Germany, Mainz	1996	250
Stirling Danmark	Waste stream power	Biomass-powered generators	Denmark, Kgs Lyngby	2004	9
Cogenco	Waste stream power	Combined heat and power generators	UK, Horsham	1991	70
Green Fuels	Waste stream power	Waste oil to diesel conversion	UK, Stonehouse	2003	10
Econcern	Waste stream power	Holding companies focusing on innovation	Netherlands, Utrecht	1984	950
A2SEA	Wind power	Offshore wind farm construction	Denmark, Fredericia	2000	160
Winwind	Wind power	Low maintenance wind turbines	Finland, Oulu	2000	150
France Eoliennes	Wind power	Micro wind turbines	France, Fay aux Loges	2003	116
SkySails	Wind power	Towing kites for ships	Germany, Hamburg	2002	60
Emergya Wind Technologies	Wind power	Low operating cost turbines	The Netherlands, Schoondijke	2004	Undisclosed
Proven Energy	Wind power	Small scale wind turbines	UK, Stewarton	1980	28
Quiet Revolution	Wind power	Ultra-quiet wind turbines	London, UK	2005	Undisclosed

Source: The Guardian

Italy

Enel Green Power (part of the Enel Group)
2008 revenues € 1,700 million
2008 installed capacity: 4,500 MW, including 2,500 MW in Italy

Incorporated in December 2008, Enel Green Power carved out Enel's activities in the wind, solar, geothermal, run-of-river hydroelectric and biomass fields in Europe and North, Central and South America. It is Italy's number one company with an internationally integrated renewable energy business, and Europe's generation output leader. It produces more than 17 billion KWh, enough to service some 6,500,000 households and to eliminate 13 million metric tonnes of CO₂ emissions annually.

Spain

ACCIONA
2007 energy business revenues: € 1,092 million
2007 installed capacity: 1,025 MW

Created in 1997 as a result of the merger between Entrecanales & Tavora and Cubiertas & MZOV, ACCIONA inherited its parent companies' philosophy of profitability, quality and technical rigour. The company develops and manages energies, infrastructures and services that share common customers, and has a management philosophy geared towards maximising returns. ACCIONA's energy business focusses on developing renewable facilities in more than 15 countries around the world.

UK

Solarcentury
2008 energy business revenues: £ 19 million

Solarcentury is a fast-growing and innovative UK renewable energy technology company that has charted considerable success over its 10-year history. The company sources solar photovoltaic (PV) products from leading manufacturers and offers them to customers in conjunction with specialised engineering expertise and services. Solarcentury specialises in designing and installing solar energy products that integrate within the fabric of the built environment to generate clean, on-site electricity and hot water for commercial, residential, industrial and public sector buildings. The company employs designers, engineers, project managers, consultants, and logistics and support staff.

France

EDF Energies Nouvelles
2008 renewable energy revenues: € 1,007 million
2008 installed capacity: 1,564 MW

EDF Energies Nouvelles operates throughout the renewable energy value chain, from project development to electricity generation from green sources. Fifty-percent owned by EDF, the company also has a significant international presence, especially in the United States. Active in the wind business for more than 10 years, the group is among that sector's leaders in France and internationally. Since 2007, the company has focussed on photovoltaics, its second area of strategic development. The group is also involved in bio-fuels, biogas, hydroelectricity and ocean energy.

Netherlands

Econcern
2007 energy business revenues: € 443 million

Econcern, which comprises four operating companies—Ecofys, Ecostream, Evelop and Ecoventures—became active in the sustainable energy market in 1984, and currently employ about 1,200 professionals in 19 countries. With its technical and financial understanding of energy systems, the company designs competitive projects and services, while its close collaboration with corporate clients, government organisations and financial institutions puts it in a good position to make these projects economically viable market-driven solutions. Econcern experienced strong growth in the last couple of years and won multiple awards. It strives to create a sustainable energy supply from which everyone everywhere can benefit, and tries to achieve this by market-driven innovation.

Austria

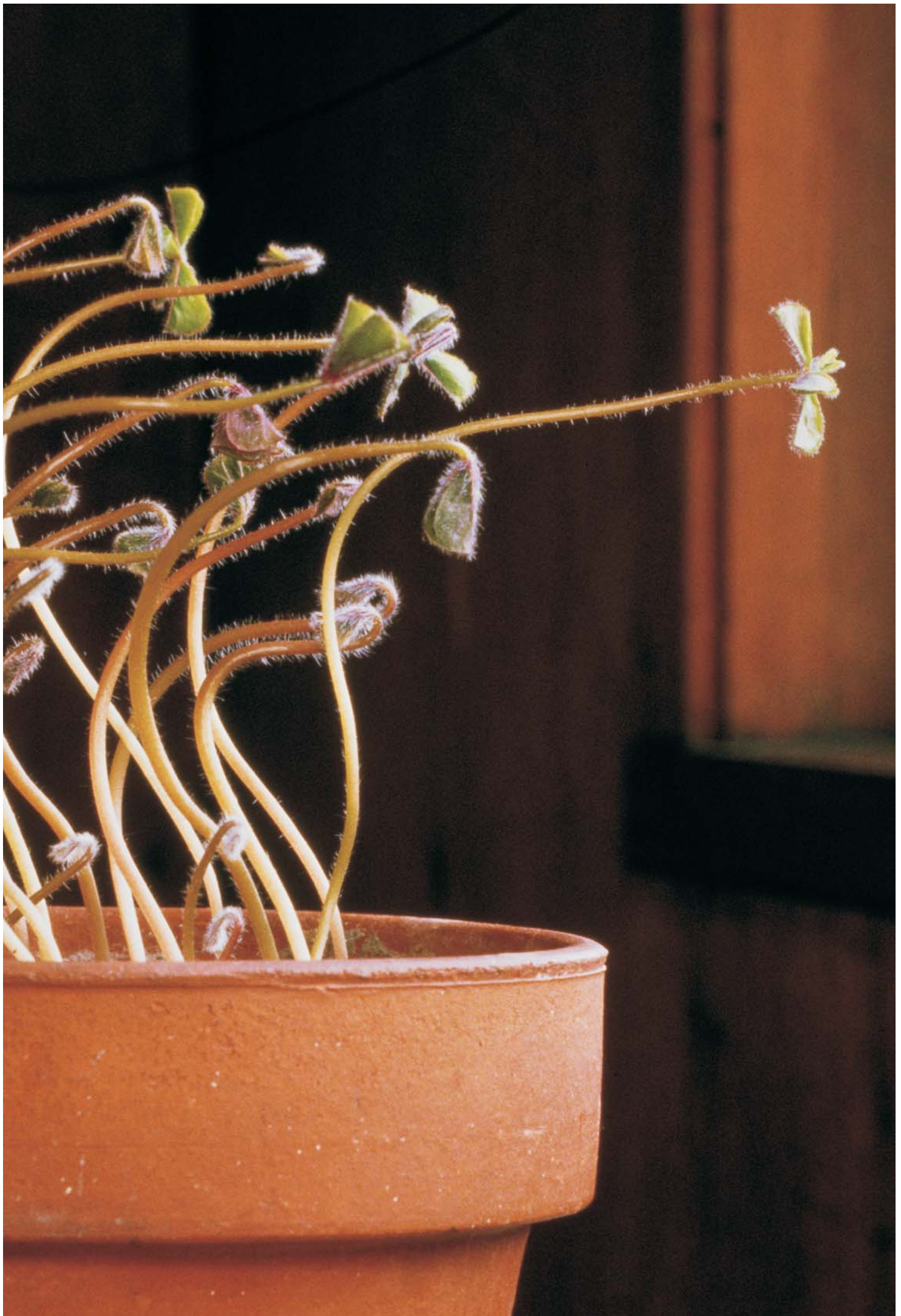
GREENoneTEC
2006 energy business revenues: € 73 million
2008 produced collector area: 1,000 m²

GREENoneTEC specialises in production of high-quality solar thermal collectors. Eight production lines—each with its own basis technology—form the foundation for more than 100 collector alternatives and assembly solutions. The production range comprises not only aluminium tray and frame collectors, but also wooden roof-integrated modular collectors, vacuum-tube collectors, facade collectors, thermal siphon systems, crane-installed modular collectors, full-surface absorbers, solar accessories and intelligent mounting systems. GREENoneTEC has developed countless innovations, including large-surface ultrasonic welding for absorbers. The company's facade and thermal siphon systems are the result of collaboration between its development department and internationally renowned institutes. Approximately 235 employees are responsible for the success of the company.

Germany

Nordex
2007 renewable energy revenues: € 747 million
2008 installed capacity: 4,800 MW

Nordex has been developing wind turbines since 1985, before international demand for wind turbines increased in the first half of the '90s. Today, more than 3,700 Nordex turbines with a total rated output of more than 4,800 MW rotate in 34 countries. The company has 18 offices around the world, and serves the growing Chinese market. It employs approximately 2,000 people.



Appendix

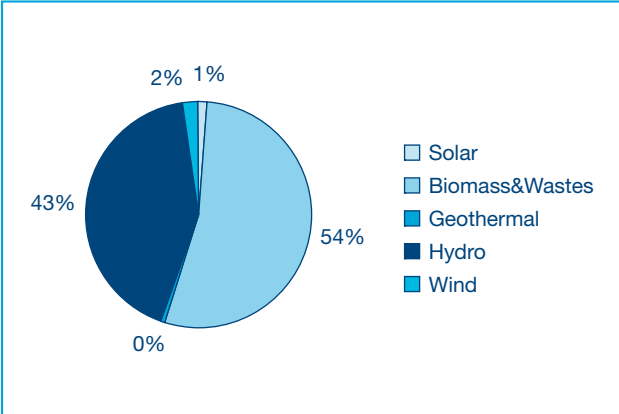
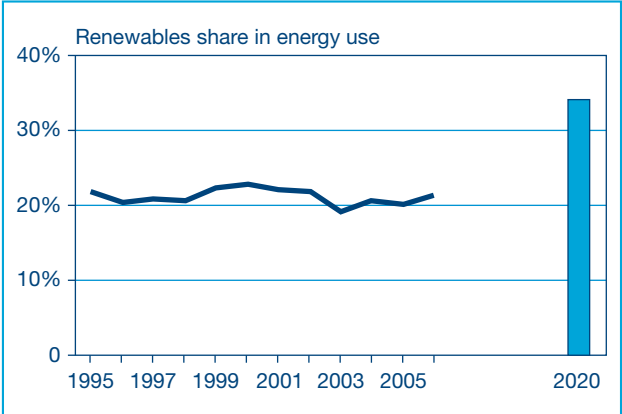
Appendix A Key characteristics of examined countries

As the information gathered on the seven countries studied clearly illustrates, the share of renewable energy use differs substantially among the countries of the European Union. This situation offers great opportunities for new investment. All data is from Eurostat.

Our study considered the renewable energy sources set out below in seven European countries:

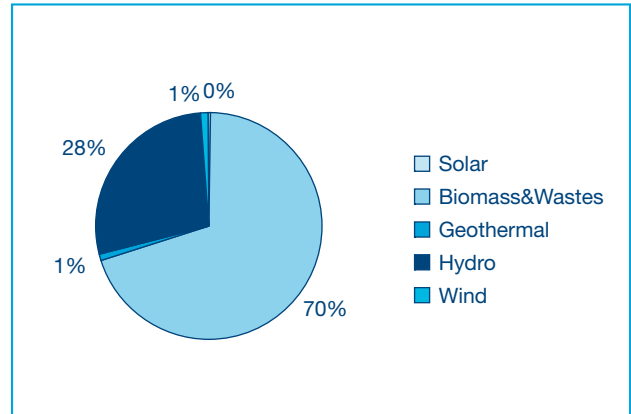
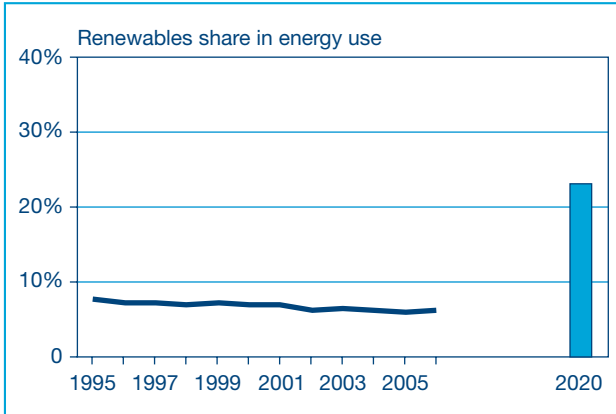
- Austria
- France
- Germany
- Italy
- Netherlands
- Spain
- United Kingdom

Austria



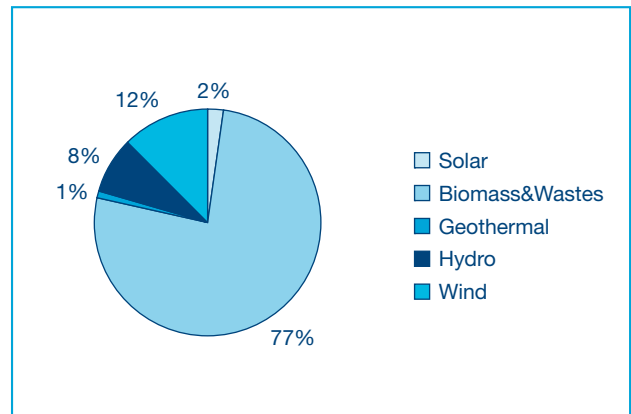
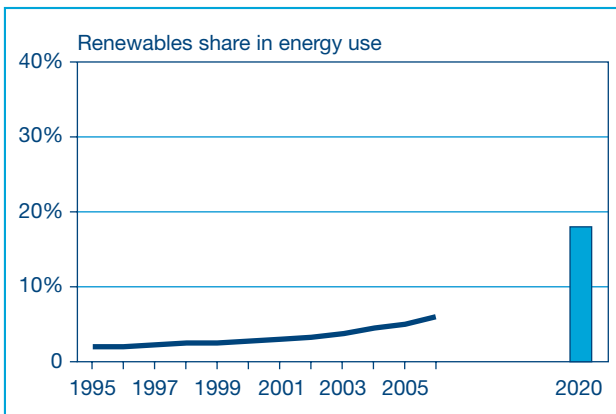
Austria has set ambitious renewable energy targets for 2020—from the current 23% to 34%. The current renewable mix is dominated by biomass (54%) and hydro (43%). The Austrian government has established both feed-in tariffs and guarantees of origin to support the drive for further investment in renewable energy.

France



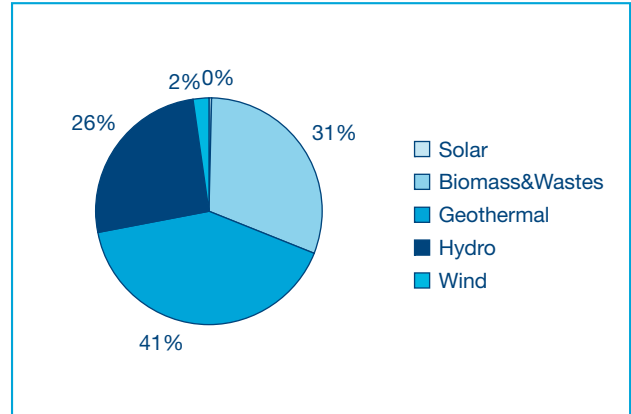
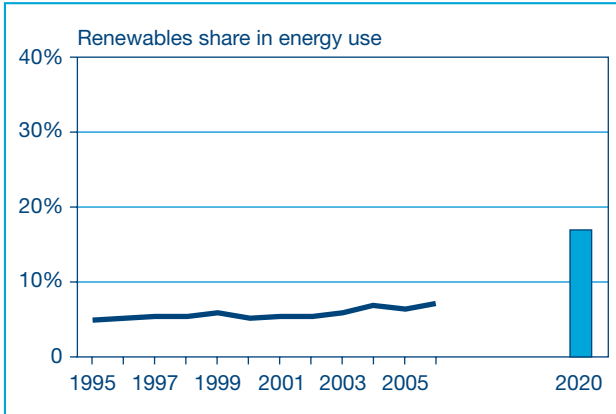
The renewable energy target for France is 23% in 2020—up from the current 10%. The dominant source for renewable energy in the country today is biomass (70%), with hydro providing 28%. The French government offers incentives for consumers, feed-in tariffs for producers, financing assistance for R&D, tax credit (accelerated depreciation over 12 months). Government guarantees cover medium- and long-term risks (2-15 years) and insures the risks taken by lending financial institutions. In the frame of its recovery plan for the economy, government recently announced many measures in favour of renewables including simplified administrative procedures, implementation of a € 1 billion fund for renewable heat and increased public investments (one solar station in each administrative region of France, tenders for biomass stations, state buildings to be revamped with photovoltaics).

Germany



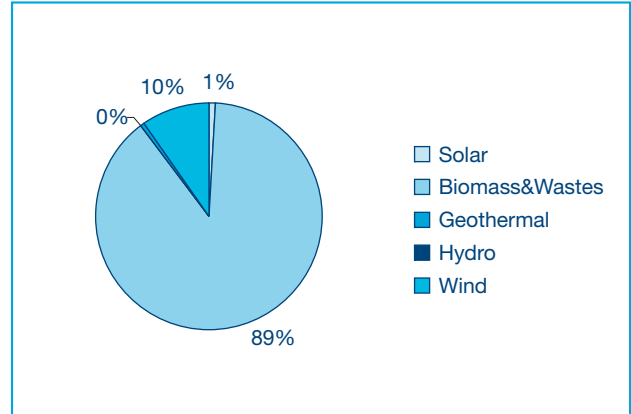
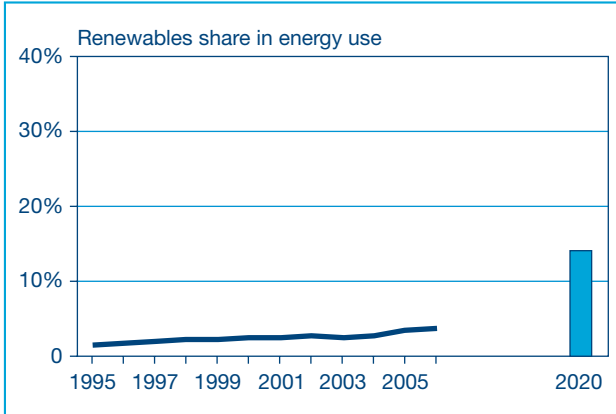
Germany's target for renewable energy use in 2020 is 18%—up from the current 6%. Biomass currently provides the largest share of renewable energy (77%) in the country. Interestingly, wind is the second-largest source of renewable energy, providing 12%. The government's Renewable Energy Sources Act (EEG) and its Market Incentive scheme are the main support programmes for the country's renewable energy goals.

Italy



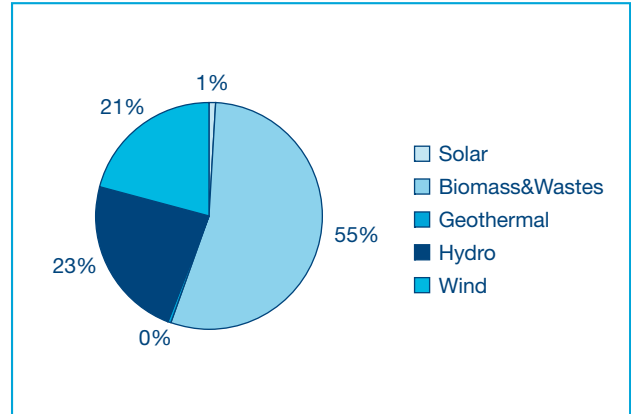
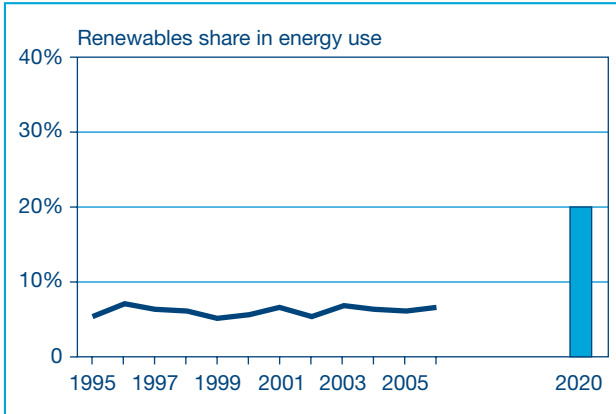
Italy's target for renewable energy in 2020 is 17%—up from the current 5%. The largest share of renewable energy in the country is now provided by geothermal (41%), whereas biomass makes up 31%, and hydro contributes 26%. The country has put in place obligatory renewable energy production targets—3.05% of the total production of the energy companies in 2007—and a Green Certificate System (a cap-and-trade mechanism).

Netherlands



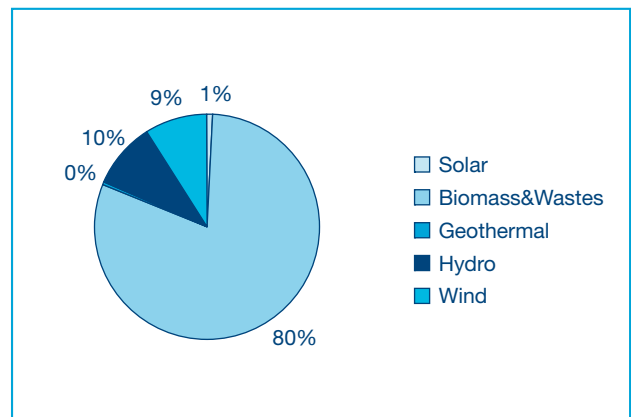
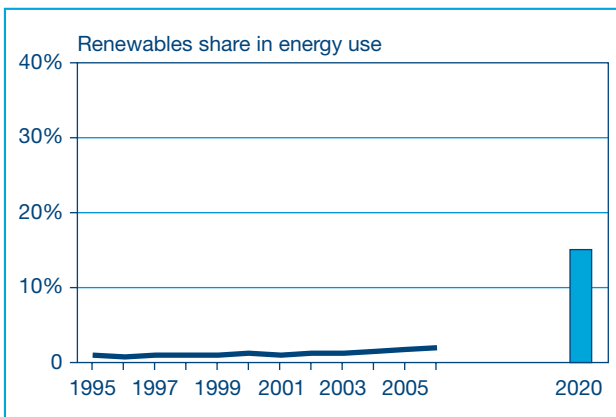
The Dutch renewable energy target for 2020 is 14%—up from the current 2%. The bulk of renewable energy currently produced in the Netherlands is provided by biomass (89%). Wind contributes another 10%. The government has created a fiscal policy to stimulate renewables in the form of the Energy Investment Deduction (EIA), and a decree on promoting sustainable energy production subsidises renewable energy production.

Spain



Spain's renewable energy target in 2020 is 20% — up from the current 9%. Biomass is currently the largest renewable contributor (55%) in the country, followed by hydro (23%), and wind (21%). The ICO-IDEA provides financing for renewable energy and a Royal Decree (661/2007) guarantees producers a variable subsidy.

United Kingdom



The United Kingdom's renewable energy target for 2020 is 15% — up from the current 1%. Currently biomass is the country's largest contributor to renewable energy (80%). Hydro (10%) and wind (9%) make up the rest.

Appendix B Calculations

Renewable energy source	Assumptions	Information source
Wind	Average load factor, 25-30% Average size of windmill, 2 MW Investment: € 1,500/kW	NWEA ECN, ECN-E—07-069
Biomass	Average efficiency biomass to electricity 20% Energy content wood, 20 GJ/tonne Volume/weight, 1.4 m ³ /tonne Wood revenue, 8 m ³ /ha Load factor 70% Investment: € 2,900/kW	Probos.net http://zebu.uoregon.edu/1998/ph162/117.html
Solar	Capacity, 0.1 kW/m ² Load factor, 11% Investment: € 3,800/kW	ECN, ECN-C—08-090
Hydro	Annual production Hoover Dam: 4TWh Load factor: 35% Investment: € 2,000/kW	Hydrocoop, France www.uh.edu http://www.usbr.gov/lc/region/pao/brochures/hoover.html
Geothermal	Geothermal electricity production Iceland 2.6 TWh Load factor 90% Investment: € 3,400/kW	Energy statistics in Iceland 2007, Orkustofnun Geothermal energy association
Ocean	Capacity, 31 MW/km ² Load factor, 100% Investment: € 2,750/kW	Wikipedia Unionleader.com

The ranges found in literature are wide. Numbers must be regarded as indicative.

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