

ENERGY ATLAS

Facts and figures about renewables in Europe

2018



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Chief executive editors: Rebecca Bertram (Heinrich-Böll-Stiftung, Berlin), Radostina Primova (Heinrich Böll Foundation European Union, Brussels)
Editorial support: Jules Hebert (Heinrich Böll Foundation, Paris),
Klara Bulantova (Heinrich Böll Foundation, Prague), Kyriaki Metaxa (Heinrich Böll Foundation, Thessaloniki),
Katarzyna Ugryn (Heinrich Böll Foundation, Warsaw), Molly Walsh (Friends of the Earth Europe)

Managing editor: Dietmar Bartz
Art director: Ellen Stockmar

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English Editor: Paul Mundy
Proofreader: Maria Lanman
Fact checking by Infotext Berlin

Contributors: Maria Aryblia, Rebecca Bertram, Alix Bolle, Alice Corovessi, Felix Dembski,
Dörte Fouquet, Petra Giňová, Krzysztof Księżopolski, Nikos Mantzaris, Jan Ondřich,
Joanna Maćkowiak-Pandera, Radostina Primova, Andreas Rüdinger, Marion Santini, Stefan Scheuer,
Wojciech Szymalski, Joan Herrera Torres, Claude Turmes, Theocharis Tsoutsos and Molly Walsh

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Editorial responsibility (V. i. S. d. P.): Annette Maennel, Heinrich Böll Foundation

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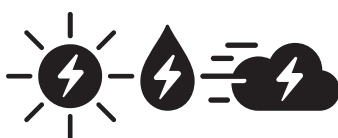
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Heinrich-Böll-Stiftung, Schumannstraße 8, 10117 Berlin, Germany, www.boell.de/energyatlas
Friends of the Earth Europe, Rue d'Edimbourg 26, 1050 Brussels, Belgium, www.foeeurope.org/energyatlas



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Conventional energy comes from a few large, powerful firms. But for renewable energy sources, it makes sense for the generation capacity to be owned by individuals and communities. Policies that encourage this create local support for the development of renewable infrastructure instead of opposition.

18 CITIES TESTBEDS FOR ENERGY INNOVATION

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38 CZECH REPUBLIC

GO-AND-STOP

Strongly embedded coal and nuclear power industries, coupled with a poorly designed support scheme for renewables and political uncertainty – the Czech Republic faces an uphill battle in the shift to renewables.

40 GREECE

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Plentiful sunshine and breezy seas and mountains: Greece has strong potential for renewable energy. But the country's debt problems have stalled progress towards a cleaner future.

42 SPAIN

RICH IN SUN, POOR IN POLITICS

Sun-drenched and zephyr-kissed, Spain occupies a corner of Europe that is ideal for solar and wind power. After an initial surge of investment in renewables, the flaws of the government's energy policy became evident, and the authorities slammed the brakes on investment. There are signs that they may now be relenting.

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POWER TO ALL OUR FRIENDS: THE INCONSISTENCY OF POLICIES

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INTRODUCTION

The Energy Atlas tells the story of Europe's energy transition. It is a story of a past where Europe was supplied largely by a small number of big energy companies, and of a future, which lies increasingly in the hands of cities and municipalities, and millions of ordinary energy citizens across Europe.

The energy transition is already well underway. However, it is happening at different speeds across the continent. For the past 100 years, geopolitical strength has depended on access to fossil fuel resources. With the support schemes for renewable energy and the rise of citizen energy, the energy system is taking a new course towards greater democratization and decentralization. With the Paris climate agreement, Europe is facing the global responsibility to keep global warming within 1.5°C.

Renewable capacity in the EU has increased by 71 percent between 2005 and 2015, contributing to sustainable development and more local jobs. In the most advanced countries and regions in Europe it is often the local government and citizens who are driving the transition. At the time of publication of this Atlas, the EU's next generation of energy legislation is in the process of being finalised. The targets and regulations agreed to take effect by 2030

“ The energy system is taking a new course towards greater democratization and decentralization.

will shape Europe's energy system for the next decade – one of the last critical chances to take sufficient action to avoid catastrophic climate change.

Cooperation on the European level is key to ensuring the right conditions for switching to renewables. Back in 2010, several countries in the Union were already on their way towards integrating large amounts of renewable energies into their systems. They also pushed for stable and reliable frameworks at EU level, as well as ambitious binding targets.

We can already tell that the EU's 2030 'Clean Energy package' sets out roughly the right direction for the path towards renewables, but it fails to ensure the speed and depth of the transition. The proposed renewable energy and energy efficiency targets are far too modest, particularly given the falling technology costs and availability of new renewables technologies, thus jeopardising the progress achieved in previous years. The EU energy framework needs to be better aligned with its long-term climate commitments.

The next big challenges in Europe's energy transition are the heating and transport sectors. So far, renewable technologies have not penetrated the transport, heating and cooling systems as much as they have the electricity system. In transport, we are beginning to see a shift to electrified transport and electric vehicles – driven by fast-advancing storage and battery technology and decreasing cost.

Bringing the heating, cooling and transport sectors together with the power sector – connecting sectors that are currently isolated from one another – will allow Europe to reach a 100 percent renewable system with technology that is already available today. This will enable us to overcome the longstanding renewable energy challenge – that of variable supply. When electrified, the heating, cooling and transport sectors will become large sources of flexible storage that back up the electricity sector. When wind and solar energy is plentiful these sectors can flexibly be used by heating systems and the batteries of electric vehicles, making 'backup' nuclear or fossil fuel capacities redundant.

The advantages of renewable energy are clear, especially when they are owned and controlled by communities: cleaner air,

” The EU energy framework needs to be better aligned with its long-term climate commitments.

warmer homes, industrial benefits. Furthermore, money stays local, more jobs are created, energy poverty is reduced, and most importantly, renewable energy contributes to saving the planet.

With this Atlas, we aim to contribute to an open and facts-based discussion on the European energy transition, whilst advancing this ambitious European project that unites European citizens.

Dr. Ellen Ueberschär
Heinrich Böll Foundation

Jagoda Munic
Friends of the Earth Europe

Dr. Dörte Fouquet
European Renewable Energies Federation

Susanne Rieger and Lucile Schmid
Green European Foundation

12 BRIEF LESSONS

ON EUROPE'S ENERGY TRANSITION

- 1 Energy has historically been a key driver of European **COOPERATION**. But current EU proposals are not enough. To comply with the Paris Climate Agreement, we **MUST GIVE UP** fossil fuels altogether by 2050.



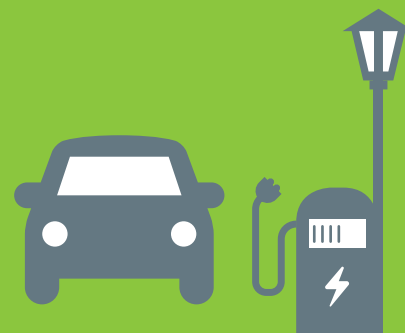
- 2 A 100% renewable energy system in Europe is now technically possible using existing **STORAGE** and **DEMAND RESPONSE** technologies.



- 3 Stronger **INTERCONNECTIONS** of markets and infrastructure across Europe will make the energy transition cheaper for all Europeans.

- 4 The biggest potential lies in **INCREASING EFFICIENCY**. Europe-wide we could reduce our energy demand by half by 2050.

- 5 A switch to 100% renewables in Europe will trigger **SYSTEM CHANGE** – away from centralized, monopolistic utilities to decentralized, community power projects and innovative business models.



- 6 Framed by smart strategies and legislation, this system change can be driven by **CITIZENS, CITIES AND ENERGY COOPERATIVES**, leaving much more wealth in communities.

7 Digitalization can make this transformation more **DEMOCRATIC AND EFFICIENT**, and can reduce the bill for the end consumer.



8 The European energy transition promises to increase **PROSPERITY** in a sustainable way (creating more local jobs) and boost Europe's global **LEADERSHIP** in green innovations.



9 Since 2013, renewables have helped **SLASH** Europe's import bill for fossil fuels by more than a third, **CUTTING ITS DEPENDENCY** on unstable and unpleasant regimes.

10 A **SOCIALLY JUST TRANSITION** is both essential and viable: all over Europe, the renewables sector already provides more well-paid, secure local jobs than the coal industry.



11 **ENERGY POVERTY** is being tackled by pioneering community power projects, acting in solidarity with those in their own community addressing this challenge.



12 Europe's Neighbourhood Policy should **INSPIRE AND SUPPORT** other countries to decarbonize their economies. A socially just energy transition in Europe's neighbouring regions can stimulate their progress and stability.



HISTORY

FROM COAL TO CLIMATE

In the EU, an Energy Union is emerging from a bewildering array of packages, policies, projects and proposals. They map the shift from concern over how energy markets function to efforts to promote renewables and curb greenhouse gas emissions.

Energy has played a major role in the history of the European Union. Coal was the first fuel to be exploited; signed in 1951, the Treaty of Paris established the European Coal and Steel Community. With the signing of the Euratom treaty in 1957 to promote nuclear power, energy was once again the backbone of European integration. The economic base of energy cooperation was further strengthened with the Treaty of Rome in 1957 that created the European Economic Community, the predecessor of today's EU.

Energy-supply issues dominated the early years of European integration. However, governed by protectionist policies, national energy markets remained largely isolated from one another. Spurred on by the 1973 oil crisis, Europe's leaders developed a more coordinated approach to jointly tackling energy shortages. But the Single European Act of 1987 was the first serious attempt to deepen integration and remove barriers to cross-border energy trade.

The realization that humans were influencing the climate came in the 1980s. In the 1997 Kyoto Protocol, the EU committed to an 8 percent cut in greenhouse gas emissions by 2012 compared to 1990 levels. In the same year, the Amsterdam Treaty included sustainable development as a cross-cutting objective.

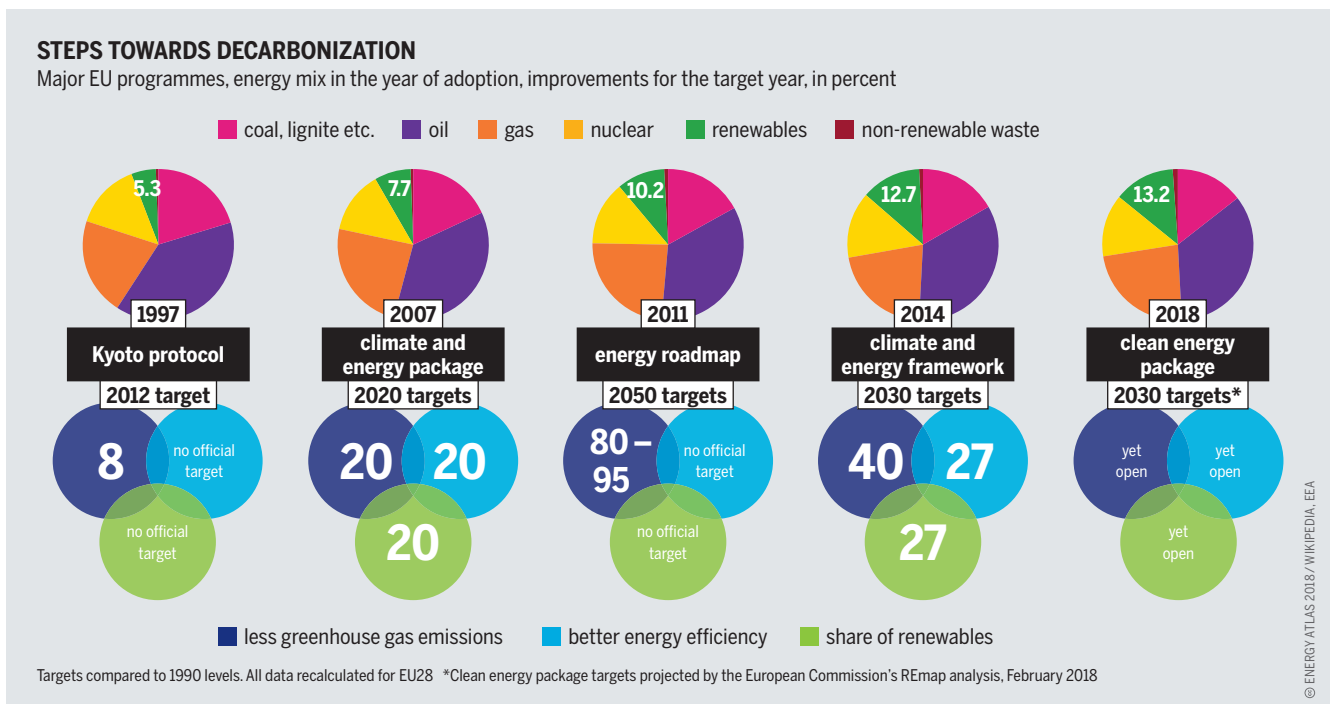
A major obstacle to cross-border energy trade was the monopolistic structure of the national markets for generation and transmission, preventing third parties from accessing the grid. To overcome this, in 1996 and 2003, the EU adopted the first electricity directives that aimed at increasing competition in the power market and ensuring a free choice among electricity suppliers. Similar directives for gas were issued in 1998 and 2003. The third energy market package in 2009 aimed to break up vertically integrated energy utilities.

The 2009 Lisbon Treaty, for the first time, included a separate section on energy. This outlined the objectives of EU energy policy, namely to, "ensure the functioning of the energy market; ensure security of energy supply in the Union; promote energy efficiency and energy saving and the development of new and renewable forms of energy; and promote the interconnection of energy networks."

In the past decade, climate threats have increasingly been a driving force in the EU's energy policy. An energy and climate package agreed in 2007 set binding sustainable energy targets for 2020. These are a 20 percent cut in greenhouse gas emissions, a 20 percent share of renewables in final energy consumption, and an indicative target of 20 percent improvement in energy efficiency.

In 2014, the EU adopted its 2030 energy and climate framework that called for a greenhouse gas reduction goal

*On paper, the goals read well.
But achieving them requires
unanimity, courage and creativity*



The supply and consumption of fossil fuels and nuclear power still steer the EU's industrial production and diplomatic stance

of at least 40 percent, at least a 27 percent share for renewables in the energy sector, and at least a 27 percent improvement in energy efficiency. These targets form a basis for the Clean Energy Package currently being negotiated, which lays out the legal groundwork for future energy policy. But these cuts are still not steep enough to fulfil the EU's commitments under the Paris Agreement and to keep global warming below 2 degrees Celsius.

Europe imports 54 percent of its energy. Yet the European Commission has limited competency in its external energy policies. Member states have sovereignty over foreign and security matters, and they find themselves in different positions in terms of their reliance on imports and on different suppliers and transit countries. The 2004 enlargement of the EU gave a new push for a more coordinated external energy policy, mainly because the new eastern members were dependent on Russian gas supplies. The European Neighbourhood Policy, launched in the same year and revised in 2015, sets the framework for how the EU engages with its neighbours to the east and south in advancing its sustainable energy goals. The Energy Community, signed in 2005, aims to extend the EU energy market rules to non-members in southeastern Europe.

2005 also saw a commitment by EU leaders to develop a coherent energy policy with three pillars: competitiveness, sustainability and security of supply. The repeated gas disputes between Russia and Ukraine in 2005–6, 2008 and 2009, as well as geopolitical tension in Northern Africa and the Middle East leading to the increasing vulnerability of the external energy supplies, have reinforced the need for such a policy.

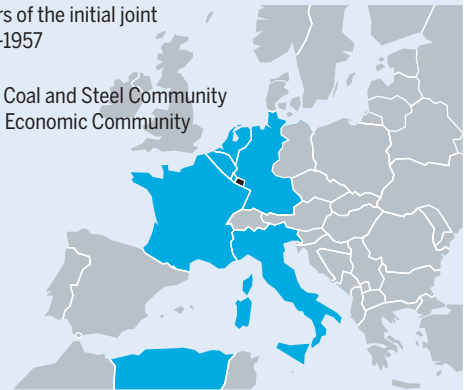
The shift towards renewable energy holds untapped potential to reduce the continent's dependence on external suppliers and enhance its energy security. Europe is beginning to look inwards and to drive forward the development of its internal energy market. The Energy Union, a project launched in 2015, tries to bring the 2030 climate and energy framework and the energy security strategy under one roof. The Paris Agreement of the same year committed the EU to deep cuts in greenhouse gas emissions. The "Clean energy for all Europeans" package of 2016 aims to align EU internal energy legislation with its Paris commitments.

Overall, energy policy is shifting from a phase of fragmentation to a period of gradual synchronization between member states and the EU. Energy lies at a crossroads between climate objectives, national interests and supranational regulation, sectoral dynamics and geopolitical conflicts. EU energy policy is also undergoing a major change. We are witnessing not only a shift from fossil fuels to renewable energy sources, but also to new ownership models, and increasing decentralization and democratization of energy supply and distribution. Europe has a historic mission: to serve as a global model for energy transition and green innovations, and to lead the way in curbing global warming. ●

EUROPEAN INTEGRATION AND ENERGY POLITICS

Founding members of the initial joint institutions, 1951–1957

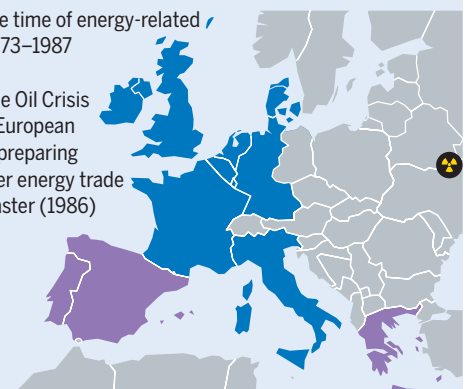
- 1951 European Coal and Steel Community
- 1957 European Economic Community
- 1957 Euratom
- Saarland



Algeria still a part of France. Coal-rich Saarland became a part of West Germany in 1957

Membership at the time of energy-related historic events, 1973–1987

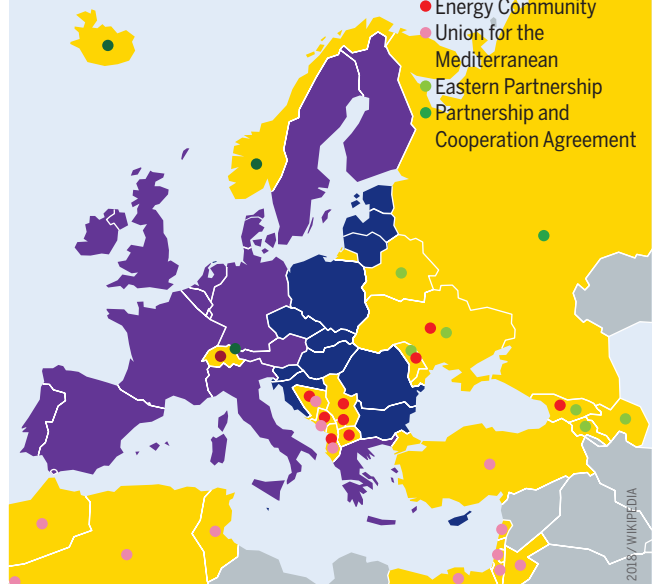
- 1973, during the Oil Crisis
- 1987, with the European Single Market preparing for cross-border energy trade
- Chernobyl disaster (1986)



Greenland, member with Denmark since 1973, left in 1985

Institutional cooperation with neighbours, including energy issues, since 2004

- EU members until 2004
- new EU members, 2004–2013
- related non-EU members:
 - European Economic Area
 - in bilateral cooperation
 - Energy Community
 - Union for the Mediterranean
 - Eastern Partnership
 - Partnership and Cooperation Agreement



The Union for the Mediterranean and the Eastern Partnership form the European Neighbourhood Policy. In 2017, the United Kingdom decided it would leave the EU ("Brexit"). Observers and former members excluded.

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VISION

LOOKING TO BE LEADER

Europe is making progress towards its energy transition at a rate few imagined ten years ago. There is still a long way to go, but the continent is now in a position to become the global leader in green energy. It needs to make the right policy choices today to seize this opportunity.

The world's climate is changing faster than ever, and the people of Europe are more and more informed about its dangers. That awareness is being converted into action. Citizens, governments and corporations are realizing that converting to greener forms of energy is not an expensive and painful exercise, but one that brings economic benefits: cost savings, new industries, local jobs that cannot be relocated, and energy security.

Europe is already a world leader in many green technologies, including onshore and offshore wind power. The energy transition offers export opportunities to disseminate

this know-how worldwide. Competition from North America and the Far East is pushing Europe to invest further in research and innovation, and to establish conditions where green technologies can flourish. These include a dynamic domestic market that allows the large-scale deployment of renewable energy, a construction sector focusing on “positive-energy” buildings (ones that produce more power than they consume), and green transportation. With better interconnections between national power grids and the transport and heating sectors Europe can easily get 100 percent of the energy it needs from renewable sources, thereby reducing our fossil fuel import bill to zero.

The Paris Climate Agreement of 2015 has shown that the world will only be able to limit climate change if it abandons the use of fossil fuels. Carbon risk is a tangible problem, and investors will gradually pull out of fossil fuels in favour of green technology. The accord has raised awareness about the potential of renewables and the benefits of energy efficiency. Flagship projects are emerging with EU financial support, such as offshore windfarms in the North Sea and Baltic Sea, the conversion of district heating from fossil fuels to renewable energy, and European corridors for electric mobility.

For the past 100 years, geopolitical strength has depended on countries possessing or having access to energy resources. In the future, it will rely on gaining competitive advantage from the best environmental technologies. The countries that advance solar and wind power, smart grids and energy storage will be one step ahead. Reducing their fossil-fuel imports will strengthen their energy security. This is the case for Europe. Accelerating the deployment of green technology will reduce Europe's dependence on countries like Russia and Saudi Arabia and increase its geopolitical clout.

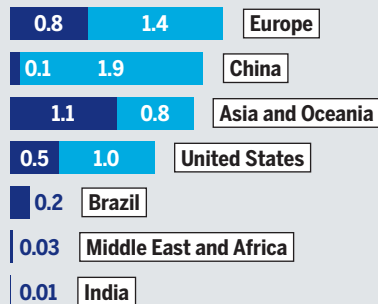
But Europe's economy still relies heavily on fossil fuels, mostly for heating, cooling and transportation. Transport remains the hardest sector to decarbonize: more than 90 percent of vehicles in the EU burn fossil fuels. However, the “dieselgate” scandal, where carmakers tried to cheat on official emissions tests, has become a serious setback for diesel engines. The growing awareness of the harm that diesel exhaust does to human lungs is likely to hasten the uptake of electric vehicles. Fewer cars in cities, allocating more space to walking and cycling, and greener public transport can change mobility patterns in cities and trigger cleaner air and better health.

The energy transition is also a battle for democracy. When it comes to making change happen, an all-powerful market cannot be left without any checks and balances. For too long, citizens have been at the mercy of economic and

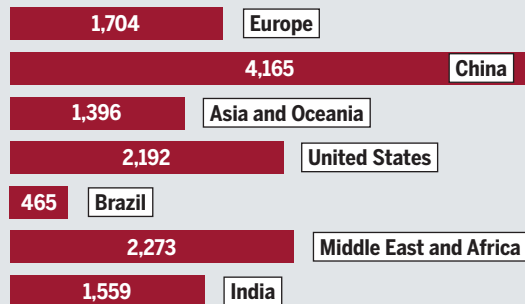
TODAY'S R&D FOR TOMORROW'S MARKETS

Investment in future and forecast demand, by countries and regions

■ corporate and government research and development expenditure in renewables, billion US dollars, 2015



■ primary energy demand for all energy types, million tonnes of oil equivalent, forecast 2035



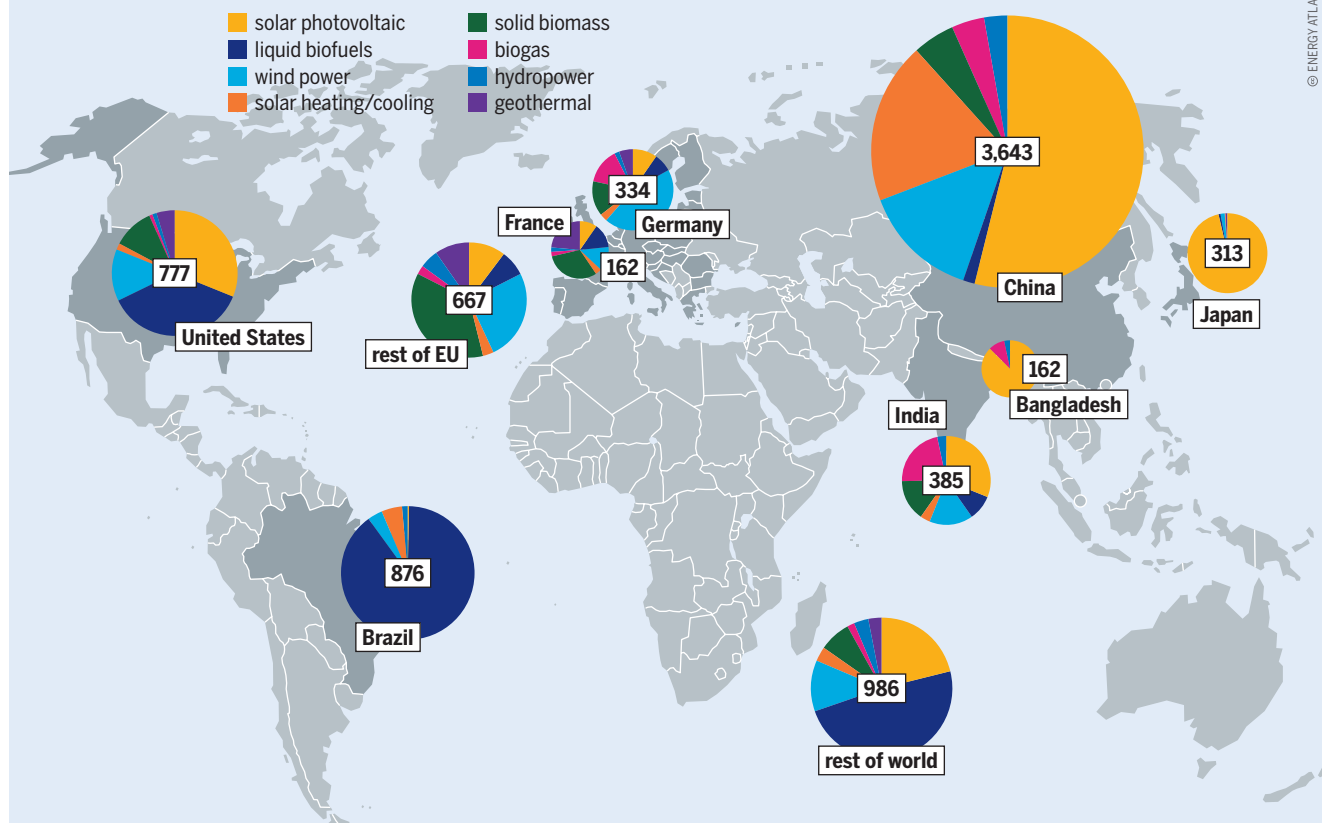
Due to inconsistent data, primary energy demand in “Asia and Oceania” (without China and India) covers South East Asia and Japan only.

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These technologies are an opportunity for Europe to be a leader in green innovation

EMPLOYMENT BY RENEWABLES – CHINA, EUROPE AND REST OF THE WORLD

Jobs by main energy sources, selected countries and regions, thousands, 2016



Data on larger hydro plants incomplete and not taken into account. Due to environmental impacts and farmland conversion, liquid biofuels constitute the most questionable class of renewables.

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geopolitical interests that are beyond their reach. Empowering people and giving them the right to choose is essential because it is citizens who pick up the bill. The energy transition allows customers to be more than just passive subjects unable to exert influence on decisions. Millions of individuals, cooperatives and local authorities can play a vital role in the energy transition by owning, or co-owning, renewable-energy generation facilities; they can be actively involved by producing their own electricity and employing smart meters to optimize their energy consumption. The pro-climate movement of European local authorities is blooming. Millions of citizens are turning to renewables, individually or by joining cooperatives.

The transition must go hand-in-hand with new economic perspectives for coal-producing regions. Low prices for carbon on the EU's Emissions Trading Scheme have artificially extended the lifespan of coal- as well as lignite mines and power plants, increasing the economic pain for those regions when the switch finally occurs. Instead of ignoring this, the progressive and firm shutdown of mines and power plants should be coupled with effective planning and management and a 'fair transition' for workers at both the local and regional levels to avoid a major social crisis.

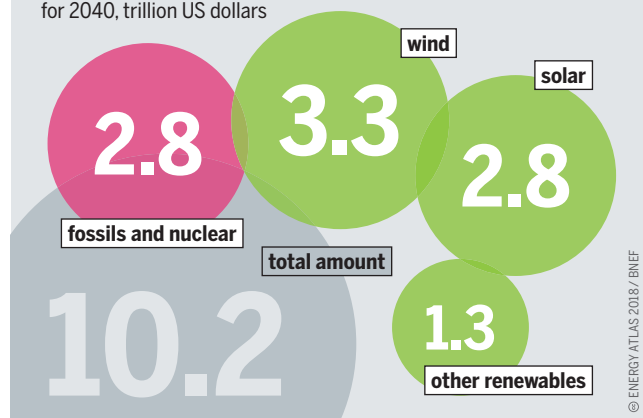
For 2040, analysts expect that 72 percent of all invested funds will be used to generate renewable energy

Renewables have created 8.3 million jobs worldwide so far, and more than 1.1 million in the EU

Past EU policies have triggered the energy transition in Europe. Policy decisions made today will define the framework for the next decades. The right choices will determine whether the EU can seize the twin opportunities presented, helping to save the planet from climate catastrophe and making it the world's leader in green technology. ●

THE FINANCIAL DOMINANCE OF WIND AND SOLAR

Worldwide energy investment stock by energy sources, estimated for 2040, trillion US dollars



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ECONOMY

MAKING PROGRESS, MORE WORK NEEDED

Renewables have moved from being a sideshow to the main act in Europe's energy theatre. Government support has been key to this – but renewables are increasingly able to stand on their own.

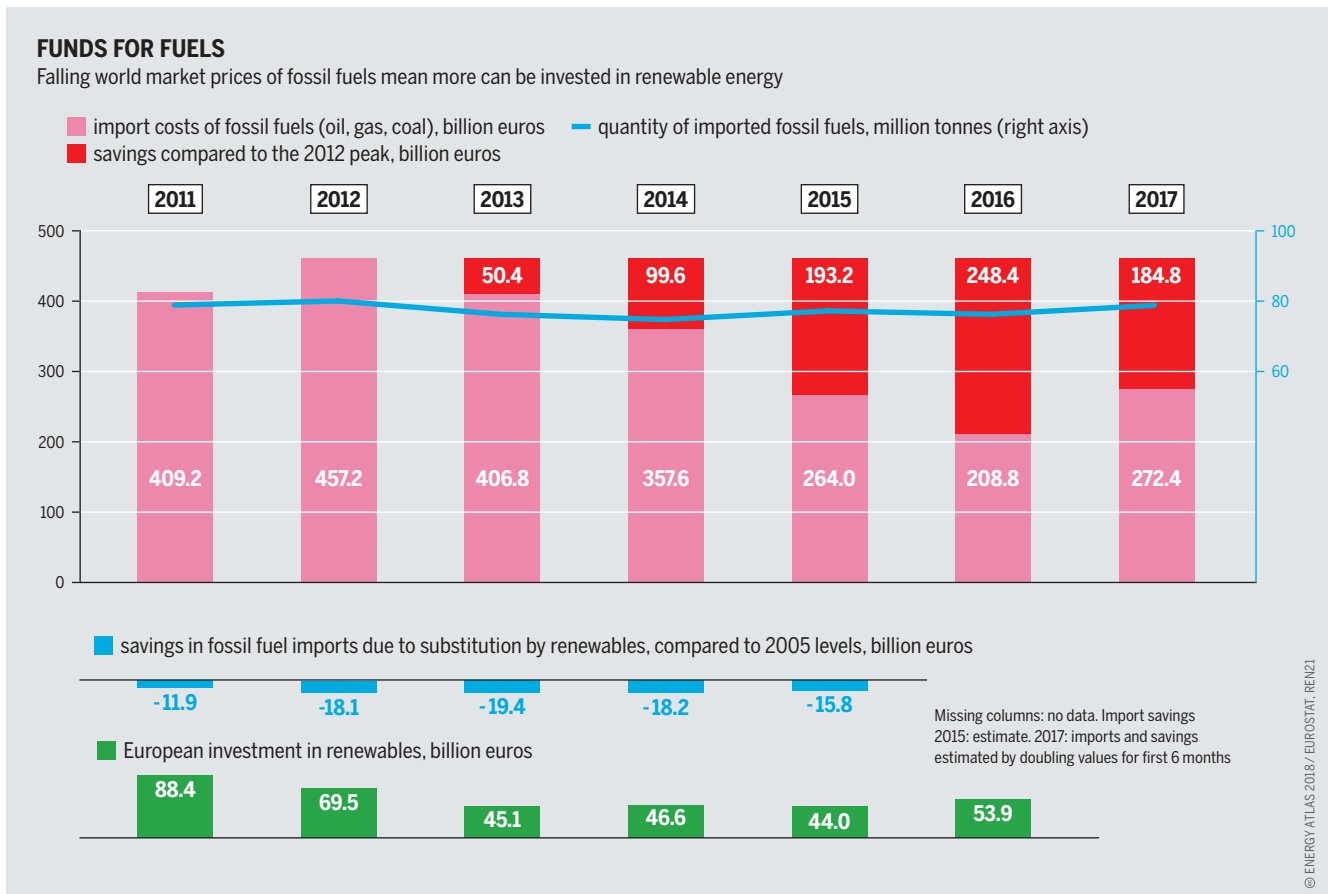
Ten years ago, renewables were regarded by many as a threat to economic prosperity and growth. Advocates of the fossil-fuel industry, in particular, claimed that wind, solar and biomass sources were simply too expensive, and realistically would never be able to provide more than 3–4 percent of the demand for electricity. They feared that a switch to renewable energy would slow economic development across Europe. Nevertheless, a number of European countries, most prominently Denmark and Germany, forged ahead and invested in pioneering renewable-energy sources, despite their apparent costs and unproven role.

Today, renewables are no longer a fringe technology. They have accounted for the majority of new generating capacity for eight years in a row, and in 2015 they made up 16.7 percent of the EU's final energy consumption. The

biggest boost has come from the rapidly falling costs of the technologies. Since 2009, the cost of solar has dropped by a staggering 75 percent, and wind by 66 percent. Of course, stark differences still remain among member states of the EU; renewables currently account for 30 percent of gross final energy consumption in Finland and Sweden, but just 5 percent in Luxembourg and Malta.

However, one trend is very clear: renewables are becoming ever more competitive with conventional sources such as natural gas, coal and nuclear. The build-up of renewables has helped the EU reduce its fossil-fuel consumption by 11 percent since 2005 and to cut the import bill for fossil fuels by more than 35 percent since 2013. Renewables have mainly been used to replace coal (half of the fossil fuels substituted) and natural gas (28 percent). Substituting oil has been less successful because renewables are not yet widely used in the transport sector, where oil is the main fuel.

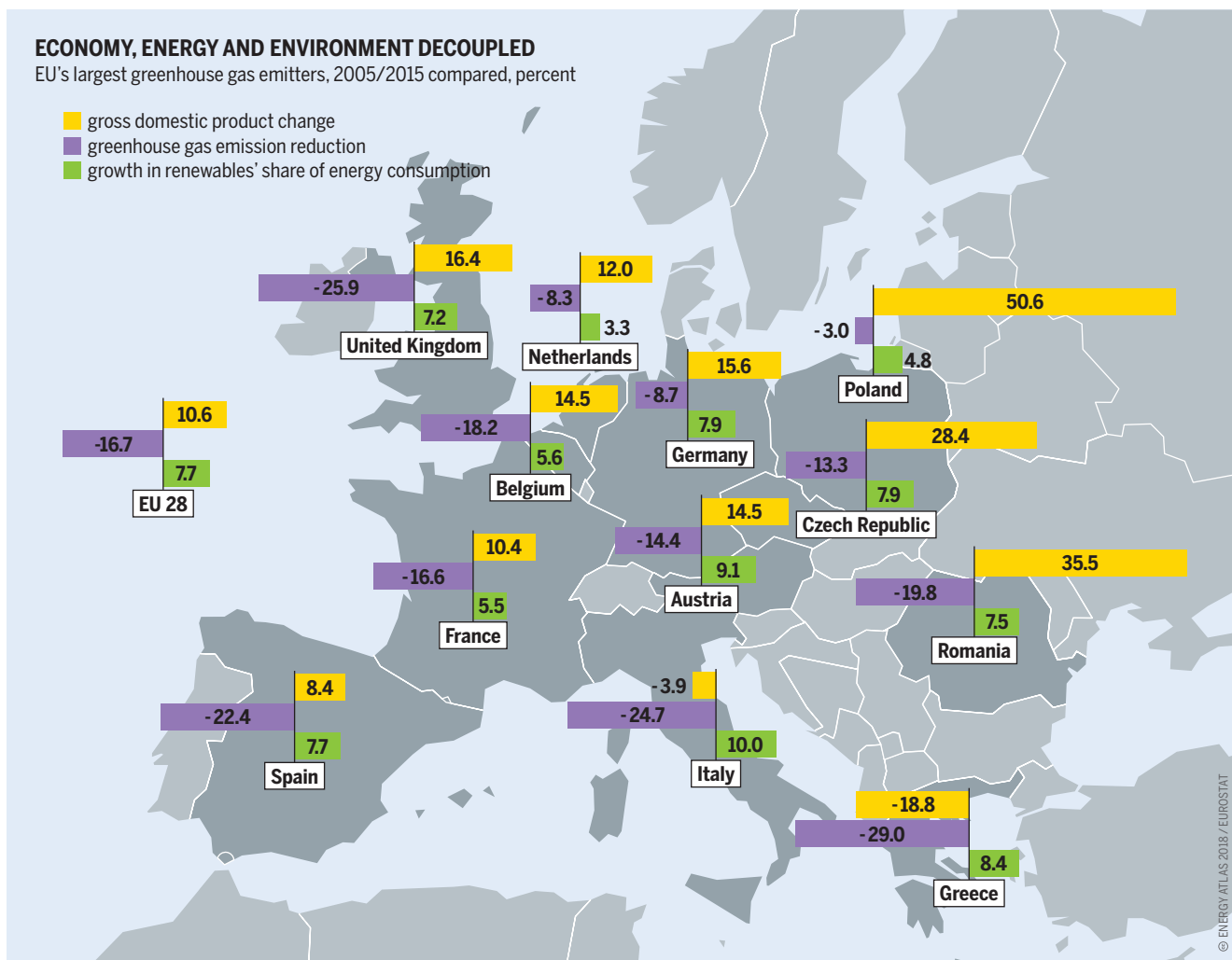
A great deal of money will become available for investment in renewables if expenditure on the import of dirty energy sources can be saved



ECONOMY, ENERGY AND ENVIRONMENT DECOUPLED

EU's largest greenhouse gas emitters, 2005/2015 compared, percent

- gross domestic product change
- greenhouse gas emission reduction
- growth in renewables' share of energy consumption



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With moderate economic development in the EU, emissions fell sharply and renewables started to boom

Throughout Europe, fossil fuels have traditionally benefited from hefty public subsidies, creating a powerful incentive to burn them. Renewables have also received incentives, for example in the form of feed-in tariffs where producers of renewable energy receive a fixed purchase price for the power they generate. But these incentives have been nowhere close to those offered to the fossil-fuel industry. Across the EU, the EU itself and its members' governments distribute over 112 billion euros a year in handouts to the fossil-fuel sector. In contrast, renewables receive 40 billion euros. A switch from fossil fuels to renewables would free up money for more pressing social and welfare needs.

The rise of renewables has not slowed economic growth in Europe. Between 2006 and 2015, the European economy grew by a sluggish 0.7 percent while the share of renewables in final energy consumption grew by 7.7 percent. But the economy was held back by the global financial crisis of 2008–10, not by the growth in renewables. Since 2005, greenhouse gas emissions in Europe have fallen by 10 percent, and for the first time, the continent has seen a decoupling of its economic growth and greenhouse gas emissions. In essence, this is what the energy transformation can do: trigger economic prosperity while reducing the carbon footprint caused by burning fossil fuels. Renewables play a major role in driving this trend.

While Europe has been a world leader in investments in renewable energy, its share in global investment fell from 46

percent in 2005 to 17 percent in 2015, as other regions discovered the economic opportunities offered by renewables. Nevertheless, Europe aims to be a global leader in research and innovation in this field. The EU's biggest research programme, Horizon 2020, allocates 6 billion euros to renewable energy for the period 2014–20.

The renewable sector is already a big employer, providing more than a million jobs in Europe in 2014. In terms of jobs per capita, Europe's renewable sector was number two in the world in 2014. It now ranks fifth, behind China, the United States, Japan and Brazil, and it is in danger of further losing out to emerging economies. Most jobs in renewable energy are in the wind, solar and biomass sectors, as these technologies have seen the fastest global growth rates and the sharpest cost decreases in recent years.

Europe aims to cut its greenhouse gas emissions by 80 percent by the middle of this century. To achieve this, the share of renewables will have to grow significantly, not only in the power but also in the heating, cooling and transport sectors. The economic realities of renewables – as well as environmental or climate concerns – make them a preferred alternative to fossil fuels, and many Europeans already benefit directly from this development. ●

CITIZENS

MANY DROPS MAKE A RIVER

Conventional energy comes from a few large, powerful firms. But for renewable energy sources, it makes sense for the generation capacity to be owned by individuals and communities. Policies that encourage this create local support for the development of renewable infrastructure instead of opposition.

The two countries in Europe that have installed the most renewable energy since 2009 are Denmark and Germany. These are also the countries with the highest citizen participation in the energy transition. In Germany, many different ownership models exist, and only five percent of the installed renewable energy capacity is owned by large, traditional energy utilities. In Denmark, wind projects are given permits only if the developers are at least 20 percent owned by local communities.

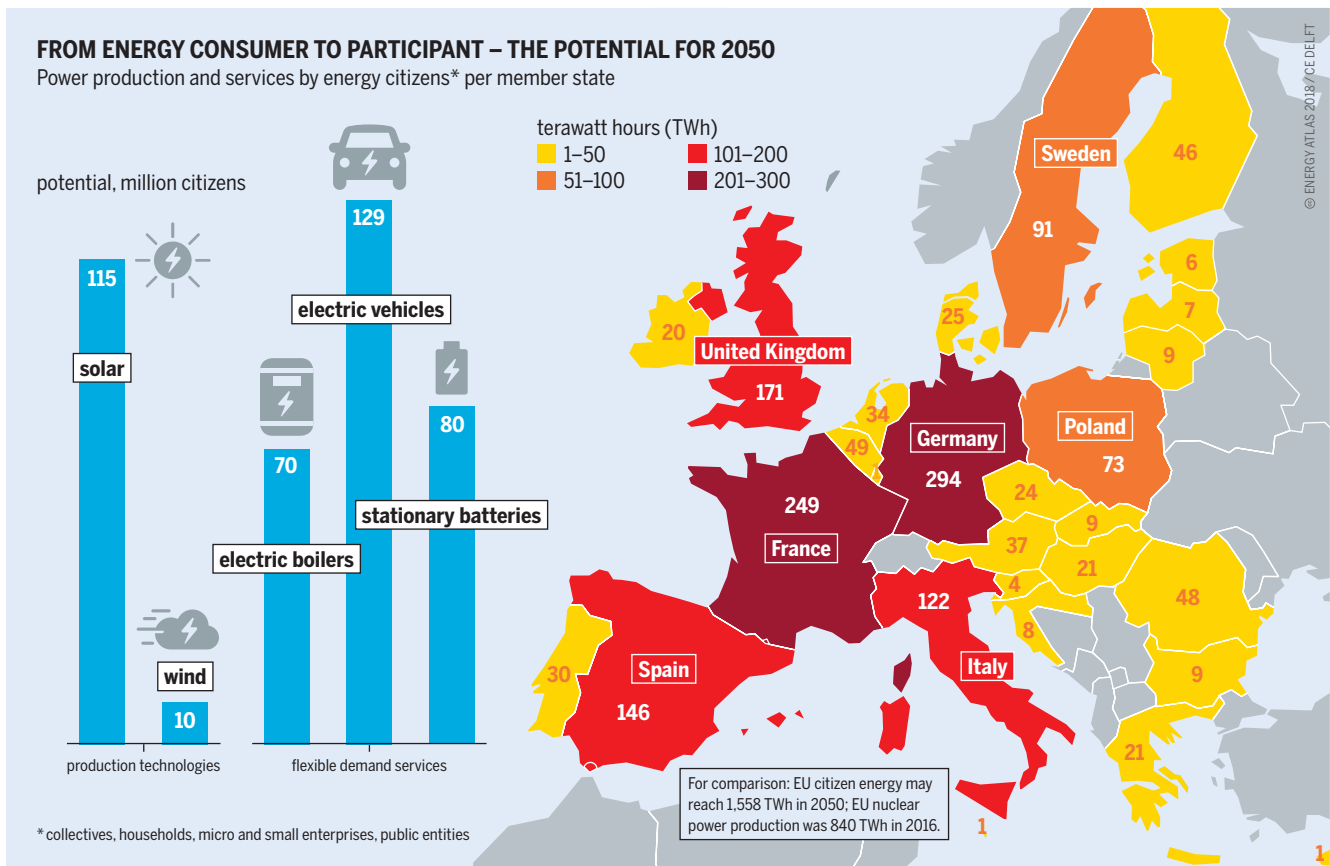
In many countries public objections have slowed or blocked the development of renewable energy. But if citizens own, or co-own, renewable installations, they are more likely to welcome projects, and less likely to object to them. It is easy to understand why people are less keen on large infrastructure in their community when all the profits flow out of

the local area and they do not have any say in where and how the project is developed. Such nimbyism has been a serious problem particularly in the United Kingdom and now also in Belgium, France and other parts of Europe. It is therefore essential to put people and communities at the heart of the Europe-wide energy transition.

The energy transition is a challenge that needs to be acted on at every level of society. The proposed Clean Energy package of 2016 is an attempt by the EU to set the goals and rules for the European energy system in the period up to 2030. But large chunks of legislation like this can seem remote and obscure. Many normal citizens see that their energy systems are owned by a few big companies, which make a lot of money, are governed by a small elite of managers in their corporate headquarters and are subject to policymakers in Brussels.

But community renewable-energy projects already exist in all shapes and forms. The cooperatives and community groups that own and run them connect the local with the European levels. When citizens own and do well out of the energy system, concepts like the European energy transition

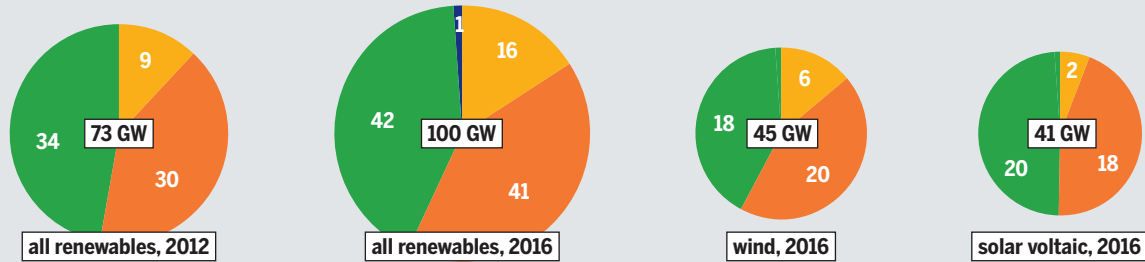
In 2050, hundreds of millions of “energy citizens” may produce twice as much power as today’s nuclear power plants



COMMUNITY ENERGY: A BIGGER SLICE OF THE PIE. THE CASE OF GERMANY

Installed renewable energy capacity for power generation, by type of owner and sector, 2012 and 2016, gigawatts (GW), estimated

■ community energy participants* ■ financial and strategic investors ■ large power generating companies ■ others



* community energy participants include the following:
Citizen participation (e.g., fund investments, minority interests in operating companies)
Community-owned producers (e.g., regional energy cooperatives and majority interest in operators)
Individual owners (e.g., individuals, farmers and farm cooperatives)

Terminology based on Renewable Energy Agency, Germany. Does not include pumped storage power plants, offshore wind turbines, geothermal or biological waste. Differences due to rounding

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are no longer distant but have a relevance and importance to people's lives.

There are many reasons a community may want to invest in a local energy project. Projects that are locally owned generate eight times more profit to the local economy than equivalents that are owned by transnational developers. That both helps the local economy develop and brings intangible benefits such as a sense of pride in the community.

There is no central database, so it is difficult to estimate the number of citizens involved in the energy transition. But it is clear that many thousands of diverse projects exist across Europe. Eastern Europe is lagging behind as suitable policy conditions do not exist, and governments still give special treatment to fossil fuels and nuclear energy. These countries have huge potential; with the right policy framework, community energy will be able to spread eastwards.

A 2016 report by CE Delft, a research organization, estimated that 264 million "energy citizens" could generate 45 percent of the EU's electricity needs by 2050. The same report also shows the potential of different types of energy citizens: in 2050, collective projects and cooperatives could contribute 37 percent of the electricity produced by energy citizens. These are the projects that often have the largest positive impact on the local economy.

Achieving such levels of ownership will depend on the right policies – but these are lacking in many countries. One of the biggest barriers is the current overcapacity in the energy market: the amount of electricity being generated exceeds the demand. This is because a lot of fossil and nuclear energy is being subsidized in order to maintain "energy security", thus stifling the market for community-owned renewable projects.

Current rules make it unlikely that millions of people will participate in the energy transition in the next decade. Changes are needed, and much will depend on the decisions

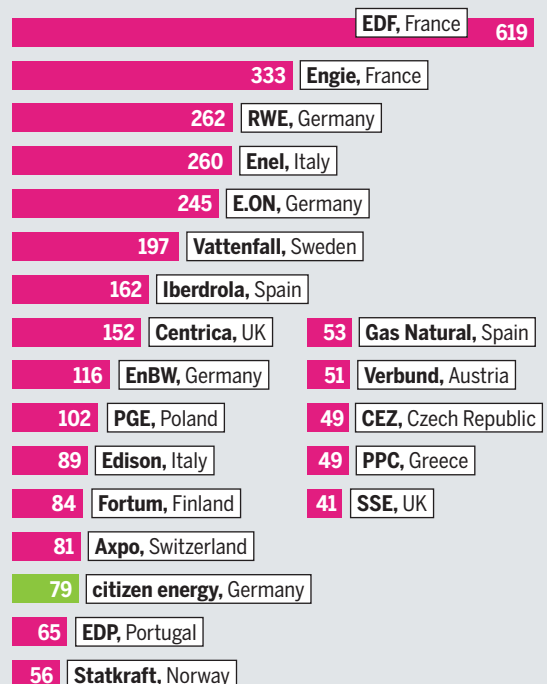
Europe's dominant energy producers are lobbying hard to keep the sector shaped by large generation units

Clean electricity generation grew by a quarter in four years. But citizens' share fell slightly, with Big Energy regaining some share of the generation market

made in finalizing the proposals put forward in the Clean Energy package. A stable, supportive framework would mean a right for citizens and communities to produce, consume, store and sell their own energy. It would require eliminating the excess charges and administrative barriers that block community projects, as well as creating a level playing field so that they can enter the market. ●

EUROPE'S LARGEST ENERGY RETAILERS

Sales in terawatt hours, 2015 and Germany's citizen electricity sales for comparison, 2016



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TESTBEDS FOR ENERGY INNOVATION

Changing national laws and policies is cumbersome, time-consuming and risky: what if the law or policy proves to be a dud? Cities, on the other hand, can be a hotbed of innovation. They are big enough to try out new ideas on a large scale, but small enough to brush them aside if they do not work out – and the best ideas can be scaled up to the national level.

Cities have become front-line players in efforts to adapt to and reduce the impact of climate change. Agenda 21, passed at the Earth Summit in Rio in 1992, called for action to promote sustainable development at all levels, from international down to local. Since then, cities have made big strides in this direction. At the European Parliament in 2009, hundreds of European cities undertook to reduce their CO₂ emissions, and launched the EU Covenant of Mayors movement. This has since spread worldwide, bringing together over 7,700 local authorities committed to energy and climate action. During the United Nations Climate Change Conference in Paris in 2015, close to 1,000 local leaders pledged to make their cities carbon-neutral by mid-century.

Cities consume over two-thirds of the world’s energy and account for some 70 percent of its CO₂ emissions. They both contribute to climate change and are victims of its impacts. Cities suffer from flooding, rising sea levels, landslides, and extreme heat and cold. They are affected by water shortages, smoke from wildfires, and migration of rural residents as a result of climate change in surrounding rural areas. Faced with these challenges, as well as existing environmental problems such as air and water pollution and waste disposal, cities have huge incentives to address climate change.

As part of Europe’s energy transition, local authorities have tried to reduce the impact of climate change in high-profile ways: by promoting renewable energy tech-

nologies, by exploiting big data, and by developing smart power grids. But the question of who will own, control and benefit from this wave of new technologies is overlooked, and remains unanswered at the national and EU levels.

Cities are coming up with responses. The administrations of Barcelona, Paris and Ghent, for example, are reconsidering the notion of energy as a “commons”: energy sources such as the wind, sunlight, hydro, biomass and geothermal are natural resources, so should be treated as common goods and allocated to benefit society as a whole, not a small number of individuals. The shift from an extractive to a regenerative economy can make sharing such resources more equitably possible. In the UK, more and more local authorities are tackling “fuel poverty” (inability of people to keep their home warm at a reasonable cost) by putting energy management back into local, public hands. Bristol promotes projects that aim to reduce energy use (for instance by insulating buildings) and generate renewable energy. These initiatives are firmly linked to a local currency, the Bristol Pound, whose objective is to strengthen the local economy by keeping money circulating within the city. In October 2017, Paris, Copenhagen and Oxford announced plans to ban petrol and diesel cars, well before national bans come into effect. In the Netherlands, “gas-free” districts were established before the government decided to phase out the use of gas for cooking and heating.

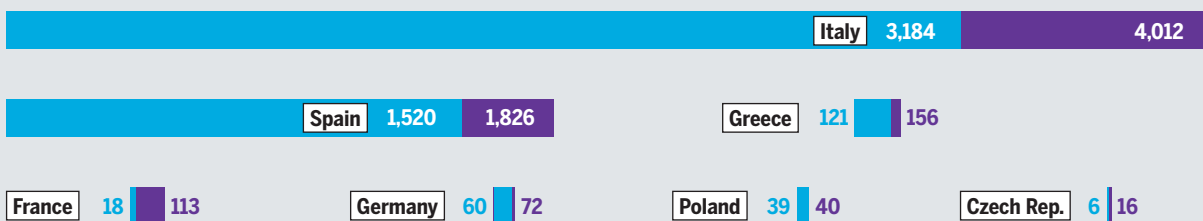
More and more local authorities are helping citizen-driven energy projects get off the ground, either by investing directly in local energy cooperatives, or by providing subsidies, legal and technical expertise, and access to public facilities. Rather than seeing the energy transition as a problem, they see opportunities for regional economic development. They find access to new capital by tapping into local savings and generating revenue streams that benefit the local com-

Thousands of cities are making their own efforts to achieve and exceed the EU climate and energy targets

EUROPEAN CITIES GOING GREEN

Members of the Covenant of Mayors for Climate & Energy, selected countries, 2018

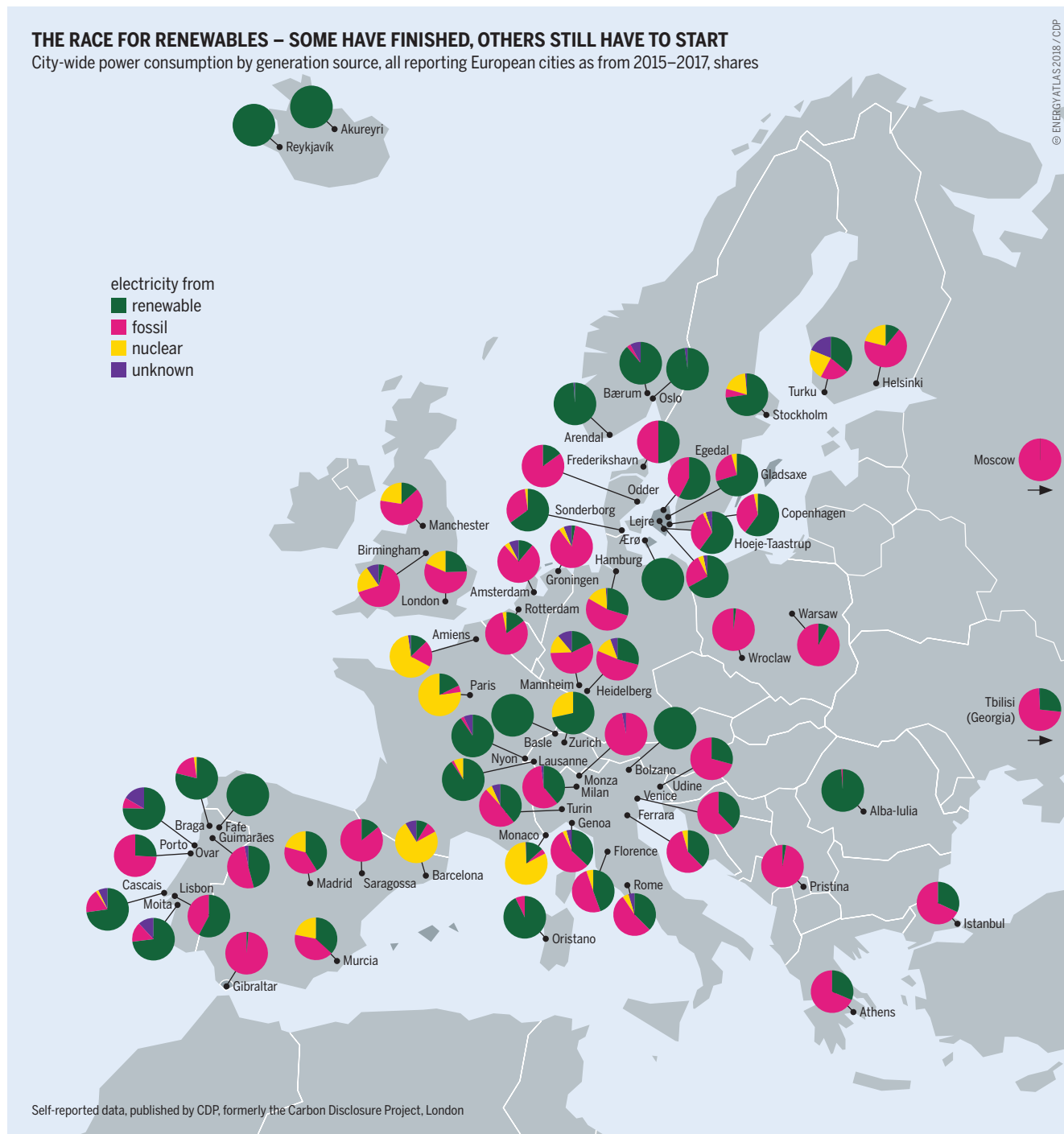
■ signatories with climate action plans ■ total number



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THE RACE FOR RENEWABLES – SOME HAVE FINISHED, OTHERS STILL HAVE TO START

City-wide power consumption by generation source, all reporting European cities as from 2015–2017, shares



munity instead of a handful of distant shareholders. They influence the financing of energy by issuing “green bonds” (bonds used to finance environmental investments) and by bulk-buying power to cut costs. Revolving funds encourage energy saving: municipal departments that conserve energy are permitted to keep part of the savings to spend on other initiatives. Litoměřice, a town in the Czech Republic, is one of many local authorities that have successfully introduced such a scheme. Paris has outlined crowdfunding as a key strand of its 2050 climate-neutral strategy and has announced plans to become an international hub for green finance.

The EU’s Clean Energy package of 2016 will influence the energy landscape for decades to come. It will determine whether local authorities, citizens’ cooperatives and other

Dozens of cities in Europe voluntarily report on the sources of their power. This shows cities are leading the way in Europe’s energy transition

new actors are given fair access to the market, alongside the current dominant players. Technology-enabled, decentralized energy systems can only grow to their fullest potential if these decentralized actors are empowered. This calls for the introduction of new, multi-level governance models, better adapted to the challenges of tomorrow’s energy system.

In January 2018, the European Parliament voted to ask EU member states to set up permanent energy and climate dialogue platforms with citizens and local authorities. These will give local authorities the opportunity to play a central role in the energy transformation. ●

ENERGY POVERTY

WAITING IN THE COLD AND DARK

Imagine living in a household without adequate heating, electricity or hot water. Such conditions may be familiar in the developing world, but they are surprisingly common in the EU too. Renewable energy is part of the solution to a disturbing problem.

An estimated 50 to 125 million people – between 10 and 25 percent of the EU’s population – are at risk of “energy poverty”. That has serious consequences for both the individuals and families concerned and for society as a whole: low quality of life, health problems, and economic and environmental impacts such as illegal wood cutting and air pollution from burning unsuitable material.

There is no common definition of energy poverty at EU level. Indeed, less than one-third of the EU’s member states officially recognize energy poverty, and only four – Cyprus, France, Ireland and the United Kingdom – have a legislated definition. The topic was finally put on the political agenda in 2016, in a speech given by Maroš Šefčovič, the Vice-President of the European Commission in charge of the Energy Union, the project to coordinate the transformation of Europe’s energy supply.

Energy poverty is particularly prominent in eastern and southern Europe. In Bulgaria and Lithuania, an estimated 30 to 46 percent of households struggle to keep their homes warm. In Bulgaria, the lack of access to affordable energy and unfair practices by energy monopolies have led to big demonstrations and even the resignation of the government in 2013. In countries such as Portugal, Greece and

Cyprus, 20 to 30 percent of households suffer from energy poverty.

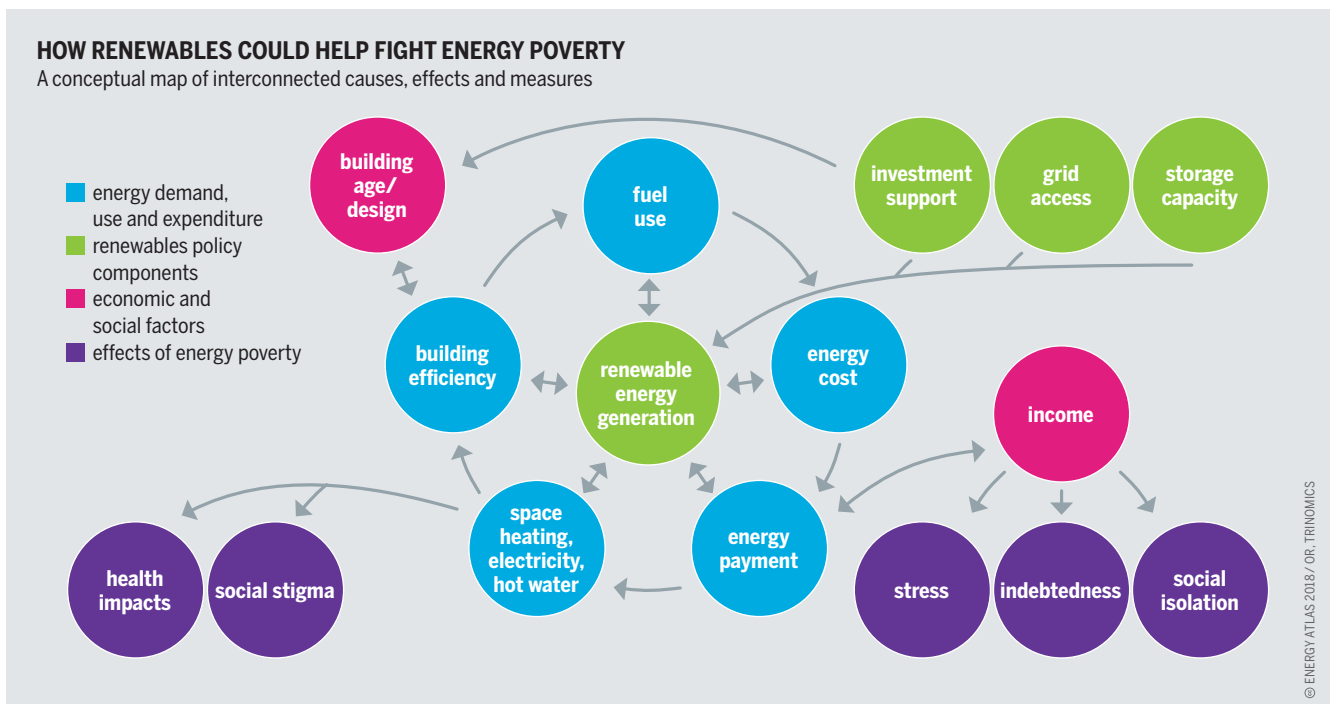
Energy poverty is related to income poverty, but it is not the same. In spite of being income-poor, a household may not suffer from energy poverty because a district-heating system supplies it with affordable heating. Households that are slightly better-off in terms of income may have to pay more and still end up with inadequate heating because of high energy prices and poorly insulated housing.

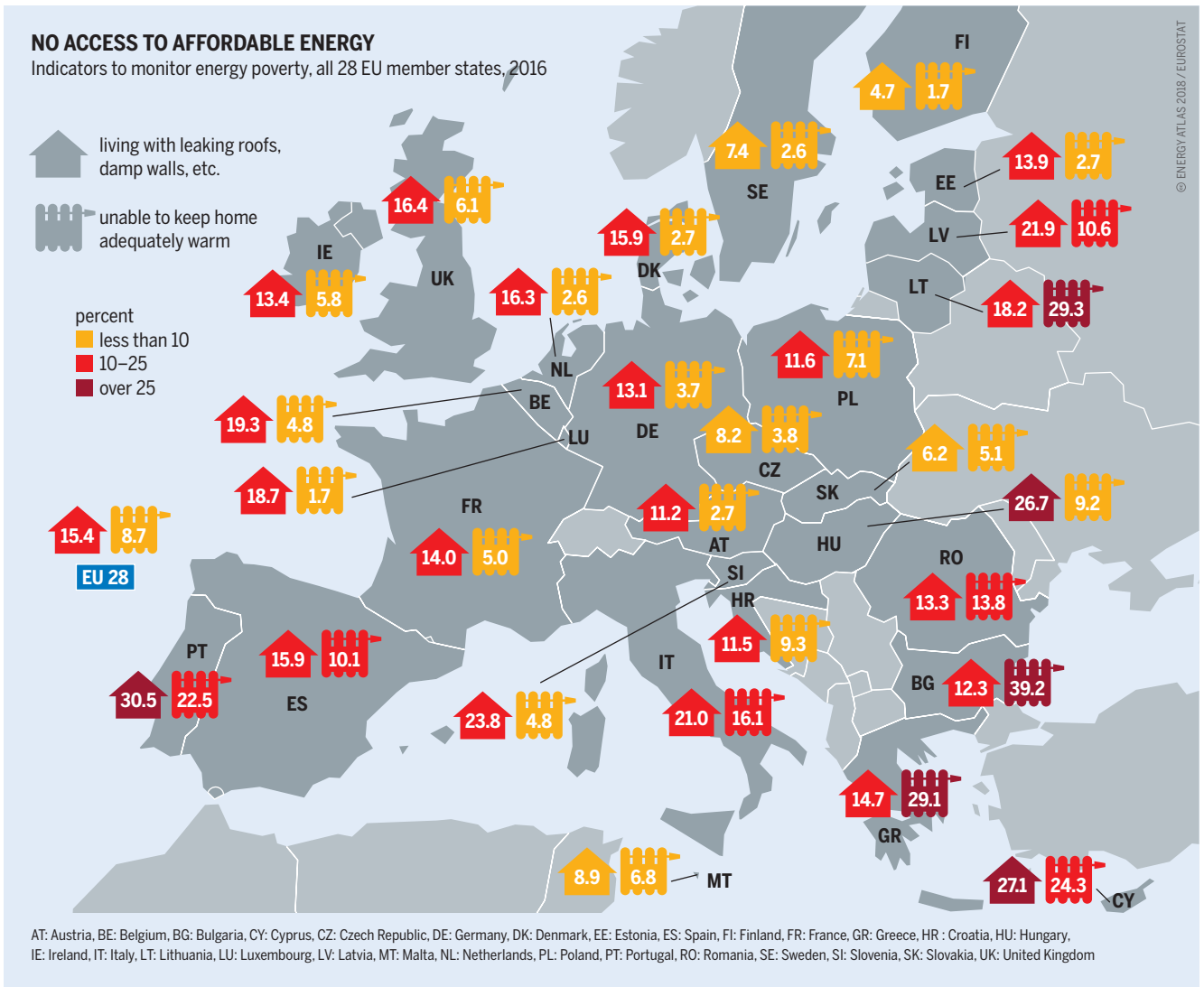
The lack of a common definition is one reason many policymakers still struggle to grasp the concept of energy poverty. Two related initiatives – the EU Fuel Poverty Network and the European Energy Poverty Observatory – will play a key role in developing a common definition. In addition to formulating indicators to measure energy poverty, these two organizations are disseminating information as well as facilitating stakeholder and public engagement on this issue.

How to tackle energy poverty? Most initiatives treat it as a social problem. Rather than providing short-term benefits, they focus on increasing the income of vulnerable households indirectly and in the longer term – for example by improving the energy efficiency of buildings and by promoting citizen energy and “prosumerism”, the production of energy by consumers, for example using solar panels.

The Picardie Pass Rénovation is a French initiative that retrofits and upgrades buildings, financed through ener-

The use of renewable energy sources can disrupt the cycle of poverty, debt and cold helping to reduce serious social and health consequences





gy performance contracts – schemes where the expected savings are used to pay for the improvements. Les Amis d’Enercoop, an energy cooperative based in Paris, collects donations via the energy bills of its members and uses them to support local initiatives tackling energy poverty. Members of Som Energia, a cooperative in Catalonia, pay an extra charge that covers part of the power bill of more vulnerable consumers.

These initiatives reflect the spirit of the EU’s Clean Energy strategy, which calls for the provision of affordable clean energy for all citizens and greater resilience of the European energy market. But uncertainty remains. Is the Clean Energy strategy solely about mitigating climate change, or does it also have a social aspect? How can policies for decarbonizing energy supplies and transforming the grid benefit vulnerable consumers? And how can they be implemented in an economically feasible and socially attractive way? The answers to these questions are still to be found. Yet, improvements in efficiency and prioritizing renewable energy sources will undoubtedly play a major role.

If the energy transition is to take energy poverty seriously, the measures and objectives put forward in the proposed Clean Energy package must be revised. They must take into account the differences in economic and social situations in the EU’s member countries. The European Commission

The extent of energy poverty in the EU varies widely – in Bulgaria, the rate is ten times higher than in Sweden

indeed aims to strengthen the social aspects of energy efficiency measures, but this may not be enough on its own. Improving energy efficiency should not be the only goal; another equally important aspect is to embrace the changes in the way energy is generated and consumed today. In a decentralized, digitalized model, energy would be generated locally, distributed by smart grids that match the volatility of renewables production, and consumers would assume multiple roles: producers, suppliers and co-owners. That, in turn, would make energy more affordable.

Community power projects, where citizens own or participate in the production and use of sustainable energy, are an essential element in Europe’s energy transition. They enable citizens and communities to harness local resources, increase tax revenues, and create new jobs. They target two of the root causes of energy poverty: low household income and high energy prices. The lower energy-production costs of renewables should cut the power bill. Collectively, citizens can negotiate better prices. And community power projects can be a source of revenues, which local authorities can use to pay for social policies. ●

LINKING SECTORS

POWER, TRANSPORT, HEAT UNITED

Electricity is only one part of the renewables picture. Heating, cooling and transport consume huge amounts of fossil fuels. Converting them to renewable energy poses challenges, but also offers solutions to the problem of variable power generation from solar and wind sources.

Over the last decade, renewable electricity has seen remarkable growth. Between 2006 and 2016, renewables grew by an average of 5.3 percent a year in the EU, or by 66.6 percent over 10 years. By 2016, almost 90 percent of the new power generation capacity came from renewable sources, mostly wind and solar. In contrast, oil, coal and gas still dominate the transport, heating and cooling sectors; efforts to expand renewables for these purposes have had limited success. For the EU to reach its target – at least a 40 percent reduction in greenhouse gases by 2030 compared to 1990 levels – much more progress is needed.

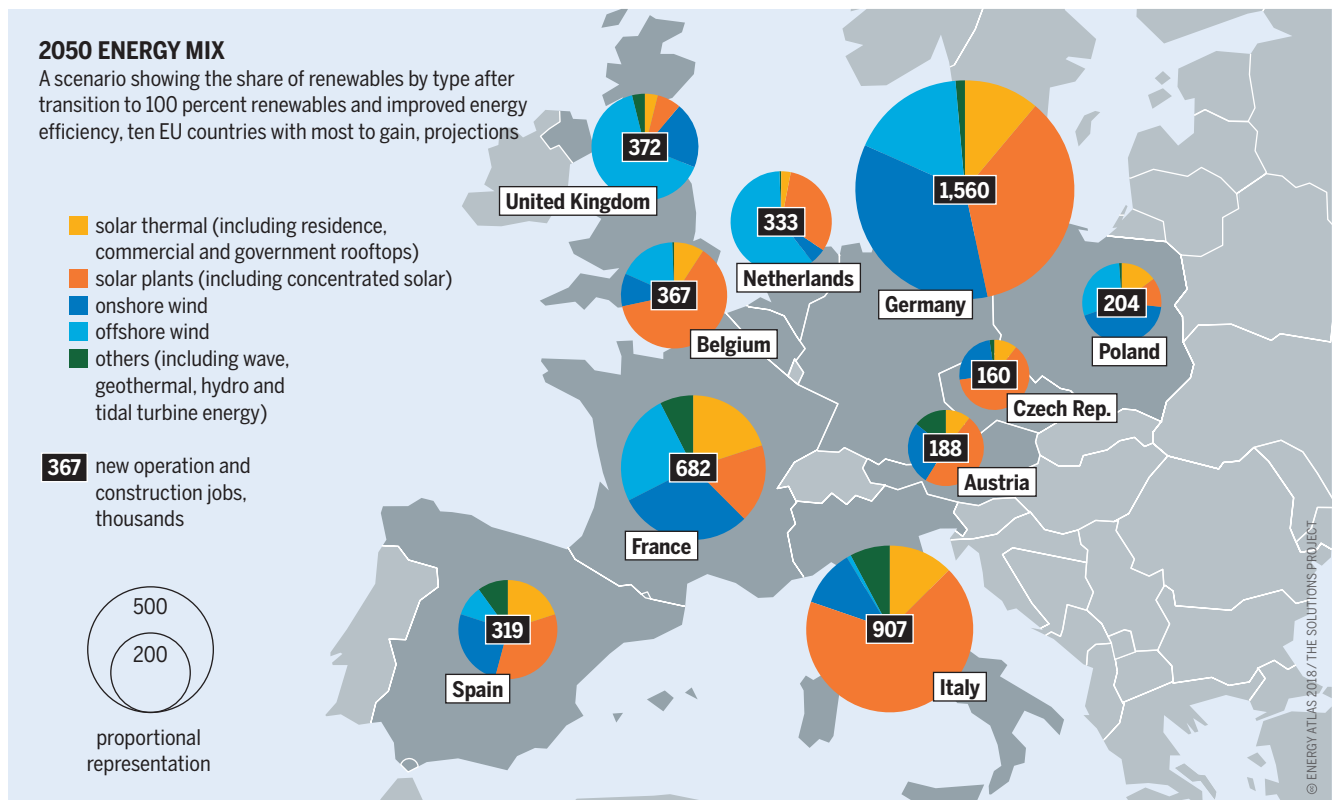
Although renewable generation capacity has increased significantly, the capacity of conventional power stations remains virtually unchanged. Such power plants function as baseload units and still dominate the power mix in most member states. This poses a challenge as Europe moves towards a renewables-based system. Most conventional power plants lack flexibility: they are not designed to be turned

off and on quickly. Solar and wind, on the other hand, produce a constantly fluctuating amount of power: they are subject to the whims of the weather, and solar panels are useless at night. As a result of the growing share of power from such sources, flexibility in the rest of the energy system has become increasingly important. It must be able to react quickly to fluctuations in both supply and demand so as to maintain a stable network.

“Sector coupling” addresses these challenges by linking the power sector with transport, heating and cooling. Interconnections would make possible the use of surplus electricity to heat homes, store heat in district-heating networks, cool industrial processes, and charge the batteries of electric cars, thus helping to replace coal and gas, and drive down emissions. By connecting the heat, transport and electricity sectors we can achieve a fully renewable system with existing available technology. Increasing the share of electric vehicles to 80 percent in 2050 would cut emissions by another 255 Mt. Such moves would also limit the cost of maintaining ageing conventional power units or building new ones.

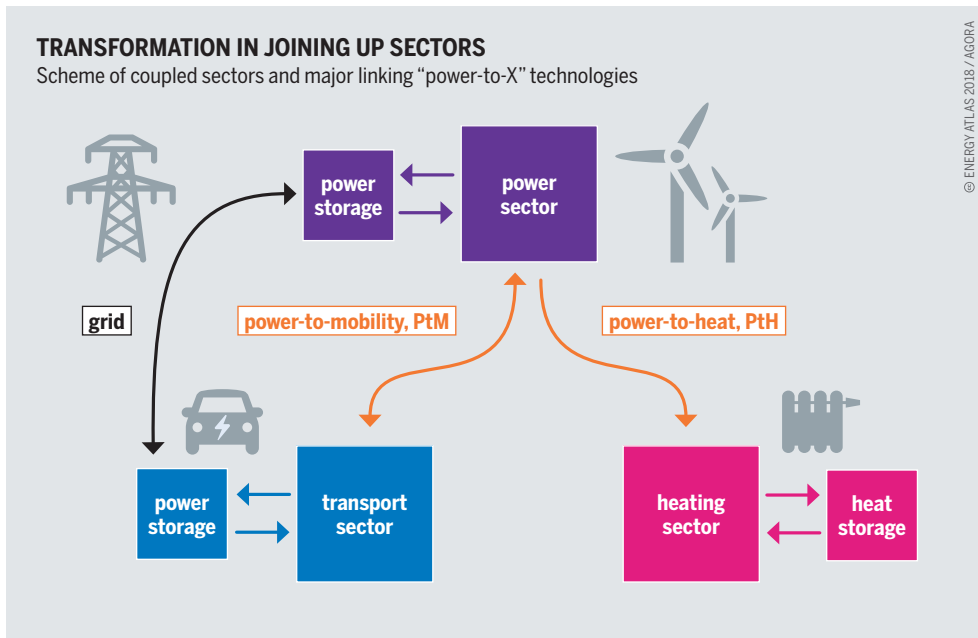
To make sector coupling commercially viable, electricity prices for end-users need to reflect the actual supply and

All sectors could be electrified if the barriers between them were removed. Biofuels are no longer necessary for this process



TRANSFORMATION IN JOINING UP SECTORS

Scheme of coupled sectors and major linking “power-to-X” technologies



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Sector coupling is the main instrument for achieving the EU's plan to reduce carbon emissions by 80 percent – and even by 100

demand. Prices should be lower when excess power is generated, and higher at times of shortage. But this is not the case. Today, households pay the same price for electricity even when demand drops at night or during holidays, when industrial production is curbed. At such times, electricity prices on the wholesale market fall close to zero or may even be negative, meaning power plant operators actually have to pay to feed electricity into the grid. The sensible thing would be to switch off some power stations, but big conventional coal and nuclear power plants are not designed to ramp up and shut down quickly.

So far, strategies to reduce emissions have been implemented independently in the heating, electricity and transport sectors. The potential of sector coupling – increased energy efficiency, reduced CO₂ emissions, and cost reductions – remains untapped. But recent years have seen a growing interest in a more integrated approach. The first is in transport, where excess power could be stored in the batteries of electric vehicles, reducing the need for liquid fuel.

Coupling heating and cooling with the electricity sector will happen in two ways: through electrification and through technological innovation. In most places around the world, individual residential buildings are heated using coal, gas or low-quality fuels. In many cases, electrification may be the only alternative when there is no access to a gas network and when it is not cost-effective to build a network that supplies heat directly.

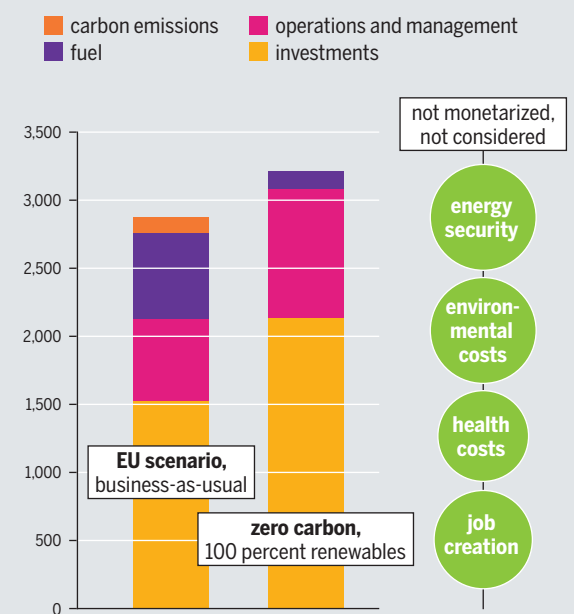
New technologies such as power-to-heat could also be useful. This is a hybrid system where electricity is used to supplement traditional heating methods such as burning wood or gas. On sunny, windy days, electricity generation from renewables is particularly high. Using such power to heat homes is a new approach that is spreading quickly in countries with a lot of solar and wind potential.

A 100 percent renewable EU energy system is possible. All major factors taken into account, it is not too expensive

Sector coupling is indispensable for the transition to renewable energy. It will attract the use of innovative technologies such as heat pumps, electric cars, power-to-heat solutions and demand-side management. Bringing these technologies into the market requires a more systematic, integrated approach, driven by a wide policy mix. Sector coupling will increase the system's flexibility and strengthen energy security. At the same time, it will reduce the need to build new generating units and permit the phase-out of the oldest, dirtiest power plants throughout the European Union, leading to a reduction in CO₂ emissions and lower long term costs. ●

THE PRICE TAG FOR SMART EUROPE

Annualized costs by sector for business-as-usual and zero carbon scenarios, EU 2050, billion euros, forecast 2050 prices



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ELECTRICITY

UNDER CURRENT

The switch to renewables is not just a matter of covering a few acres with solar panels, erecting wind turbines, and then plugging in. Electricity grids must be carefully managed to precisely balance the demand for power with its supply. That is no easy task.

Renewable energy plays an increasingly important role in the European energy mix. Thanks to improved technologies, wind and solar have recently become the dominant sources of the fuel mix when market and weather conditions are favourable. Even the more technologically challenging projects such as offshore wind farms have managed to attract private financing at market rates without any need for fixed feed-in tariffs. But a complete energy transition in Europe cannot happen overnight; much-needed

market mechanisms must be put in place, thus ensuring flexibility, that in turn enables renewables to take on a greater share of the energy mix.

Wind and solar tend to dominate the energy mix when the weather conditions are right. Unlike fossil-fuel plants, wind and solar plants do not need to cover fuel and carbon costs, and operating and maintaining them tend to be cheaper. They can therefore underbid fossil-fuel power plants and are dispatched first into the grid as the cheapest generators. However, this poses a number of challenges for electricity markets.

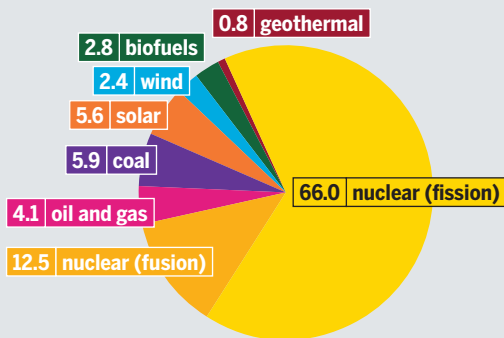
On windy and sunny days, turbines whirl and solar panels sizzle, feeding lots of power into the grid. This depresses the price of power to a level that is below the amount needed for solar and wind operators to cover the costs of their initial investment. Without support schemes, they cannot make a profit. But when the wind drops and night falls, wind and solar grind to a halt, and other sources of power (or sufficiently large storage capacity) must step in to bridge the gaps in supply.

To deal with these problems, the European Commission and many EU member countries have already implemented various mechanisms, or are considering doing so. Options include capacity auctions; permitting generators to trade their obligations to supply a certain amount of power; and balancing the supply and demand for power across different zones. Such measures would give operators of power generation, energy storage and demand-response facilities an extra revenue based on their availability and potential to regulate the power grid. If they are expected to promote the energy transition, such capacity-based payments must enable investment to support an energy system with high levels of variable solar and wind. Ideally, these payments would not subsidize further investment in unnecessary fossil-fuel infrastructure. Currently, 13 European countries including Germany, France, the Scandinavian countries and the UK offer some form of capacity payment to power generators.

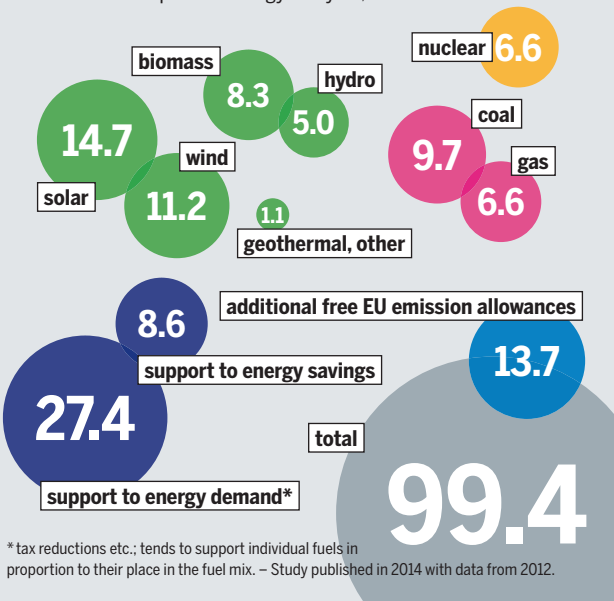
The power grid could also be better stabilized by managing the amount of power that consumers require. One strategy is to pool together consumers who are willing to adjust their immediate power consumption. These companies, known as “demand aggregators”, then offer these pools of consumers to the grid operators. If there is a shortage of power in the grid (for example on a calm, cloudy day when both wind and solar generators are idle), the grid operator can reduce the amount of power used by the consumers in the pool. By being aggregated together each individual customer only needs to reduce a small amount. On sunny or windy days when power is in over-supply, the operator can

TOO MUCH MONEY FOR DIRTY ENERGY

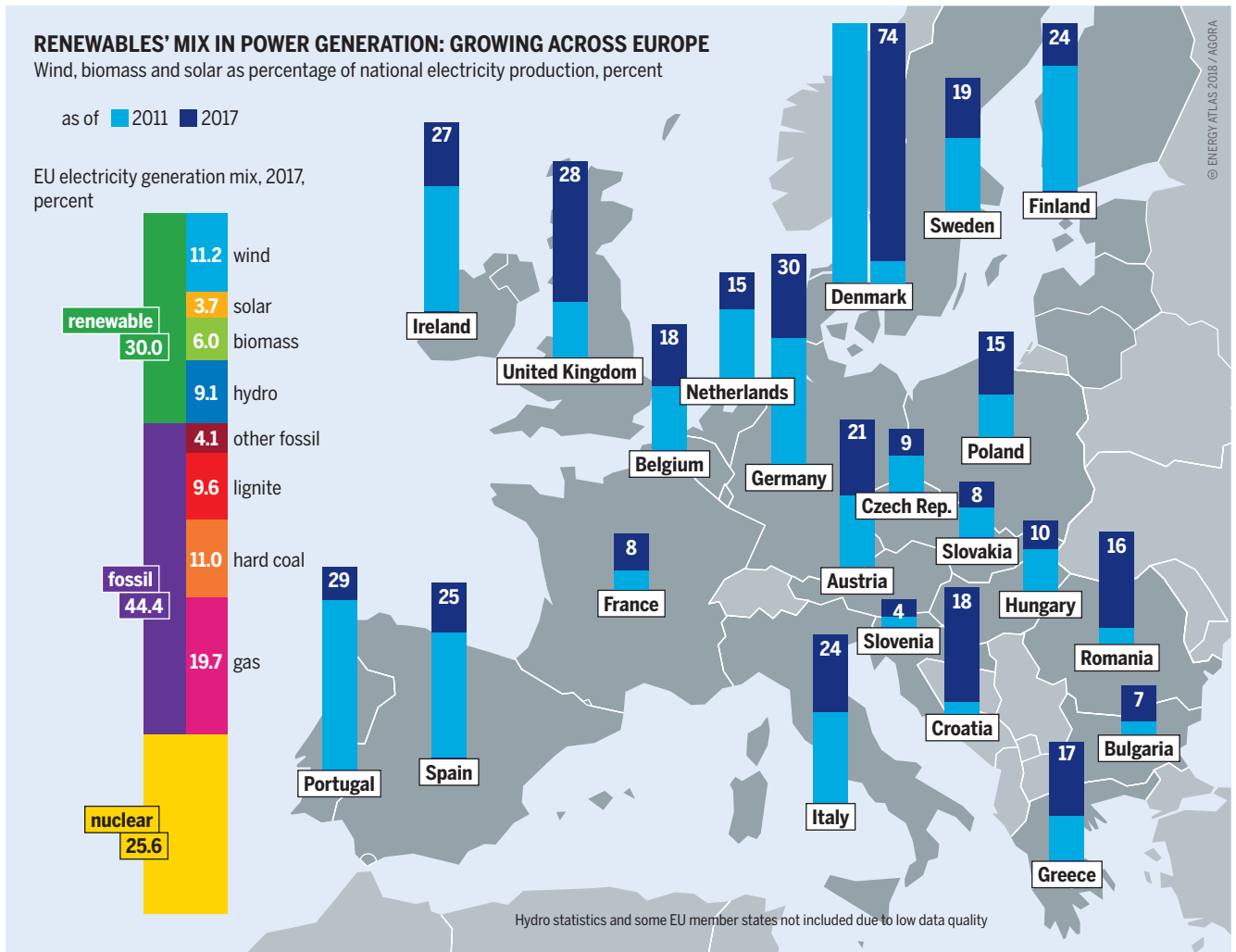
Expenditure for research, development and demonstration in 19 EU member states, 1974–2007, percent



Current subsidies per technology and year, billion euros



Rare snapshot: A study examined subsidies and research and development expenditure in the energy sector. Billions of euros still go to conventional power sources



increase consumption by the consumers in the pool. Such “demand-side responses” can decrease the cost and carbon footprint of the power supply system, while increasing its flexibility, as the pooled consumers can change their load faster than conventional power generators.

The two demand-side response technologies that have the fastest response and the biggest regulatory potential are grid-scale battery systems and electric heat boilers. Battery systems are charged up when power is plentiful and cheap, and release their power back into the grid when it is scarce and expensive. Electric heat boilers store power in the form of hot water: they use excess electricity from the grid to heat water, which can then be used as a cheap, clean source of heat for district-heating systems. Hot water can also be stored easily and economically for extended periods and released when it is needed and most valuable.

Another way of dealing with the problem of variable generation from renewable sources is to shift power from place to place. For instance from locations suited for wind generation (such as the windy North Sea) to areas with higher power consumption (big inland cities), and from places with a temporary power surplus to ones that are short of a volt or two. Such a grid has to be much more flexible and responsive than the current system, where both supply and demand are relatively easily predictable. Operating a renewables-rich power system would be difficult and expensive without an expanded grid.

Renewables are growing fast in the electricity mix, but at very different speeds. While nuclear power is already outdated, fossil fuels still dominate

To make the most out of varying conditions for different renewable sources across the continent, Europe needs to connect its individual national power grids into a large interconnected network. All the national power grids are already interconnected and power can be traded between countries. But the robustness and capacity of the interconnections vary greatly from country to country. In central Western Europe and Scandinavia, power can be traded and dispatched freely across borders. In these areas, power prices tend to track each other closely. On the other hand, there are poorly connected countries, such as France and Spain, where the interconnector capacity is nowhere near 10 percent of the national grid capacity, the EU’s target level.

The right design will unlock the full potential of renewables without compromising power-supply security. It involves revising the technical specifications governing how generators and consumers connect to the grid, reforming markets to even out bumps and troughs in supply, and reforming the carbon market. It requires building new transmission lines and increasing the interconnections between countries. All this will take significant amounts of investment, and a lot of political will. ●

MOBILITY

ON THE ROAD TO A CLEANER FUTURE

Commuters stuck for hours in fume-filled traffic jams epitomize the urgent need for cleaner, more efficient transport systems. Devising a rational transport policy must combine new technologies with proven approaches.

When it comes to reducing emissions, the transport sector (which includes road, rail, air and shipping) is stuck in the slow lane: it is now the EU's biggest source of emissions. Transport is virtually the only sector that has seen emissions rise, not drop, since 1990. Whilst its emissions have fallen mildly from a peak in 2007, they have increased again in the last three years due to an increase in road transport, both passenger and freight.

The "dieselgate" scandal that hit the headlines in 2015 has shaken public confidence in carmakers' credibility. Many car manufacturers were found to have installed "defeat devices" in their vehicles to cheat on emissions tests. They have also lobbied for years to resist tough fuel-efficiency targets. But these scandals, coupled with the push for cleaner air in our cities, spell the end of the internal combustion engine. In Germany the "transport transition" is now mentioned in the same breath as the "energy transition": the shift to cleaner sources of power.

To cut emissions, the transport system will have to both dramatically reduce individual car use and switch the remaining transport to electric power. However, since aviation currently has no realistic way to reduce its emissions, we will have to fly a lot less. The biggest emissions savings so far have come from adding biofuels into motor fuels, but these often have negative environmental and social consequences. Nevertheless, the shift towards renewable power

for vehicles is happening quickly. Sales of electric vehicles in the EU has more than doubled in three years, growing at 39 percent per year.

For an electric car to have low emissions, it must be powered by electricity that has been generated from renewable sources. Fortunately, that is increasingly likely. Over 80 percent of all new generating capacity installed in 2016 in the EU was renewable. As older power plants (typically coal or nuclear) are retired or put on standby, Europe's energy grid is becoming cleaner.

Due to their reliance on coal, countries such as Poland and Germany have the most carbon-intensive power generation in the EU. But even here electric vehicles still perform better on a lifecycle basis than diesel cars, even taking into account emissions created when manufacturing the battery and vehicle. In Poland, an average electric vehicle emits 25 percent less CO₂ over its lifetime than a comparable diesel car. In Sweden, which has one of the cleanest energy mixes in the EU, it emits 85 percent less.

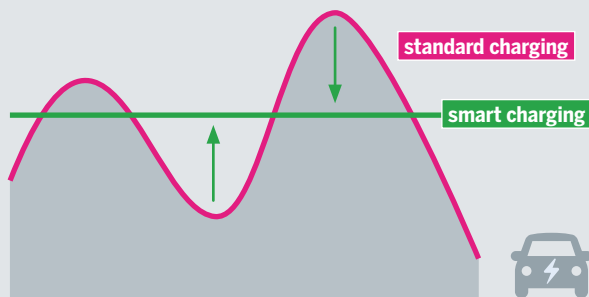
Electric vehicles convert energy to mobility much more efficiently than combustion engines. For the EU as a whole, research by the Vrije Universiteit Brussel for the NGO Transport & Environment shows that if the EU energy mix continues to decarbonize at current rates, by 2030 electric vehicles will emit less than half the CO₂ of diesels over their lifetimes. New electric vehicles now travel further between charges, and the range available to consumers is growing, as was evident by the models on display at the 2018 Geneva Motor Show.

Charge control becomes all the more effective the better electricity grids and transport networks converge

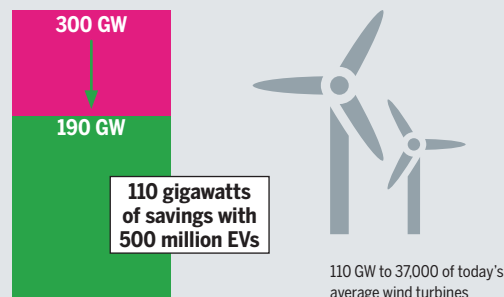
THE CASE OF SMART CHARGING

Peak load avoidance versus standard charging of electric vehicles (EVs), worldwide projection for 2040

EV fleet consumption profile during working days

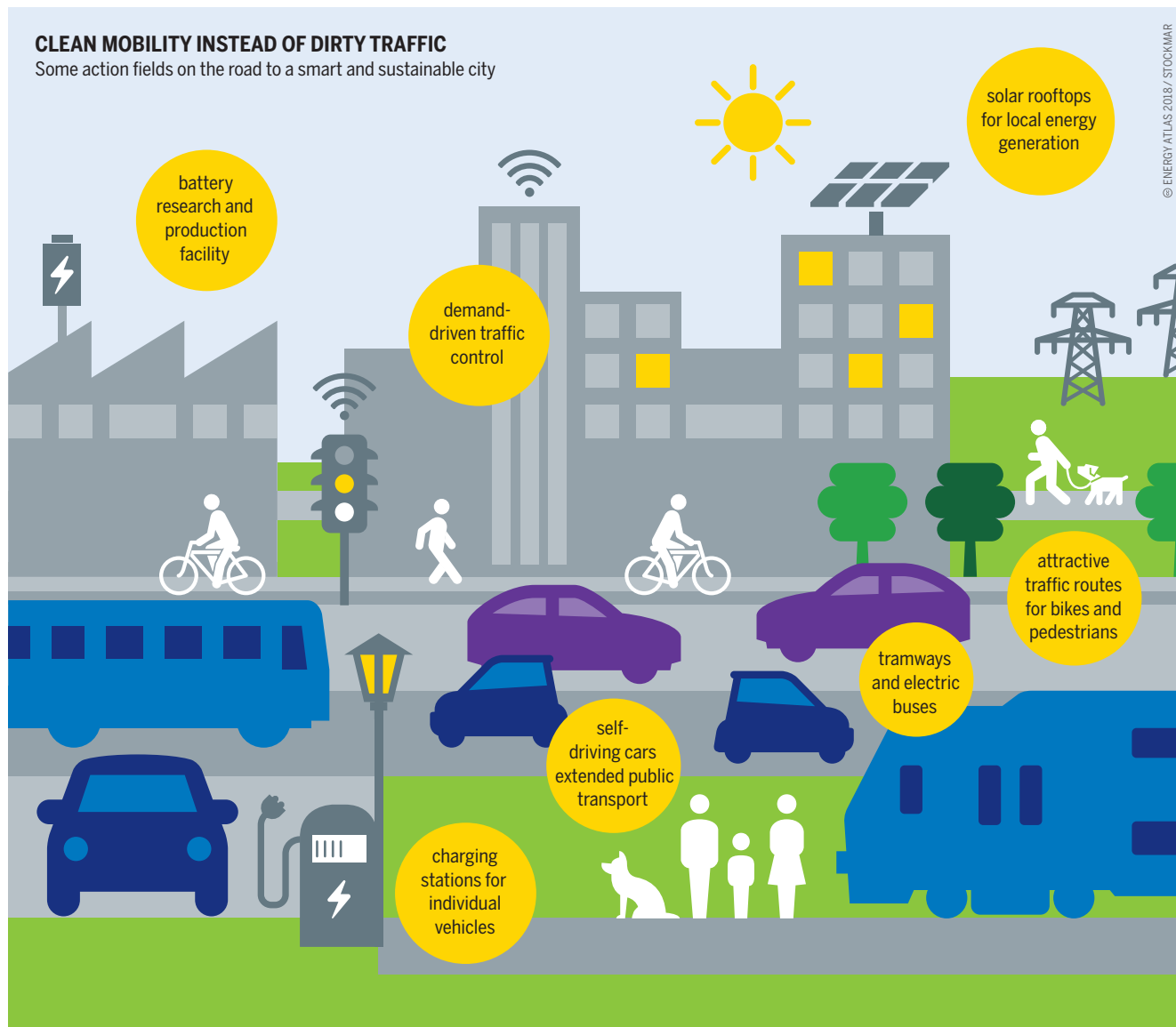


capacity reduction through smart charging



CLEAN MOBILITY INSTEAD OF DIRTY TRAFFIC

Some action fields on the road to a smart and sustainable city



Electric vehicles play a vital role because they can interact with the power grid. A fleet of electric vehicles can flexibly store and deploy power en masse. BMW's Chargeforward programme, running in California, is an example: the vehicle owners are paid an incentive if they agree to flexible battery recharging. This allows for "de-peaking", where cars are not recharged immediately, but at times of day when grid loads are at their peak.

Transferring power from vehicle batteries to the grid is also possible. Here, cars act as "batteries on wheels": the grid taps their batteries if it is short of power. Each vehicle need only return a small percentage of its stored energy to have an overall impact on the grid. However, the equipment required is still too costly: prices need to come down significantly if this approach is to be widely accepted.

It is not just cars that are going electric. Bloomberg Energy predicts that half the world's public buses will be electric in seven years. Production of electric buses in the EU lags behind demand. Because of this, cities such as Brussels, Lisbon and Stuttgart have had to delay their plans to electrify their public transport.

As for goods vehicles, the German firm MAN plans to build more than 100 fully electric urban delivery lorries a

Electrification and communication are two key technologies for mobile urban societies

year at its plant in Steyr, Austria. Daimler has committed to series production from 2021, again focusing on urban and regional delivery trucks. Volvo is expected to make an announcement soon. The Chinese firm BYD already supplies zero-emission trucks from its Rotterdam base. After launching its fully electric 40-tonne long-haul truck in 2017, Tesla is now taking orders from EU customers.

To achieve a successful transition to zero-emissions transport the European governments and the EU will have to get the rules right – for example by requiring manufacturers to have a certain percentage of their vehicles electric by a specific date.

More efficient internal combustion engines can reduce emissions in the short term, but the future lies in full decarbonization. That will mean minimizing the use of vehicles in cities, investing in public transport and infrastructure, improving urban design, encouraging people to cycle and walk, and shifting to an electric transport fleet. Get it right, and the future is electric, renewable – and bright. ●

HEATING AND COOLING

TO A CERTAIN DEGREE

Much of the time, the weather in Europe is either too cold or too hot for comfort. Heating and cooling buildings consumes a huge amount of energy. New technologies and better policies could increase efficiency and cut both costs and greenhouse gas emissions.

Heating and cooling together account for almost 50 percent of the EU's final energy demand: with heating taking by far the lion's share for both residential and industrial purposes. Fossil fuels still dominate the sector, with renewables accounting for only 18.6 percent of the energy used in 2016. Despite this, the EU leads the world in renewable heat production. Sweden has the highest share, with renewables providing 68.6 percent of its heating and cooling mix, and biomass generating 60 percent of the heat for district-heating systems. Biomass (and waste) generated 39.6 percent of the heat supplied to Denmark's district-heating systems in 2016.

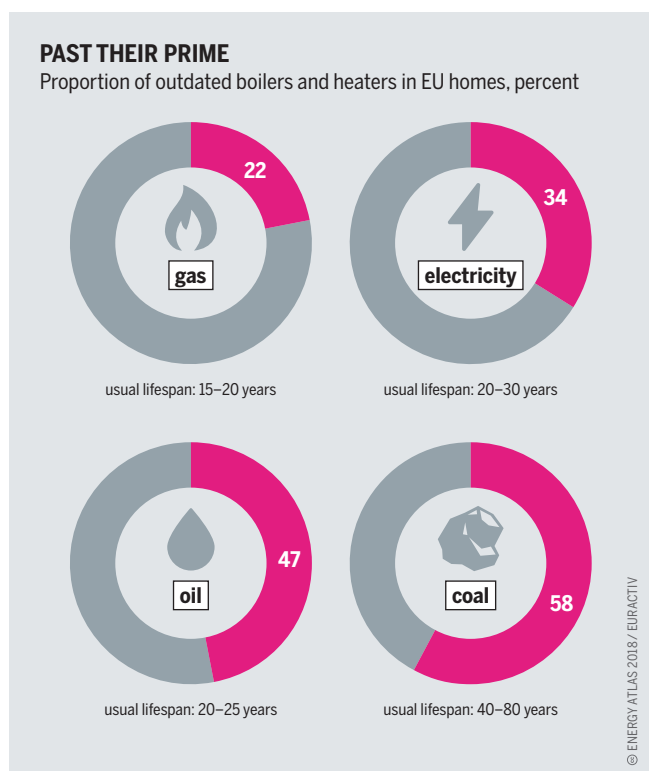
Since most of this energy comes from fossil fuels, the sector has a significant impact on Europe's carbon footprint. Three strategies offer the most potential. First, expanding a range of renewable technologies to provide zero-carbon energy. Second, increasing the efficiency levels of buildings and using up-to-date district-heating networks to reduce overall energy demand. And third, electrification to replace fossil fuels with sustainable renewable power.

Energy efficiency is at the heart of the European Commission's "Clean energy" package of measures, launched in 2016. This includes proposals for funding to accelerate the refurbishment of buildings and integrate renewables, as well as support for research and innovation on clean energy. The carbon footprint of buildings will depend on many factors: the geographical characteristics, user needs, the building type, the availability of resources, the intensity and frequency of use, the existing infrastructure, and the possibility of expanding the building stock.

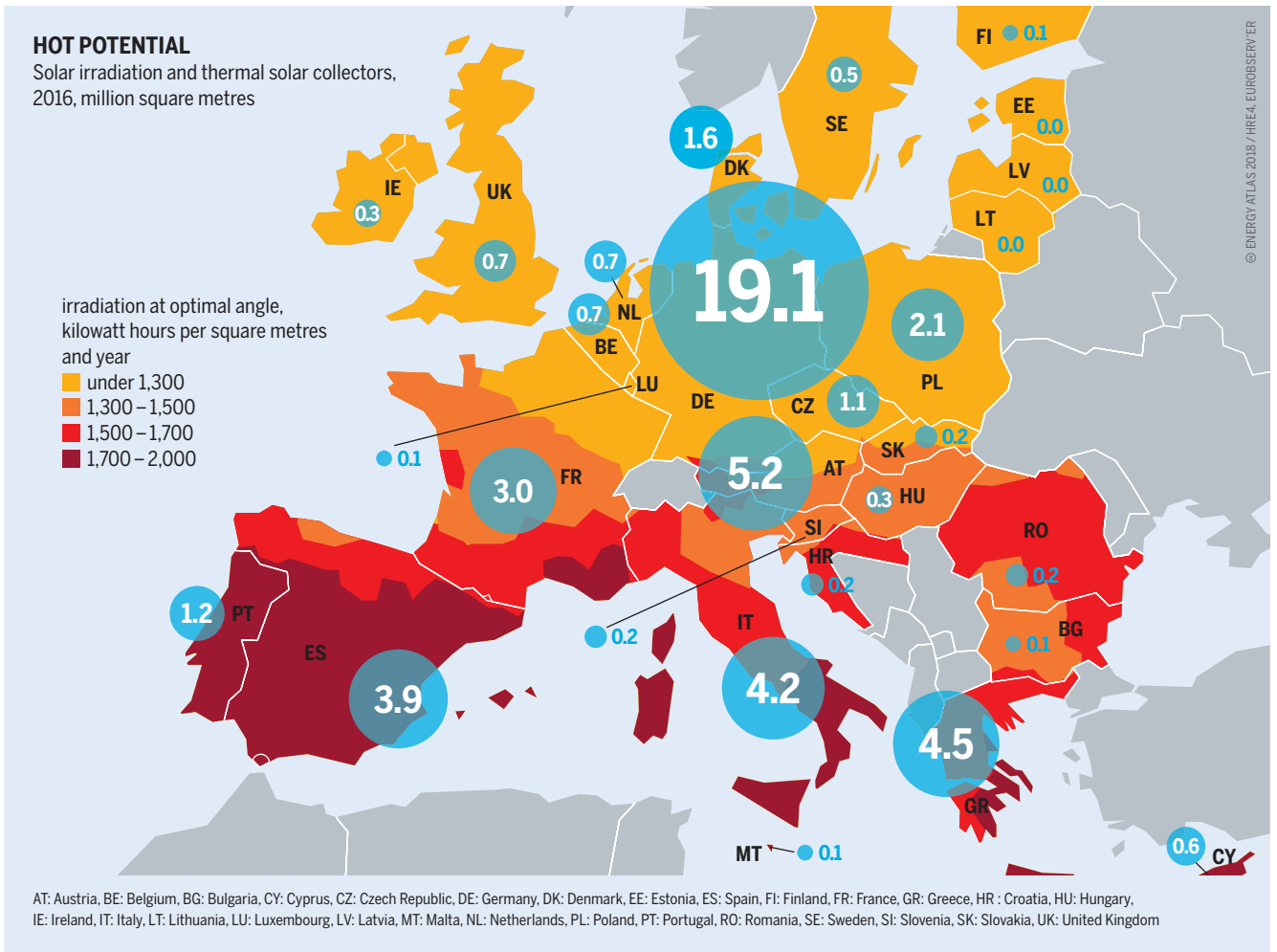
To reduce the amount of CO₂ emitted by buildings, they must be designed to minimize energy losses. However, a building's energy efficiency can also be increased; adding insulation, using natural ventilation, using plants or other sources of shade, applying heat-reflective paints, and installing solar panels to generate power or heat water will positively affect the amount of heating and cooling a building needs. That, in turn, makes it possible to install heating and cooling systems, and avoid unnecessary costs and energy consumption. A "solar active house" combines many of these technologies: solar panels heat a large tank of water as a heat store. Insulation, controlled ventilation and heat recovery reduce the energy losses to a minimum and save significant amounts of fossil fuels.

Sunshine is one of Europe's most sustainable sources of renewable energy for heating and cooling. Solar thermal systems can produce heat directly, or heat a fluid that is then used to produce steam in a power plant for electricity production. (In contrast, solar photovoltaic systems convert sunlight into electricity directly). Sunlight can also be used to run cooling systems for buildings. Solar thermal currently produces 20 terawatt hours (TWh) of heat energy, accounting for only 1 percent of the total heating load demand in the EU and 3.3 percent of the electricity generation. There is clearly a lot of potential to further exploit solar thermal energy. According to some specialists, it could provide between 4 and 15 percent of the EU's demand for heat by 2030, and between 8 and 47 percent by 2050. The lower figures are for the business-as-usual scenario; the higher figures are with full research and policy support. In the latter situation, solar thermal could contribute 580 TWh by 2030 and a massive 1,550 TWh by 2050.

Apart from the high fossil fuel dependence, another big challenge is the heavy reliance on biomass in the renewable energy mix of the sector and its side effects, such as deforestation and land conflicts. Moreover, biomass has to fulfil very strict sustainability criteria (biodiversity, air quality, etc.) and be local. Biomass (mainly wood) accounts for 15 percent of the total residential and industrial heat production in the



Investing in more efficient heating improves residential energy efficiency, reduces emissions, saves money, and creates jobs



EU, representing 92 percent of the renewables in the heating sector. Lastly, heat can be extracted from the ground (geothermal energy), the air or water via heat pumps.

The EU is gradually replacing electricity generation from fossil fuels with renewable sources and waste heat to cover heating and cooling demands. Electric boilers could replace oil or gas-fired units. Heat-storage systems could save energy and boost efficiency. Using renewables to generate heat and power and to feed district-heating and -cooling schemes could reduce greenhouse gas emissions and reduce costs for consumers. Such cross-cutting technologies will be the next big thing in the sector.

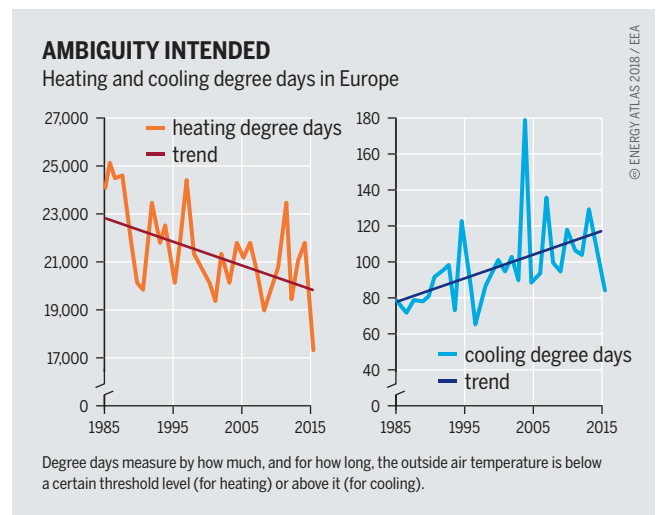
Many barriers remain for their wide-scale uptake. Consumption is distributed among millions of houses and other buildings. Retrofitting them will be costly. National and regional markets for the heating and cooling sector are fragmented. Cheap fossil fuels, and government subsidies for extracting them, make it harder for renewables to compete. EU member states are still lukewarm in terms of policy support.

The European Commission recognizes the need to increase the share of renewables in heating and cooling. The proposed Renewable Energy Directive foresees an increase

Southern Europe's huge solar potential for regulating indoor temperatures and for industrial use is still largely untapped

of just 1 percent per year until 2030 – not enough to make any real impact. On the positive side, this strategy does for the first time highlight the importance of renewable energy for district heating and cooling. Coupling the heating, transport and power sectors together could be the solution to these challenges. ●

Fewer heating and more cooling days – climate change in Europe is easily recognizable



ENERGY EFFICIENCY

GETTING MORE FROM LESS

Draughty, poorly insulated buildings, outdated factory equipment, home appliances that slurp power instead of sipping it. Much of the energy we use is wasted. European Union policy directives are trying to change this.

The idea of energy efficiency underlies modern economies and societies. During the industrial revolution, the development of ever more energy-efficient techniques made products that were once exclusive available to much larger numbers of people. The energy that was saved was absorbed by increased consumption; new sources of energy were tapped to meet demand – first coal, then oil and natural gas, and then nuclear. Europe became dependent on oil and gas imports, and until recently, put a lot of hope on nuclear power. But little thought was given to improving energy efficiency at the consumer or industry levels.

Yet there is huge scope to do so. The International Energy Agency regards energy efficiency as a resource that every country has in abundance. Improving it is the quickest and least costly way of addressing both energy security and environmental and economic challenges. Services, products, behaviour and processes can be designed to use less energy. These measures include efficient industrial plants, better insulation of buildings, economical motor vehicles, more walking and cycling, and switching from wasteful tungsten-filament light bulbs to LEDs.

Getting the policies right is vital. Around the turn of the century, the European Union realized the need for a common energy policy. In 1998, a first EU-wide target was agreed to improve energy efficiency by 1 percent a year over twelve years. Since then, a comprehensive energy efficiency framework has gradually been put in place, involving legislation on products, industrial processes, vehicles and buildings.

In total, EU energy efficiency legislation is estimated to deliver savings worth the equivalent of up to 326 million tonnes of oil per year by 2020. Half of these savings come from minimum performance and labelling requirements for appliances (such as washing machines and freezers). The other half comes from the implementation of two Directives, on the energy performance of buildings and on energy efficiency. Buildings are responsible for 40 percent of the EU's energy consumption and 36 percent of its CO₂ emissions. The Energy Performance of Buildings Directive of 2010 requires governments to set minimum standards. All new buildings must be nearly zero-energy by 2020. A building that is for put up sale or rent must have an energy performance certificate that rates its energy efficiency and CO₂ emissions.

The Energy Efficiency Directive of 2012 requires member governments to help the EU improve its energy efficiency by 20 percent by 2020 (compared to 1990 levels). It is up to the governments to decide how to put this into effect. Govern-

ments can impose “energy efficiency obligations”, which require energy distributors to save 1.5 percent of their energy per year through efficiency measures. Such schemes currently deliver 40 percent of national energy savings in the EU. Alternatively, governments can achieve the same amount of savings with energy-saving measures, such as improved heating systems, installing double-glazed windows, insulating roofs, and promoting cleaner mobility. The Directive also requires large companies to undergo energy audits of their energy consumption, and provides for incentives for small and medium enterprises to do so.

Other widely applied policy tools are financial and fiscal schemes to support building improvements or the purchase of more efficient products and vehicles, as well as energy taxation. Driven by these policies, efficiency gains led to 10 percent less energy consumption in the EU between 2010 and 2015, while the economy grew by 5 percent.

With its Clean Energy package of 2016, the European Commission for the first time puts efficiency at the centre of its energy strategy, highlighting its potential for creating jobs and growth. The package revises a wide range of legislation, including the Directives on energy efficiency and the performance of buildings. However, it lacks ambition on the efficiency target that will likely be set around 30 percent by 2030. This is far below what is needed to tap the economic savings potential and fulfil the Paris climate agreement.

The debate so far among member states and in the European Parliament has focused on “sharing the burden” of reducing greenhouse gas emissions. It misses out on the many benefits of higher energy efficiency as the bedrock of climate-protection policies.

Energy efficiency produces concrete changes for citizens, providing them with healthier homes and cities, better transport systems, and improved control over the energy system. Consumers are more prepared to change their behaviour and to invest in energy-saving technology. For example, by switching to the more efficient home appliances developed in response to eco-design and labelling requirements, or by renovating buildings to the higher energy performance based on EU minimum-efficiency standards.

The EU is the world's largest energy importer: its net energy-trade balance reached 316 billion euros a year between 2007 and 2016. Money spent on energy imports supports undemocratic regimes, causes deforestation and results in oil spills. And, this money is no longer available to support the transition to a safer and cleaner energy system, which provides local jobs, reduces energy poverty and creates public income. These arguments find particular resonance in central and eastern Europe, where there still remains a large potential for the improvement of energy efficiency. ●

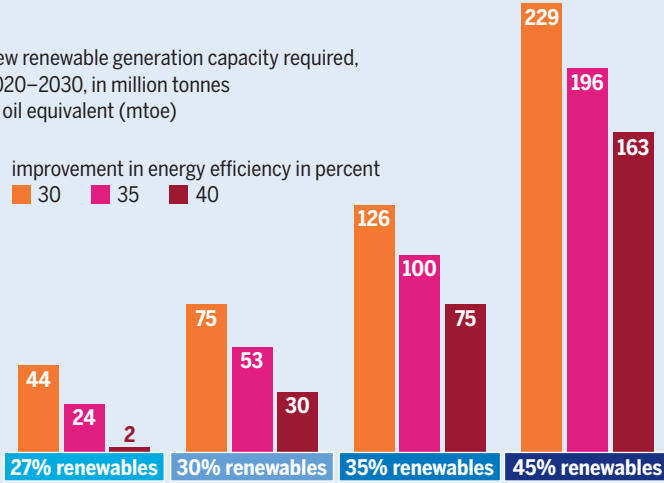
Energy efficiency gains and the increase of renewables in the generation mix mutually benefit from each other

THE HIDDEN HELPER OF THE ENERGY TRANSITION

Predictions for three levels of energy efficiency and four levels of renewables, European Union

New renewable generation capacity required, 2020–2030, in million tonnes of oil equivalent (mtoe)

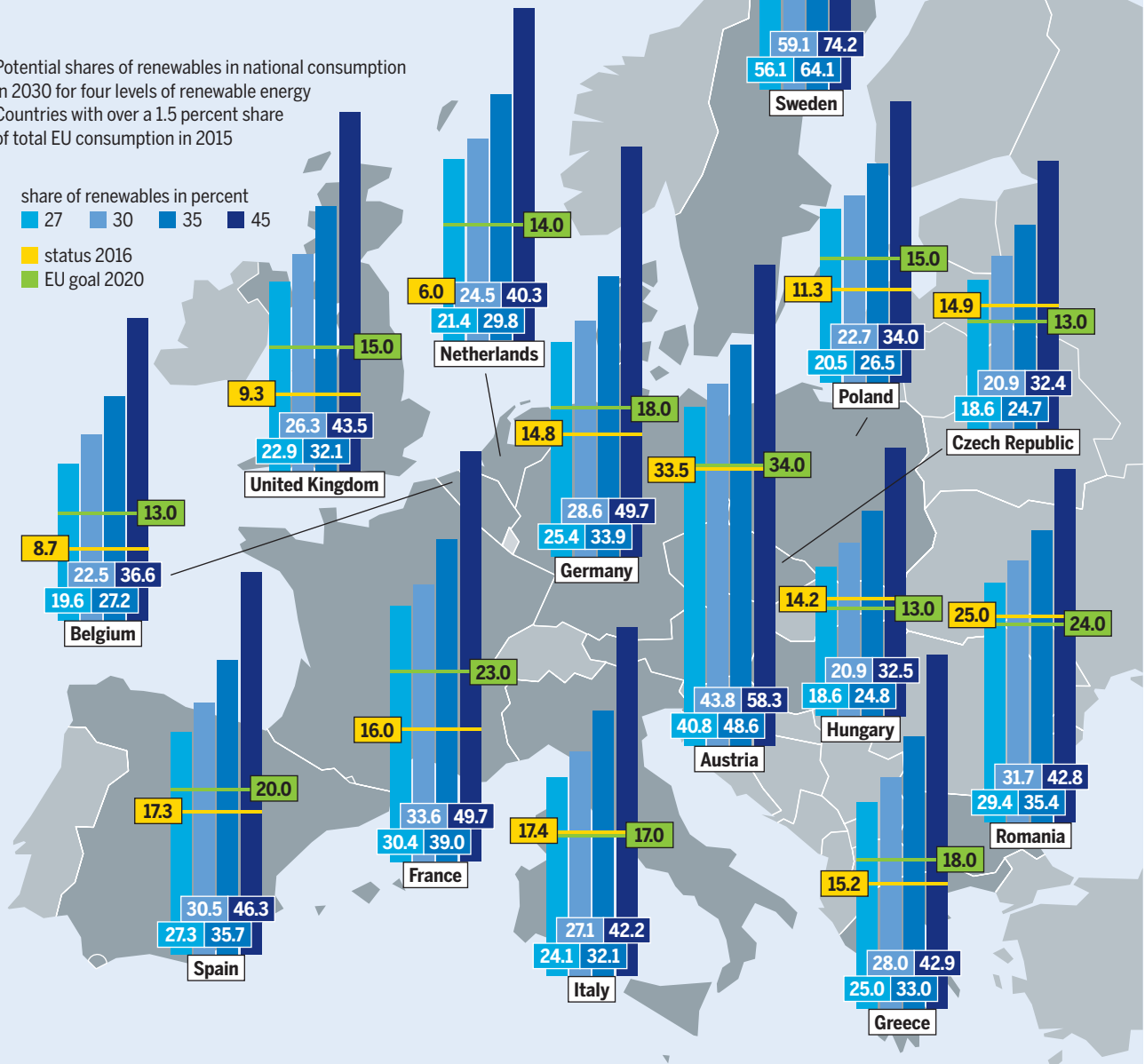
improvement in energy efficiency in percent
 30 35 40



Higher energy efficiency enables higher renewable shares as it helps to reduce generation capacities needed. With 45 percent renewables and 30 percent better efficiency by 2030, 229 mtoe in new renewable capacity would be required. With 40 percent improvement, only 163 mtoe extra is needed. For comparison, in 2010–20 the EU will add about 80 mtoe in extra renewable capacity.

Potential shares of renewables in national consumption in 2030 for four levels of renewable energy
 Countries with over a 1.5 percent share of total EU consumption in 2015

share of renewables in percent
 27 30 35 45
 status 2016
 EU goal 2020



DIGITALIZATION

TAKING A QUICK BYTE

The spread of renewable energy means a switch from a few large power plants to many smaller sources. But how can millions of solar panels and wind turbines be integrated into a reliable system that balances out supply and demand? Digitalization provides the answer.

On 20 May 2015, the German power grid faced a challenge unheard of just 10 years previously. Beginning at 10 a.m., a partial solar eclipse reduced the amount of light reaching the ground by 70 percent. As the sun disappeared behind the moon, solar panels with the capacity of six nuclear power plants ceased to generate electricity. Grid operators had planned for this day months in advance. At any given moment, electricity grids require the same amount of electricity to be fed into them as is taken out. Even a minor imbalance between the two can cause a power surge or blackout. The sudden loss of such a large amount of generation capacity is a worst-case scenario.

There had been much discussion as to whether fast-reaction gas-fired power plants could make up for such a sudden loss of power on the grid. Indeed, they could. But when the sun returned at noon, it was at its highest point. More than 1.5 million photovoltaic systems came back on line with the force of 12 nuclear power plants. Grid operators scrambled

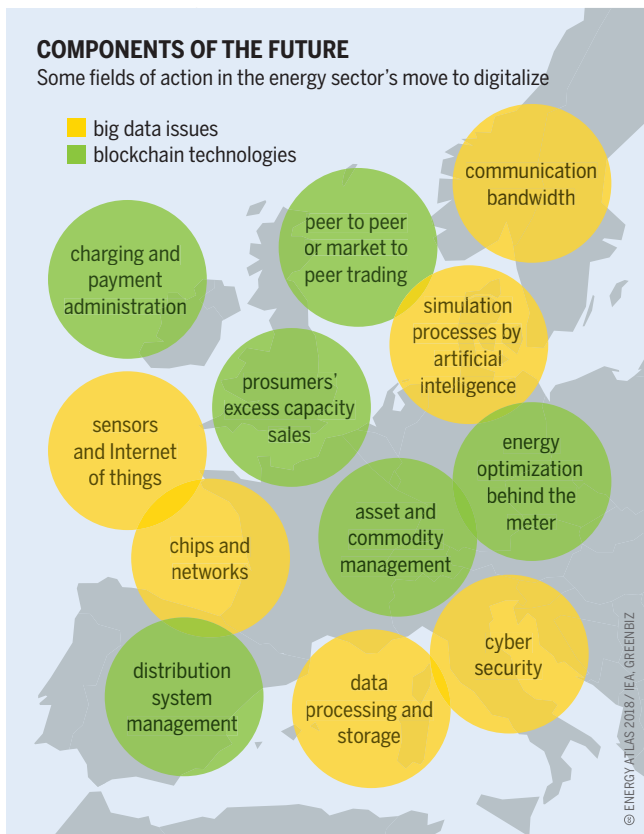
to make way for the sudden surge in solar generation. The large fossil-fuelled power plants, which had just filled the gap in generation, had to be shut down again. Within just two hours, the German power system had switched much of its power generation from one source to the other, and back again. By noon it was all over, and renewables again covered 40 percent of German electricity demand.

The fuss over the solar eclipse shows how much the energy system has changed over the past 10 years. Big, monopolistic utilities no longer control the energy system. The grid has become a marketplace. The transition towards renewable energy means that power generation is shifting from a few hundred large, centralized power plants to millions of small, decentralized solar panels and wind turbines. Realization of the goal of 100 percent renewables means that in the future even unpredicted cloudy weather may have the same effect as a solar eclipse. The capacity of power lines is a scarce resource, and supply needs to be perfectly matched in real time with the demand of millions of customers. An increase in communication and interaction between generation, demand, storage and the grid will be required to make sure the grid remains stable. The key to that is digitalization.

Today, most of the energy infrastructure is not digitalized at all. Most of the information technology that is used goes into forecasting power generation and predicting the weather. Digital trading and billing systems exist, but are mostly the domain of large energy corporations. Household customers are effectively barred from accessing the digital infrastructure behind the energy supply system.

The energy industry resembles the information-technology industry before the invention of the personal computer. Information technology existed back then; however it was mostly used in large-scale applications such as banking, space flight or university research. But the unrestricted interaction between persons on the network enabled by the personal computer and the Internet led to a burst in innovation. Initial steps are now being taken to democratize technologies in the energy system. These include the bundling of small-scale storage units into large “virtual power plants”. Small-scale producers of electricity can consume their own power or sell it directly to neighbouring houses. Electric vehicles can be charged through lampposts.

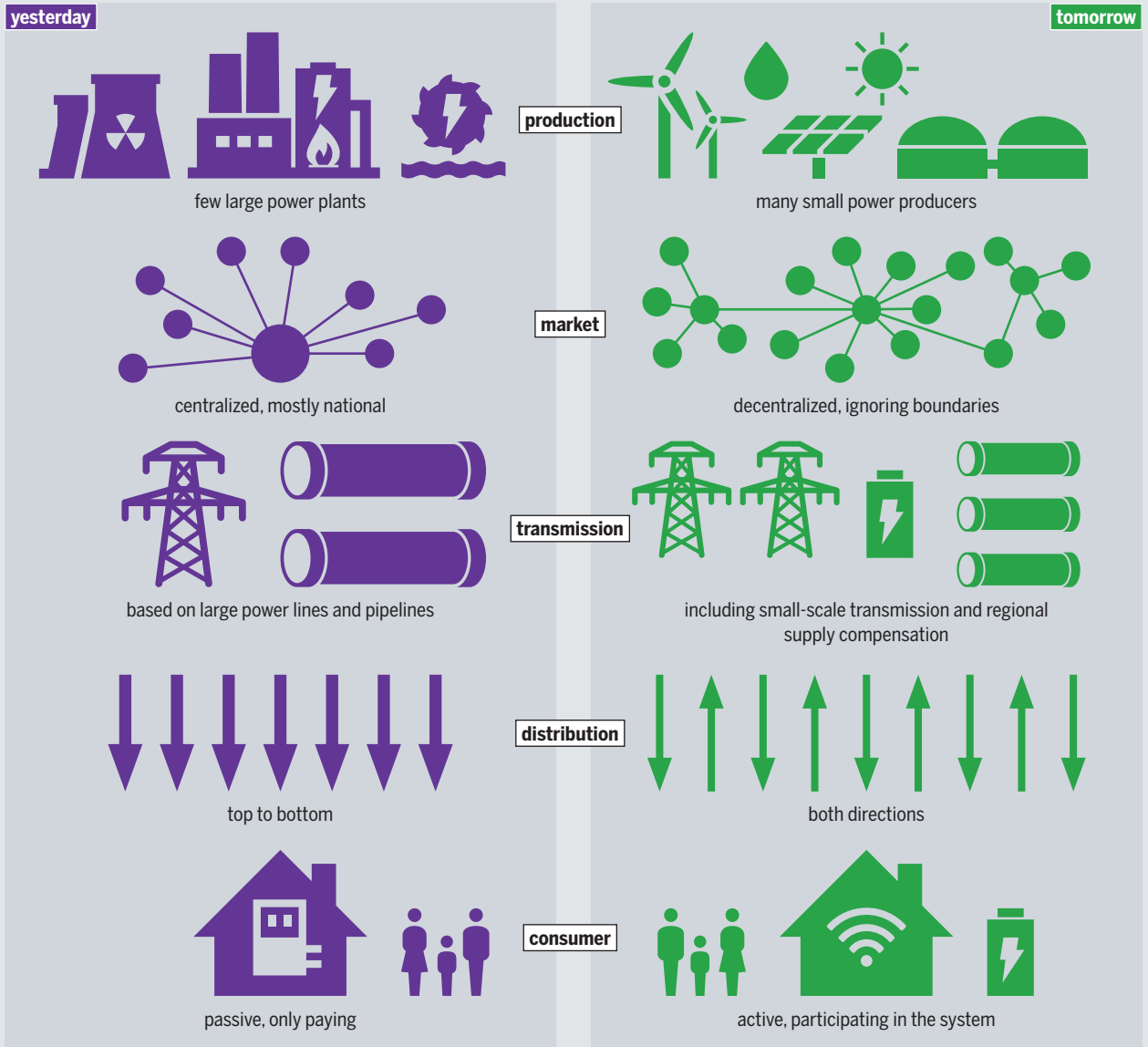
Why is digitalization in the energy sector still in its infancy? Bringing new technologies and ideas into a tightly regulated sector is challenging. Experts say the energy system in Germany alone is covered by more than 10,000 sections of law. Energy giants will look for legal arguments to bar new technologies from market entry. Young companies often find themselves in legal battles over the most trivial issues. It



“Digital electricity”, as some call it, will become the key energy feature within the next decade

STAYING BIG OR GETTING SMALLER

Expected structural changes in the energy system made possible by the increased use of digital tools



took, for example, five years for German courts to decide if a power meter which is not mounted on the wall may be used. Digital (or “smart”) meters – the most basic devices to access the energy system – are still unavailable in many European countries. Markets for flexibility during hours of high demand are developing slowly and are often restricted to large consumers, such as paper mills or wastewater treatment plants. Small-scale, flexible devices such as home-storage units still have to be bundled into larger virtual power plants to generate revenues for their owners.

In its proposed Clean Energy Package, which sets a new framework for all European energy markets, the EU is attempting to create access to the energy system for all “active consumers”. The draft legislation tries to remove the barriers that households face to generate, store and sell their own electricity. If these attempts are successful, they may fundamentally change the way average customers take part in the energy transition – comparable to the opening of the Internet to commercial Internet providers in the early 1990s.

With digitalization still in its infancy, the battle is against Big Energy, an abundance of legalese and lawmaker’s lethargy

The future of a digitalized energy system largely depends on whether new technologies are used as tools for democratizing the energy system, or as a means for increasing the efficiency of incumbent energy giants. The Internet has become a hotbed of innovation not because it is “digital” but because everybody can easily generate and share ideas with a much wider community. Some hail digitalization as the future market maker of a decarbonized system. Renewables, battery storage, electric cars and the grid would silently and digitally negotiate the flow of green electricity in the background, while people go about their daily lives. Others see digitalization as a mere hype. Because of the vital role of electricity for modern life, they say that control over the system should be best entrusted to large, experienced energy companies. It remains to be seen which view will prevail. ●

EUROPEAN UNION

MORE AMBIVALENT THAN AMBITIOUS

After a stuttering start, the European Union's energy sector is now undergoing a profound transformation. Instead of losing steam, the European Commission and the governments of member states must now set ambitious targets, and design policies that enable the continent to reach them.

Renewable sources – dominated by wind and solar – account for a large majority of new power installations in the European Union. In 1997, the European Commission set the first targets – by 2010, about 22 percent of electricity consumption and 12 percent of total energy consumption for the EU as a whole were to come from renewable energy sources. The Commission also set targets for each member state.

But these targets were not binding, and they proved insufficient to drive the uptake of renewables. Most were missed. Subsequent EU legislation, in the form of the Renewable Energy Directive of 2009, imposed binding national targets on member states, and an overall EU goal of 20 percent renewables by 2020.

In 2014, the bloc set itself further targets: 27 percent of its total energy consumption was to come from renewables by 2030. At time of writing, the EU is expected to agree to 30 percent. But renewables are growing fast, and this figure is too modest – it would mean slowing down current rates of expansion. To encourage EU member states to reach their renewables potential, a higher target is needed. A report on “National benchmarks for a more ambitious EU 2030 renewables target” by Ecofys, an energy consultancy, and TU

Wien, a technical university in Vienna, finds that a 45 percent target would mitigate climate change and boost innovation, the economy and employment. Such a target would mean a big increase in the deployment of renewables compared to the period 2010–20.

Solar photovoltaic already plays a big role in several countries. In 2016, it accounted for 7.3 percent of electricity demand in Italy, 7.2 percent in Greece and 6.4 percent in Germany. Several other countries in Europe exceeded 2 percent. Small-scale photovoltaic schemes are found mainly in communal or residential developments, but several countries have bigger installations. Photovoltaic can increasingly compete on cost with traditional power sources. Worldwide, the potential for solar power is impressive; the International Energy Agency estimates that over half the world's power production could come from solar by 2050.

But many barriers remain. Spain, once an active promoter of renewables, has backpedalled and come to an almost complete standstill. Retroactive changes in rules governing support for renewables have hampered progress in Romania, the Czech Republic, Poland and elsewhere.

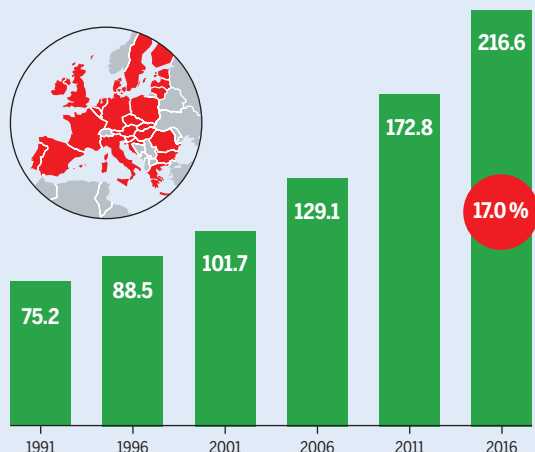
Scarcely any new hydropower facilities are planned or have been built recently in the EU. However, if they are newly built, use the latest technology and have sufficient storage capabilities, small and medium hydro plants have particular potential to boost capacity.

For wind, onshore turbines were the most cost-effective option in 2016. But there is also action out at sea: in June of that year, nine European countries agreed to co-operate on

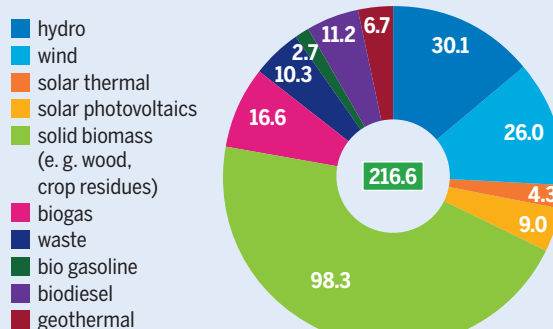
Renewables can supply much more than 20 percent of the EU's energy by 2020. Targets that are too low would slow their expansion

POWERING UP IN THE EU

Renewable energy consumption, million tonnes of oil equivalent, and share in gross final consumption of energy, percent



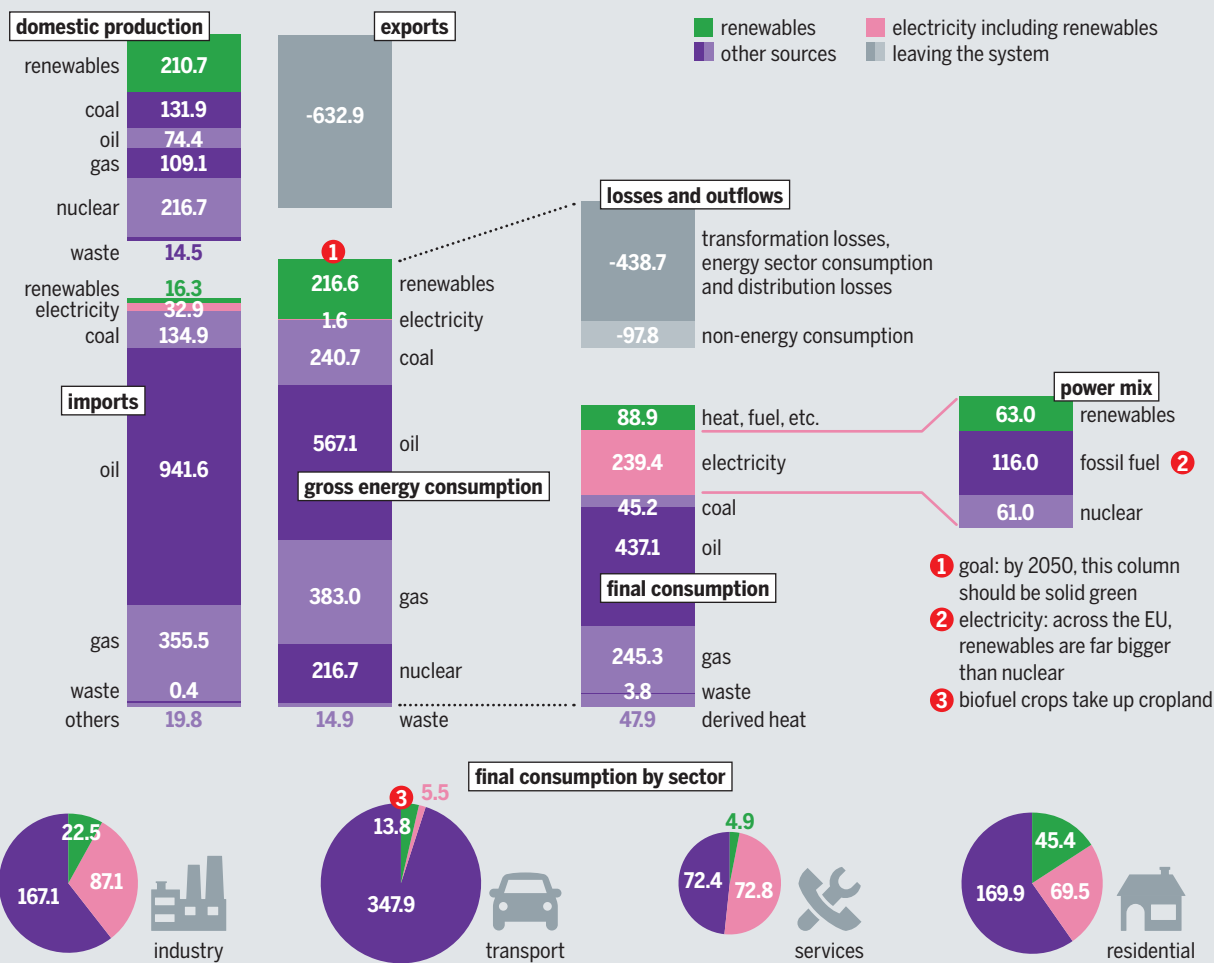
Renewable energy consumption by source, 2016, million tonnes of oil equivalent



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ENERGY FLOWS IN THE EUROPEAN UNION

Total and share of renewable energy from production to consumption, 2016, million tonnes of oil equivalent, simplified representation



Exports including marine bunkering. Coal including lignite. Non-energy consumption: mostly petrochemical products. Differences due to rounding

© ENERGY ATLAS 2018 / EUROSTAT

offshore wind power through joint tenders. Later in the year, offshore tenders for projects off the Danish and Dutch coasts saw bidders offering to generate power at record low prices. In Germany, the first-ever offshore windfarm to be built without any government support was approved in early 2017.

Despite the progress in the electricity sector, developments are often decoupled from other potential uses of renewable energy: for heating, cooling and transport.

District heating mainly uses biomass, but solar thermal is increasingly being incorporated into district heating systems, with several large projects throughout the EU. Denmark is in the lead, and in 2016, it commissioned a major solar thermal plant with 110 megawatts thermal (MWt). Countries with traditional district-heating schemes, such as Germany, Denmark, Finland and Sweden, have also modernized their facilities to allow an integrated mix of smart electric grids, large-scale heat pumps, natural-gas and thermal grids, along with energy-efficient buildings and long-term planning of infrastructure.

Europe is not a global frontrunner in geothermal development, but it is advancing nonetheless. Between 2012

Renewables are gaining, but fossil fuels still dominate the EU's energy sector

and 2016, fifty-one geothermal district-heating plants were completed, adding a capacity of about 550 MWt. In 2016, Europe had more than 260 such systems, including "cogeneration" schemes that produce both heat and electricity, with a total installed capacity of about four GWt. France, the Netherlands, Germany and Hungary lead this development.

The EU has a great potential for renewable energy. Electricity production, transportation, as well as heating and cooling can all make use of renewable energy sources. Linking these sectors together would bring even more benefits. A 2016 study by CE Delft, a research organization, found that half of all EU citizens could produce their own electricity by 2050, meeting 45 percent of the EU's energy demand. Other studies show that energy systems that are fully powered by renewables are both feasible and cost-effective. The technology already exists. The EU and its member states must step up their efforts to make the energy transition happen and to reap the benefits of renewables. ●

POLAND

WHERE COAL IS STILL KING OF THE HILL

After some initial progress towards renewable power, Poland is now treading water. A change in government has led to backtracking – this means the country will miss even its modest goals for clean power.

Poland is coal country: over 80 percent of its electricity comes from either coal or lignite. By 2017, renewables accounted for 14 percent of electricity generation, mostly from wind energy. The total energy consumption from renewables in 2016 was 11.3 percent, mostly from biomass. The National Renewable Energy Action Plan commits the country to generate at least 15 percent of its utilized energy from renewables by 2020. Poland will have serious difficulties in reaching its goal.

During the last decade, renewables at first received a boost from changes in energy market legislation, such as domestic support schemes and the introduction of European competition rules. But since 2012, big energy companies have lobbied strongly against renewables, delaying a renewable-energy bill. Since 2015, the new government has prioritized national energy security over competition practices. Investment in renewable energy sources has given way to a focus on maintaining the current power base. The few policies for renewable energy sources – a green certificates programme and support for consumers that also generate power – have been dismantled. Subsidies for small installations have been substantially reduced. An auction system for renewables has replaced the previous support scheme. The operating conditions for producers of onshore wind power

have been changed to such an extent that new installations are virtually blocked and many old operators are bankrupt or at risk.

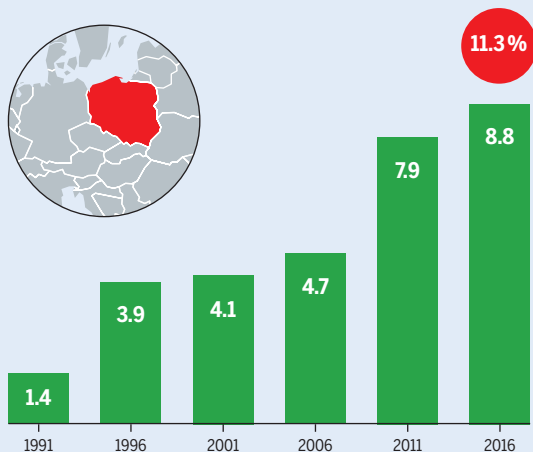
Meanwhile, big power companies have begun demanding more state support in return for stabilizing the power system. The government has changed net-metering policies. As a result, network operators have gained additional profits at the expense of owners of small renewable-energy installations. The National Fund for Environmental Protection and Water Management created “E-Kumulator”, a support programme for existing power plants to adapt to the requirements of EU air-protection directives. Overall policies for renewables have shifted from individual recipients to large energy producers and consumers.

Existing renewable energy use is based mainly on traditional sources, mostly biomass (over 70 percent). Poland’s biggest potential for renewable energy lies in the wind. The combined output of onshore and offshore wind turbines could provide as much as 27 percent of the country’s energy by 2050. Together, solar and geothermal energy could satisfy up to 20 percent of national energy needs: about the same as biomass. Solar power might be particularly useful during hot days when demand is high and traditional power plants have trouble producing enough electricity. But only 1–2 percent of the potential of solar and geothermal sources have so far been developed.

For a decade, renewables were slowly catching up the goal. But since 2015, the government has been reinvigorating the big conventional producers

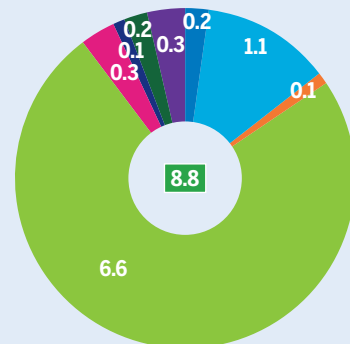
POLAND – HITTING THE BRAKES

Renewable energy consumption, million tonnes of oil equivalent, and share in gross final consumption of energy, percent



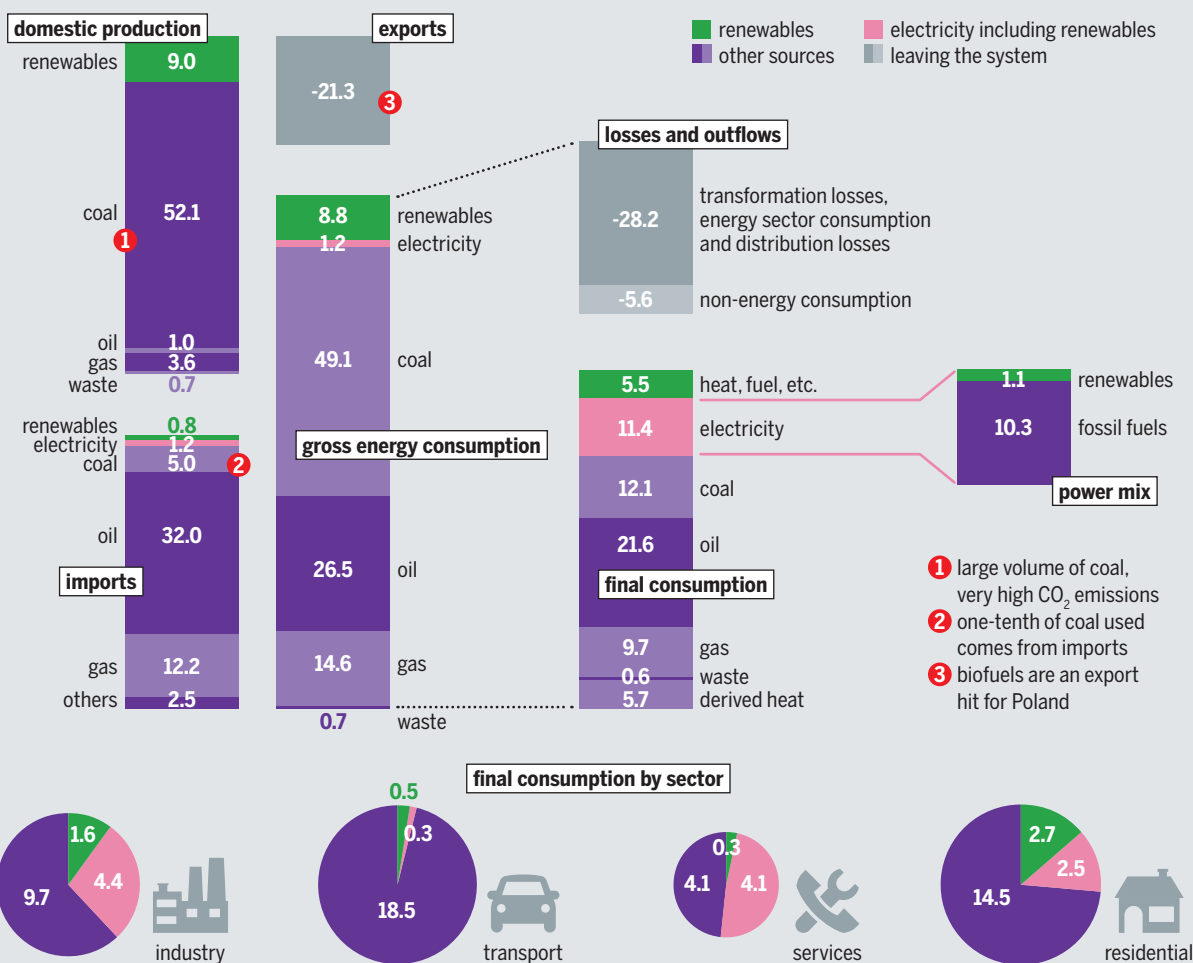
Renewable energy consumption by source, 2016, million tonnes of oil equivalent

- hydro
- wind
- solar thermal
- solid biomass (e.g. wood, crop residues)
- biogas
- waste
- bio gasoline
- biodiesel



ENERGY FLOWS IN POLAND

Total and share of renewable energy from production to consumption, 2016, million tonnes of oil equivalent, simplified representation



Exports including marine bunkering. Coal including lignite. Non-energy consumption: mostly petrochemical products. Differences due to rounding

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Coal – both lignite and bituminous – is Poland's main fossil fuel. Because it has become increasingly expensive to extract, government support for big energy companies indirectly subsidizes coal mining. In total, the average Polish citizen paid about 446 euros annually in coal subsidies and for the external costs of the coal mining sector and coal-based power generation in the period 1990–2016.

Low global coal prices have put many coal mines under heavy financial pressure, but political concerns for mine workers are delaying their closure. They are still likely to be shut down eventually. Plans to merge profitable energy companies with unprofitable mining firms have been postponed, in part due to objections by the European Commission. Meanwhile, in addition to plans to build new coal mines, new coal-extraction methods are being pursued (coal gasification) despite being uneconomic. Nevertheless, Poland is increasingly using imported coal, contrary to government declarations that it is a predominantly national resource.

Air pollution causes the most widespread harm and the biggest damage to coal's image. Polish cities have some of the worst smog in Europe. This is mainly due to ineffective heating devices, low-quality coal-burning, municipal waste

Solid biomass dominates renewables in Poland. But its potential is almost fully exploited; wind power has huge potential but needs stronger support

burning in household furnaces, and – in big cities – the large number of diesel vehicles on the roads. However, this problem is increasingly being recognized. Lesser Poland (Małopolska) and Silesia are two highly affected provinces in southern Poland that have banned the burning of low-grade coal. A nationwide ban on the sale of low-quality coal-fired burners will come into force in July 2018.

While Poland has no nuclear power, the key pillar of Poland's current energy policy is to ensure national energy security by relying mainly on domestic energy sources, including coal. Renewable energy sources are welcomed only if they do not negatively affect the national grid, which in effect means small installations which balance their production with consumption, and big, stable energy sources, i.e., biomass, geothermal, hydropower or offshore wind. Cutting greenhouse gas emissions is not the main goal, as legislators adhere to the idea that most emissions can be neutralized by carbon-sequestration in forestry. ●

CZECH REPUBLIC

GO-AND-STOP

Strongly embedded coal and nuclear power industries, coupled with a poorly designed support scheme for renewables and political uncertainty – the Czech Republic faces an uphill battle in the shift to renewables.

Just ten years ago, the Czech Republic was a leader in solar power. In 2010, the country had almost two gigawatts of photovoltaic capacity, much of it in large solar power plants. But since then, progress has stalled. The sector has had to deal with cuts in support schemes and higher taxes. In 2014, no new installations were reported.

The current government strategy is pro-nuclear and pro-coal. Power generation is currently dominated by coal (49 percent in 2015) and nuclear (32 percent). The State Energy Policy, the government’s key energy policy document, regards these fuels as strategic and important for energy security. The country has sizeable coal and lignite reserves, and it exports coal to its neighbours. It has the highest per-capita CO₂ emissions from coal in Europe. With two existing nuclear power plants and two new reactors planned, nuclear energy is considered a reliable, low-cost source of power. The uranium fuel is imported, but the government argues that nuclear reactors need only small amounts.

The Czech Republic plays a big role in the Central European energy market as its transmission system is highly interconnected with networks in neighbouring countries. Due to its location, the country acts as an important transit hub. It is also one of the world’s biggest electricity net exporters: in 2014, 41.5 percent of its exports went to Austria, 33.3 percent to Slovakia and 19.2 percent to Germany.

In contrast to coal and nuclear, renewables are considered secondary sources. Policy documents emphasize their

limits rather than their potential. The government’s National Action Plan for renewables, drawn up to comply with European legislation, aims to increase the share of renewables to 15.3 percent of overall gross consumption by 2020, an increase of almost 10 percentage points since 2005. This target has been criticized as too low and “business as usual” by environmental groups and renewable-energy advocates.

A support scheme for renewables originated as green bonuses and guaranteed purchase prices. It has undergone many changes since it was introduced in 2005. Highly advantageous conditions were attached to the subsidies to help reach the renewables targets. Falling prices of photovoltaic technology led to an unpredicted boom in installed capacity, and, paradoxically, to higher electricity prices. The utilities were forced to buy the renewable power at high rates and charge other users extra in order to cover the cost.

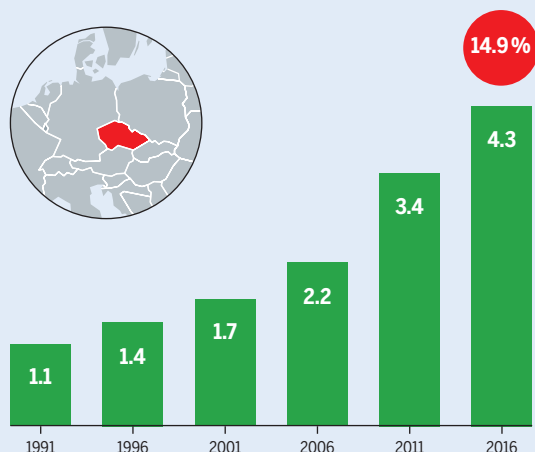
This harmed the reputation of renewables in the eyes of the public. Unstable domestic politics and government changes hindered flexible reactions such as adapting the purchase prices. Traditional energy utilities such as ČEZ, a government-controlled conglomerate, lobbied against renewables. The support scheme for new plants was stopped in 2013.

Although the decline in support for renewables was opposed by investors and non-government organizations, hardly any new renewable energy facilities have been built since. But prospects are brightening again. The government has introduced investment grants for both large and small installations on the rooftops of private companies. In late

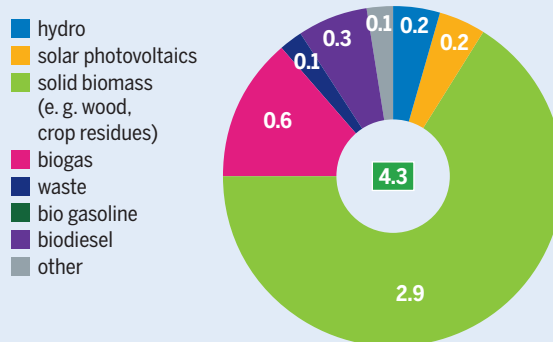
The Czech government wants to keep its centrally managed power supply. That makes life difficult for decentralized renewables

A PATH OF GROWTH IN THE CZECH REPUBLIC

Renewable energy consumption, million tonnes of oil equivalent, and share in gross final consumption of energy, percent



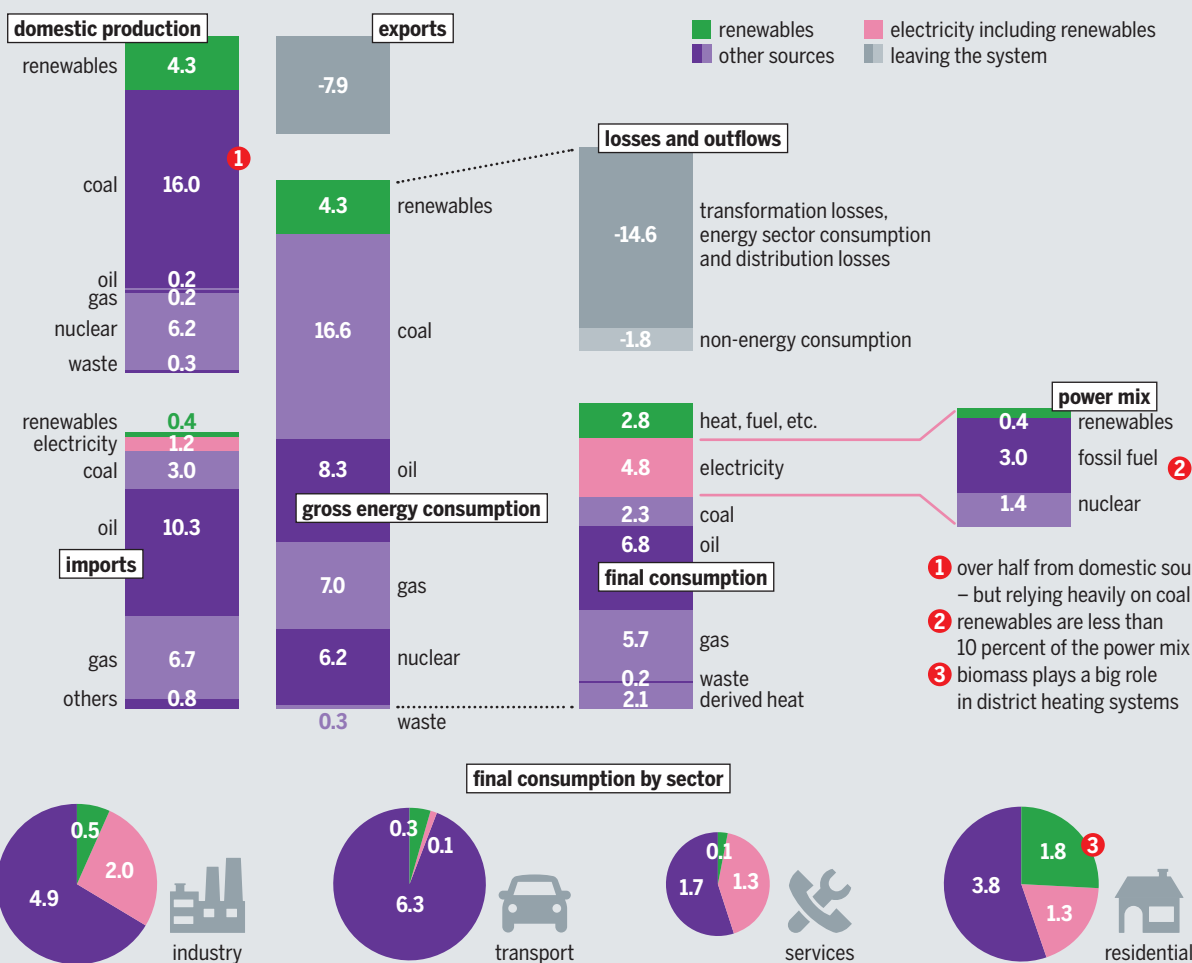
Renewable energy consumption by source, 2016, million tonnes of oil equivalent



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ENERGY FLOWS IN THE CZECH REPUBLIC

Total and share of renewable energy from production to consumption, 2016, million tonnes of oil equivalent, simplified representation



Exports including marine bunkering. Coal including lignite. Non-energy consumption: mostly petrochemical products. Differences due to rounding

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2017, the government was considering the introduction of renewable energy auctions, which would effectively bring state support for new facilities back in place.

Greater potential for renewables certainly exists, though how much is subject to dispute. Independent experts calculate that renewables, plus cutting-edge technologies, better insulation and efficient appliances, could cover up to 76 percent of electricity demand by 2050, up from 12.8 percent in 2015. The government takes a less rosy view: it forecasts that renewables will make up just 23 percent of gross generation in 2045.

The government has drawn up a “green” scenario parallel to the official one, with priorities such as decarbonization, energy savings and extensive subsidies for renewables. Nonetheless, this scenario has not been acknowledged in the official strategy. The government concedes that coal use will cease in several decades, but is turning to nuclear power rather than renewables. It opposes many of the EU’s decarbonization rules and often implements them only formally and with reluctance.

Both the grid operator and government claim that decentralized, renewable electricity generation might desta-

Even the energy profile of renewables is conventional: the direct use of heat through district heating systems is technically less demanding than converting it to electricity

bilize the grid. Experiences in countries with higher shares of renewables, such as Denmark, Germany and the United Kingdom, do not support these fears. Indeed, a 2010 study commissioned by ČEPS, the grid operator, indicated that the grid could accommodate double or triple the current wind and solar capacity by 2015.

Public opinion on renewables is changing. Approval for renewables hit a low when subsidies were ended. But inspired by other European countries, communities have rediscovered their interest in operating their own renewables. Over 40 percent of the population now believe it is possible to replace traditional energy sources with renewables. Support for renewables is likely to increase in the future. But coal’s strong position in the energy mix, the availability of nuclear power to secure supply, and fears of introducing decentralized models into a strongly centralized energy market continue to hamper the growth of renewables – and the Czech energy transition. ●

GREECE

CLOUDS WHERE THE SUN SHOULD SHINE

Plentiful sunshine and breezy seas and mountains: Greece has strong potential for renewable energy. But the country's debt problems have stalled progress towards a cleaner future.

With 50 percent more solar irradiation per square metre than Germany, Greece has among the highest potential for renewable energy in Europe. But only a small fraction is actually being used. Overcast Germany has installed more than double the solar photovoltaic capacity (499 watts per person) than sunny Greece (240 watts). Greece's wind energy potential is also grossly underutilized. The islands of the southern Aegean (excluding Crete) are an example: they could generate around 6,000 megawatts (MW) from wind – more than 70 times the current capacity – even taking into account constraints such as planning restrictions and the need to protect nature and archaeological sites. Installing, operating and maintaining the turbines could create more than 1,100 jobs.

Europe's first wind turbine was installed on the island of Kythnos in 1982. Greece's renewable energy has since expanded significantly, mainly due to a favourable feed-in-tariff and the priority given by the grid to absorbing renewable electricity. Between 2007 and 2016, wind capacity more than doubled from 846 MW to 2,374 MW. Photovoltaic capacity expanded from a mere 9 MW in 2007 to 2,611 MW in 2016.

Rising renewable capacity along with a fall in demand due to the economic crisis has led to renewables increas-

ing their share of Greece's electricity mix. 2016 was a historic year: renewables, including large hydro, supplied 30 percent of the power in mainland Greece's grid, for the first time surpassing lignite, which fell to an all-time low of 29 percent.

Two factors drove this growth. One was a 2009 European Commission Directive on energy, which triggered an ambitious national law to promote renewable sources. The second was a fall in the cost of installing renewables: between 2007 and 2014, the price of photovoltaic modules fell by 79 percent; that of wind turbines dropped 25 percent. These drivers helped overcome other longstanding barriers: the lack of coordination among authorities, delays in issuing permits, uncertain rights to land, and shortcomings in spatial planning.

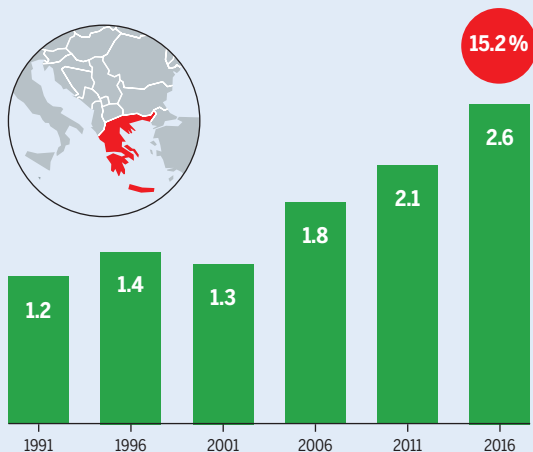
But the 2014 financial crisis in Greece stalled the growth in renewables. First, a special account that pays renewable producers fell deep into the red. As part of its debt-relief agreement with its main creditors, the government undertook to eliminate this deficit. It cut inflated photovoltaic tariffs, with retroactive effect. But the cuts also extended to wind and small hydro, which were not to blame for the deficit. And the cuts burden only the producers of renewables, although fossil fuels contributed significantly to its size.

Second, the capital controls imposed in 2015 have aggravated the problems that the Greek banking system has

Lots of ideas. But a lack of political support is slowing the uptake of renewable energy

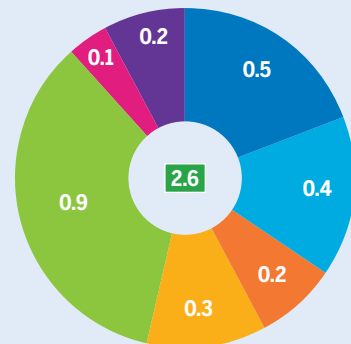
GREECE – THE SLOW STARTER

Renewable energy consumption, million tonnes of oil equivalent, and share in gross final consumption of energy, percent



Renewable energy consumption by source, 2016, million tonnes of oil equivalent

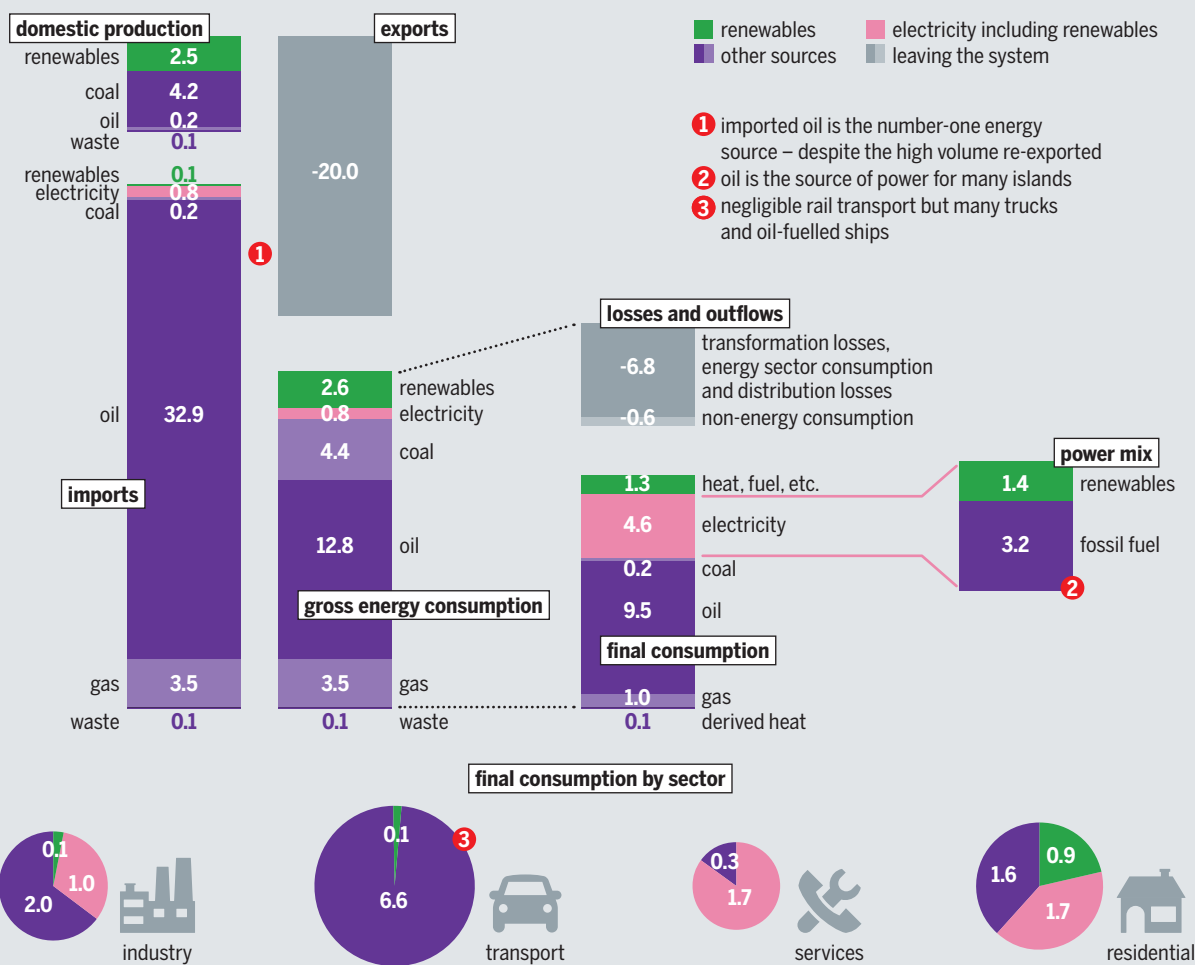
- hydro
- wind
- solar thermal
- solar photovoltaics
- solid biomass (e.g. wood, crop residues)
- biogas
- biodiesel



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ENERGY FLOWS IN GREECE

Total and share of renewable energy from production to consumption, 2016, million tonnes of oil equivalent, simplified representation



Exports including marine bunkering. Coal including lignite. Non-energy consumption: mostly petrochemical products. Differences due to rounding

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been facing since 2010. The country's cost of capital is now 12.6 percent, seven times higher than for Germany, making investments in renewables in Greece very risky. The national goal of a 40 percent share of electricity consumption for renewables by 2020 is now out of sight.

A draft law for "energy communities", slated for 2018, would recognize citizens' rights to produce, store, sell and consume their own energy. This is a step in the right direction: local organizations could become a vehicle for an equitable energy transition in Greece. They would also help assuage local resistance, especially in the many islands not connected to the mainland grid, where groups opposing wind energy have emerged. Technological solutions exist for islands that currently rely on fossil-fuel-based generators to switch to green power. The island of Tilos, near Rhodes, for example, has installed wind turbines, solar panels and batteries, along with a smart energy management system that can manage the local micro-grid.

The immediate forecast looks overcast. Renewable-energy producers will have to adapt to a new support scheme that ditches a feed-in-tariff system in favour of electricity auctions. They will also have to compete with fossil fuels, which

Greece relies heavily on imported oil and low-calorific lignite, limiting its potential to develop renewable energy sources

have powerful political backers. The government-controlled Public Power Corporation, for example, is constructing a new 660 MW lignite plant and is planning another one to generate 450 MW, despite the decline in the economics of lignite. Both the corporation and the government seem intent on persisting with oil-based power for islands that are not yet on the grid, and inter-island connections are proceeding slowly. The government also supports the construction of the EastMed pipeline to transfer gas from Israel and Cyprus to Italy through Greece.

A change in the political weather would make the outlook sunnier. The national energy market could be fully integrated, and collaboration with neighbouring Balkan countries could be intensified. Funds from the European Union Emission Trading Scheme could accelerate inter-island connections, and renewables could be developed in the non-connected islands. Such initiatives could help Greece become a true hub for green energy. ●

SPAIN

RICH IN SUN, POOR IN POLITICS

Sun-drenched and zephyr-kissed, Spain occupies a corner of Europe that is ideal for solar and wind power. After an initial surge of investment in renewables, the flaws of the government's energy policy became evident, and the authorities slammed the brakes on investment. There are signs that they may now be relenting.

With its windy mountains and plains, and many hours of bright sunshine each year, Spain has huge potential to develop renewable energy. In 2016, wind was the dominant source of power from renewables, which as a whole already contributed close to 40 percent of the electricity generated. In Europe, Spain is second only to Germany in terms of wind-power generation; it is fourth worldwide. Wind power contributes around 18 percent to gross electricity consumption, followed by hydro with 13 percent. Solar photovoltaics have huge potential but so far provided only 3 percent to the country's electricity mix. According to Greenpeace, Spain's renewable sources could generate much more electricity than the country currently uses.

The government's goal is to reach 20 percent renewables in total energy consumption (including heating and transport) by 2020. Between 2004 and 2012, the share of renewables in the overall energy mix grew from 8.3 to 14.3 percent, and Spain was regarded as an international leader in the field. However, policy changes have stalled this growth. An interim target was 16.7 percent for 2015, but Spain fell short by 1 percent. Experts now find it hard to believe that it will achieve the remaining 4 percent by 2020. They fear that Spain is jeopardizing its leading role.

The previous strong growth was driven by an effective feed-in tariff policy for renewables. This set a generous payment, especially for solar photovoltaics, and no overall ceiling for new installations. But the surge in investments led to significant overcapacity as new installations came on line, while demand stalled because of the economic crisis. Meanwhile, older conventional plants were not retired to make way for the renewables.

A poorly designed electricity-tariff system is at the root of the problem. The government compensates energy firms if the generation costs are higher than the amount the firms are allowed to charge their customers. Bills for such compensation have ballooned, and the state now owes the firms a huge sum: €25 billion, or 2.5 percent of the gross domestic product.

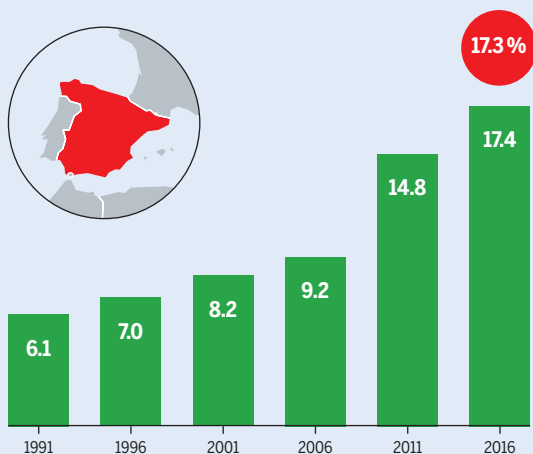
Between 2012 and 2015, the government made several changes to the policy, reducing future support and even introducing retroactive cuts. It is trying to tackle the deficit in three ways. First, it has increased the price consumers are charged for power – especially those who use less than 20 megawatt hours (MWh) a year, which includes households and small businesses. As a result, electricity prices have risen to nearly €300 per MWh, one of the highest in the EU.

Second, it has weakened the feed-in tariff policy by cutting payments for renewables. That, in turn, has created further uncertainty in the renewable sector. The costs of the so-called tariff deficit have fallen at the expense of renewable energy deployment. More than 80,000 workers in the renewables sector have lost their jobs.

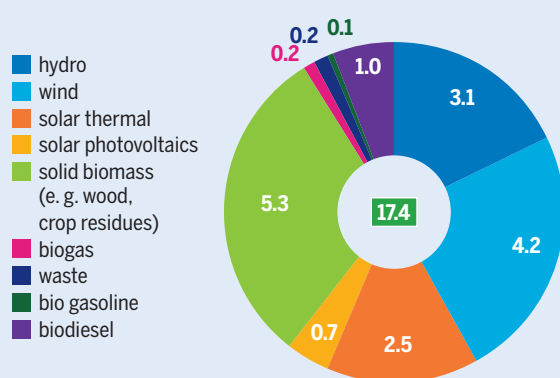
Ten years ago, Europe looked to Spain with its rapidly expanding renewables sector. Such glory days are in the past

SPAIN – YESTERDAY'S STAR

Renewable energy consumption, million tonnes of oil equivalent, and share in gross final consumption of energy, percent



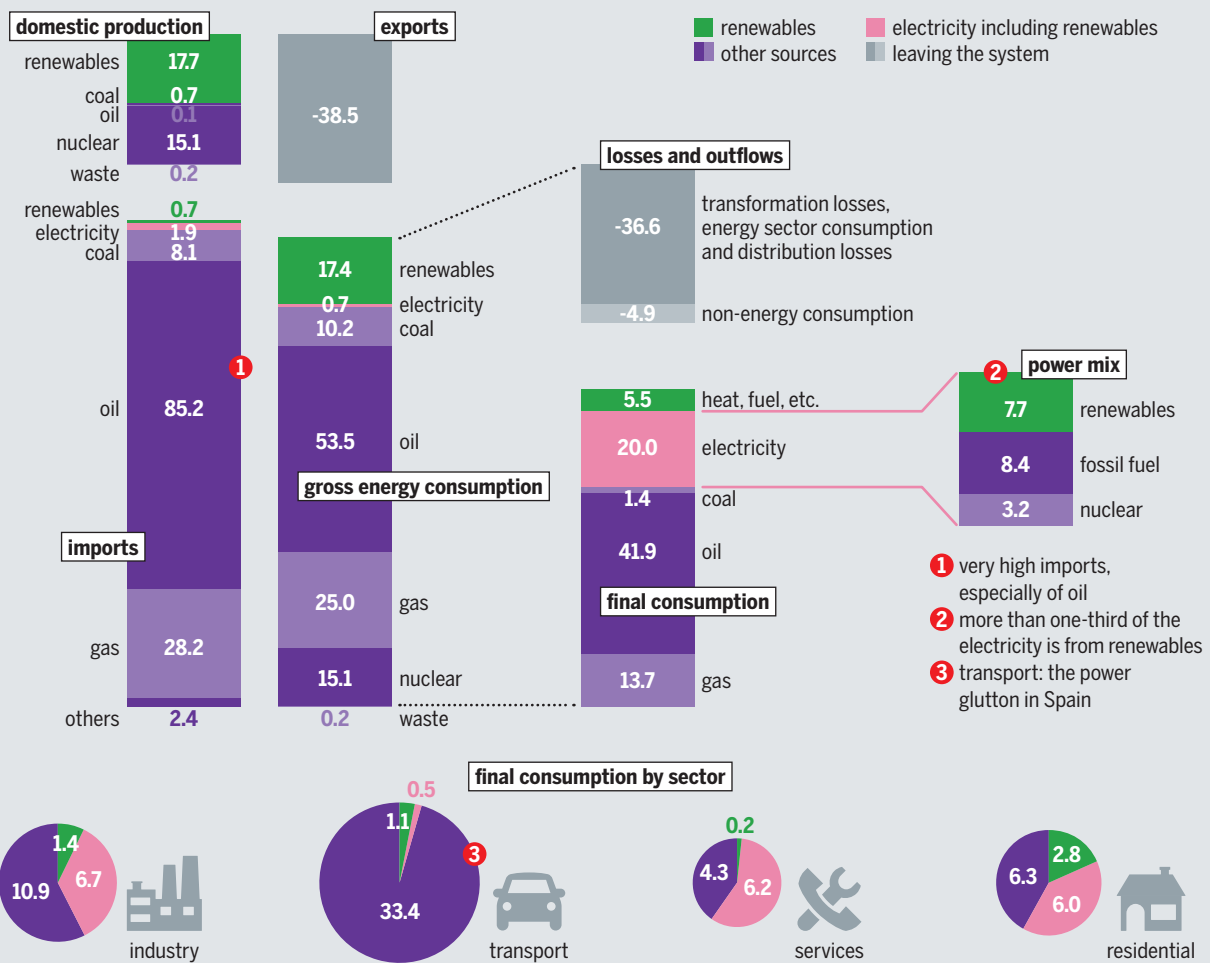
Renewable energy consumption by source, 2016, million tonnes of oil equivalent



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ENERGY FLOWS IN SPAIN

Total and share of renewable energy from production to consumption, 2016, million tonnes of oil equivalent, simplified representation



Exports including marine bunkering. Coal including lignite. Non-energy consumption: mostly petrochemical products. Differences due to rounding

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A major shift towards renewables would dramatically cut Spain's dependence on oil

Finally, the government has limited its promotion of renewable energy. It introduced a “sun tax” on self-consumption facilities (such as solar rooftops), arguing the tax was needed to cover additional system costs. Owners of solar panels must now pay a fee to maintain access to the network if they consume the electricity they themselves produce. This measure forces the owners to feed their excess power into the grid at low prices, depriving them the benefit of their own power. Levels of self-consumption have fallen to near zero as a result.

These changes have caused a lot of uncertainty, and investment in renewables has dropped. In 2012–15, their share of final energy consumption rose slowly, from 14.3 to 16.2 percent, making it one of the slowest rates in Europe. Between 2013 and 2015, installed wind power grew by more than 20 percent in Europe as a whole; in Spain, it rose by only 0.07 percent. The situation for photovoltaics was no better: generation grew by 15 percent in Europe as a whole over the same period, but in Spain by just 0.3 percent.

On the bright side, the public energy debate has gone from being non-existent to a hot topic, blending themes such as the need for a more sustainable society and for dem-

ocratic energy management. Today, cooperatives and marketing companies are multiplying, and municipal initiatives are focused on developing sustainable energy, self-generation and democratization of the model. It seems likely that citizens will push national energy policy in a sustainable direction.

Spain offers ideal geographical conditions for the development of renewable energies. Its potential for large-scale wind and solar power is among the highest in Europe. But renewables face a hostile regulatory and political environment, with the government trying to control costs and protect old power plants by preventing a further boom in renewables. However, such domestic constraints may be weakened soon. A revised EU Renewable Energy Directive could push Spain to take a more proactive stance on its energy transition. Renewables may then regain the legal and investment security needed to bring about Spain's energy transition. ●

FRANCE

ADDICTED TO ATOMS

France has long relied heavily on nuclear power. Weaning itself off this dependency and switching to renewables is proving tricky. Questions include how to overcome bureaucratic hurdles and how quickly to phase out the country's nuclear plants.

Known for its attachment to the nuclear reactors that generate up to 75 percent of its electricity, France has recently embraced a shift to renewable sources. A national debate on energy transition, organized by the government, took place between November 2012 and July 2013. It invited all the major stakeholders to create a vision for a post-nuclear, low-carbon future.

In 2015, the country adopted its first energy-transition bill. This law lays out ambitious long-term objectives with plans to cut greenhouse gas emissions by 75 percent compared to 1990 levels, and halve final energy consumption by 2050. Milestones include reducing nuclear's share of power generation from 75 percent to 50 percent by 2025, and achieving a 32 percent share of renewable energy in its final energy consumption and a 40 percent share of power generation by 2030.

Such a commitment to renewable energy is not entirely new. In the 1940s, France invested heavily in hydropower. However, the oil price shocks of the 1970s led it to develop one of the world's largest nuclear sectors, with 58 reactors capable of producing 63 gigawatts (GW). Hydro currently provides the lion's share of the country's renewable power, with a total of 25 GW generation capacity. Its pumped-storage capabilities also give it the flexibility needed to cope with high peak loads in winter: one-third of the national building stock uses electric heating. Biomass, mainly wood,

plays a big role in heating, covering over 40 percent of total primary renewable energy consumption.

France aims to achieve a 23 percent share of renewables in its gross final energy consumption by 2020. Despite recent progress, it will have to put in more effort to achieve this objective. A multiannual energy plan adopted in 2016 lays out some intermediate milestones for renewables, including a 70 percent rise in generation capacity and a 36 percent increase in heat production.

In terms of natural resources, France has one of the highest renewable energy potentials in Europe. In 2016, Ademe, the national environment and energy agency, published a study showing that a 100 percent renewable electricity system would be possible by 2050, and at limited cost. In 2017, négaWatt, an association of energy specialists, published a long-term scenario showing how the country could achieve a 100 percent renewable, carbon-neutral energy system for all sectors, including transport, by 2050.

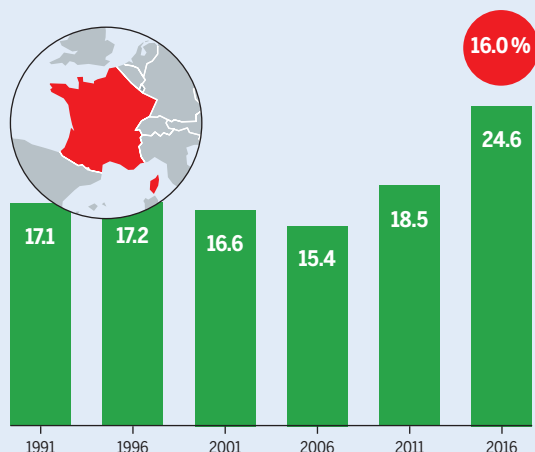
Solar and wind are the renewable sectors experiencing the most dynamic growth in recent years. Between 2010 and 2016, onshore wind-power capacity doubled to 12 GW; the objective is to hit 22–26 GW by 2023. Solar power increased eightfold over the same period, though from a smaller base. By the end of 2016, solar produced almost 7 GW; the target for 2023 is 18–20 GW. Generation costs have plummeted in the past few years – by almost nine-tenths in 10 years for photovoltaics.

But regulatory problems have hindered the deployment of renewable power. Feed-in tariffs were implemented in the

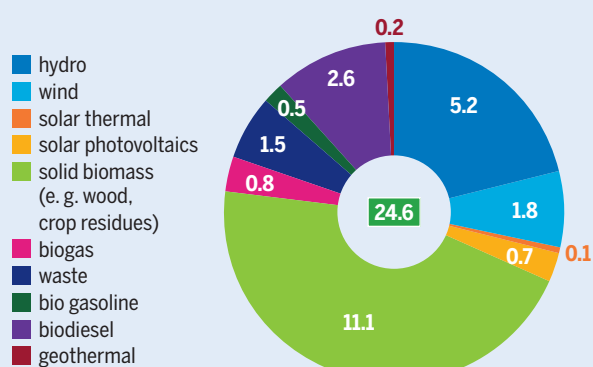
Nuclear power does not emit CO₂. But France began to rethink its energy strategy after the Fukushima catastrophe

FRANCE – THE LATE STARTER

Renewable energy consumption, million tonnes of oil equivalent, and share in gross final consumption of energy, percent



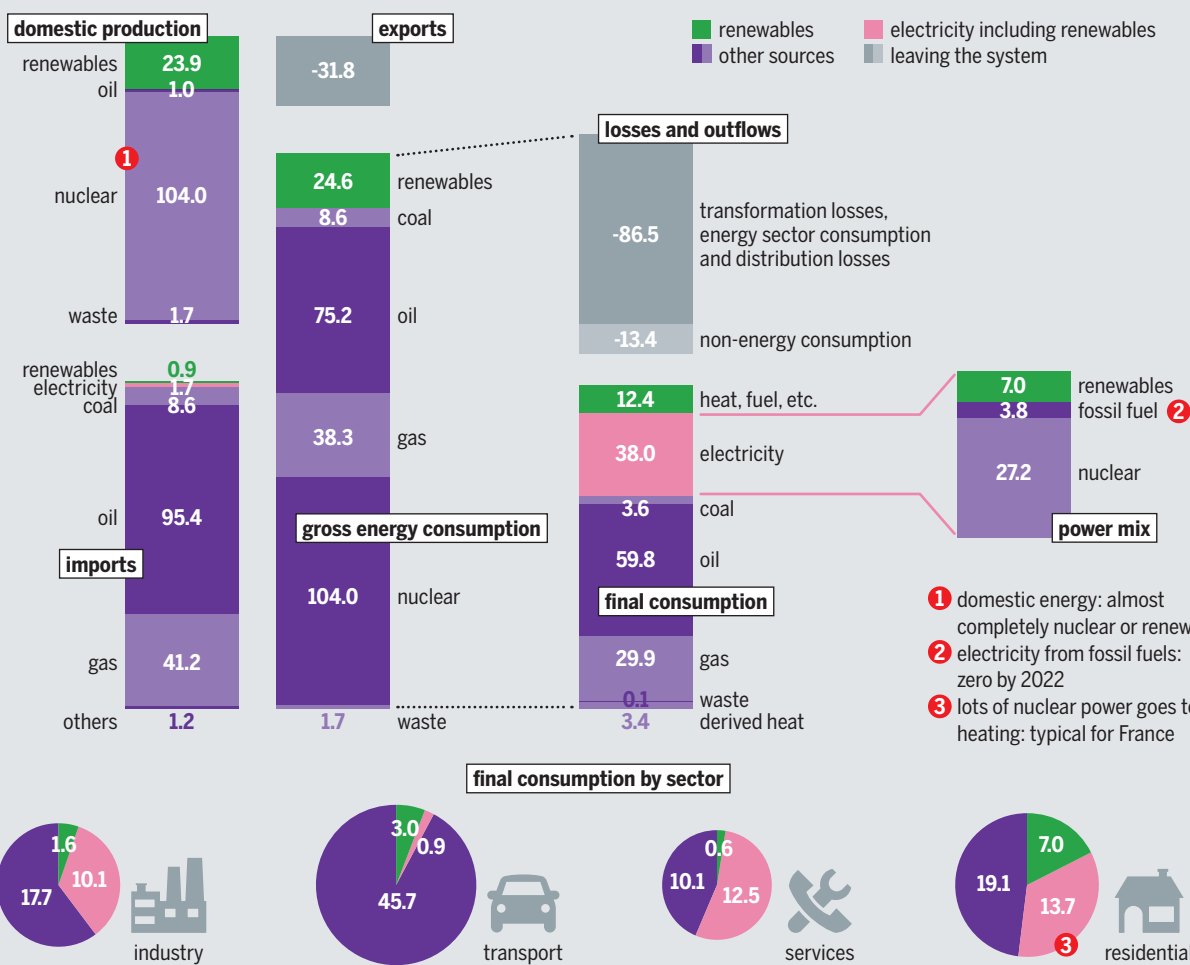
Renewable energy consumption by source, 2016, million tonnes of oil equivalent



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ENERGY FLOWS IN FRANCE

Total and share of renewable energy from production to consumption, 2016, million tonnes of oil equivalent, simplified representation



Exports including marine bunkering. Coal including lignite. Non-energy consumption: mostly petrochemical products. Differences due to rounding

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early 2000s, but suffered from stop-and-go politics; administrative hurdles have delayed permits and grid connections. Like other countries in Europe, France has evolved towards more market-oriented support mechanisms since 2014. These include market premiums and competitive tenders (primarily for solar, biomass and offshore wind) – although these entail greater financial risk. A 2015 energy transition law addresses some of these problems, but further progress is needed if the target of doubling deployment rates is to be achieved.

Competition with nuclear power is another major obstacle. In 2017, the bulk of the nuclear reactors will have an average age of 32 years and will reach their initial lifetime of 40 years in the coming decade. But Électricité de France, the government-controlled operator, plans to extend their period of operation to 60 years to benefit from the plants' very low generation costs. That is despite the concerns of the Nuclear Safety Authority and uncertainties about the technical and economic feasibility. The cost of refurbishing the reactors has been estimated at 55 billion euros: that is money that would have to come from the public purse and that could instead be invested in renewables.

Its huge nuclear sector gives France the most unusual energy profile in the EU – as well as the biggest challenge to wean itself off atoms

Cutting nuclear power from 75 percent to 50 percent by 2025 is the most challenging target in the energy plan, as illustrated by the fact that the government announced its intention to postpone the target towards 2030. Indeed, if electricity consumption were to remain stable, extending the life of reactors would be unnecessary. On the contrary, retaining a lot of nuclear capacity while speeding up the deployment of renewables could lead to overcapacity and a drop in wholesale prices for electricity.

Coordination with European climate and energy politics is also vital, considering France's political influence and its location at the heart of Europe's energy market. Recently, President Macron has proposed a Europe-wide floor price for CO₂ as part of the European Emissions Trading Scheme. Despite past disagreements over nuclear power, the energy transition strategies of France and Germany are converging, opening new opportunities for bilateral cooperation and perhaps stronger ambitions for the EU as a whole. ●

GERMANY

TURNING AROUND, BUT NOT YET ON COURSE

Germany's energy transition includes phasing out nuclear power, reducing the use of fossil fuels, and massive investment in renewables. That is in itself a big challenge, but there is more to come: the country also needs to convert its heating, cooling and transportation sectors to renewable energy.

Germany is often praised as being the frontrunner in the transition to renewable energy. It is shutting down its nuclear power plants by 2022, and their capacity will be largely replaced by renewables. Today, the country already produces 36 percent of its electrical energy from renewable sources, mostly wind and solar. Its long-term goal is to reach 80–95 percent by 2050. Interim goals are for 45 percent in 2025 and 65 percent in 2035. Germany has already come a long way down this path.

A “feed-in tariff”, which sets a fixed tariff for every kilowatt-hour of electricity fed into the grid, has been a key driver of this trend because of the stable investment situation it has created. The tariff has been reset every year to reflect the falling costs of wind and solar technologies; it usually triggers a 5–7 percent return on investment. It has allowed ordinary citizens, farmers, communities, municipalities and cooperatives to all play a role in shaping Germany’s “Energiewende”, or energy transition. Another key element of this policy is a rule that gives priority access to the grid for electricity produced from renewable sources.

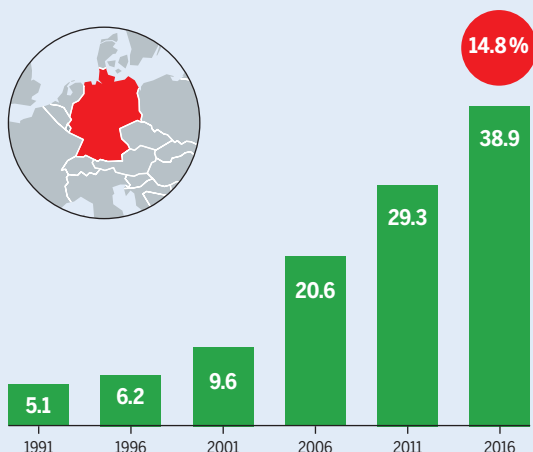
The feed-in tariff has helped Germany reach its renewable-energy goals far earlier than anyone had anticipated when the policy was first formulated in 1990. But this excellent track record has led to a new set of challenges and policy adjustments. From 2016 onwards, large solar and wind installations with more than 750 KW capacity no longer qualify for a feed-in tariff but instead must bid in a government-managed auction. The new rules favour large developers who can more easily submit the most competitive bids. Citizens, farmers and cooperatives are just bystanders again.

The biggest challenge in Germany's transition is to align the old system with the new one based on renewables. The country's traditional power utilities have had to do some drastic rethinking. At first they did not believe that renewables could play such a big role in the energy mix. The new sources of power require investment in infrastructure and digitalization to align supply and demand. They also require a stronger coupling between sectors: spreading electrification into heating, cooling and transportation. At the moment, the Energiewende targets only electricity, which accounts for just 20 percent of the energy sector as a whole. However, since heating, cooling and transport make up the remaining 80 percent and run predominantly on conventional fuels, these sectors must also be addressed if Germany

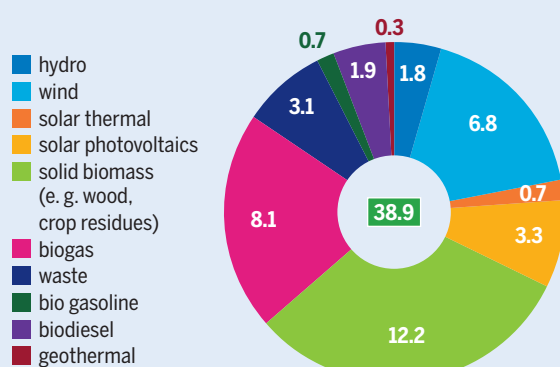
A decisive break with lignite-fuelled power stations and the internal-combustion engine would boost the demand and supply of renewable energy in Germany

GERMANY – PROGRESS, BUT ONLY IN ELECTRICITY

Renewable energy consumption, million tonnes of oil equivalent, and share in gross final consumption of energy, percent



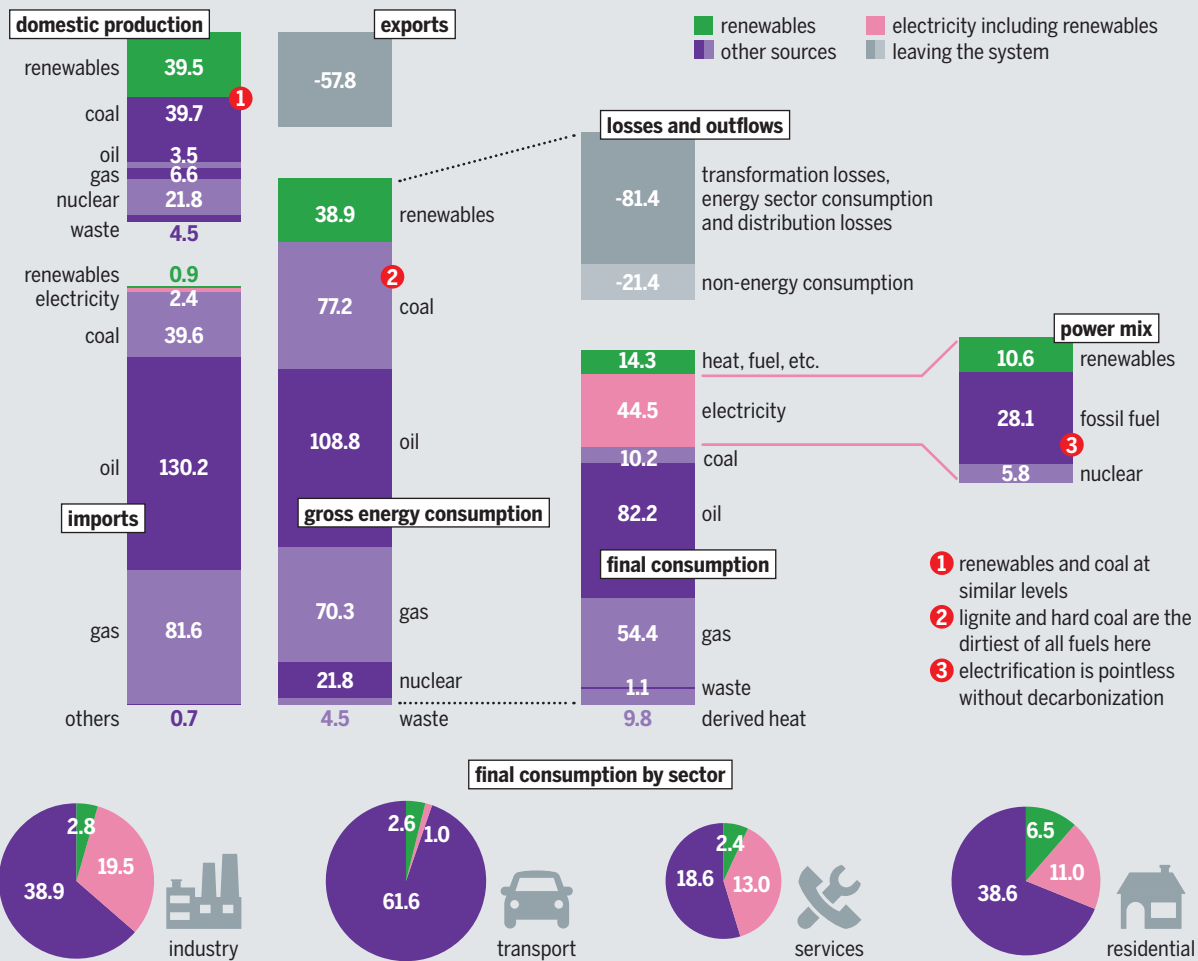
Renewable energy consumption by source, 2016, million tonnes of oil equivalent



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ENERGY FLOWS IN GERMANY

Total and share of renewable energy from production to consumption, 2016, million tonnes of oil equivalent, simplified representation



Exports including marine bunkering. Coal including lignite. Non-energy consumption: mostly petrochemical products. Differences due to rounding

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intends to accomplish its transition. This can only be achieved by investing in smart meters, infrastructure for electric vehicles, battery storage capacity – and getting serious about decreasing its energy consumption significantly.

Germany is pushing ahead with its energy transition for two reasons: to reduce its dependence on imported fossil fuels, and to comply with its goals to reduce greenhouse-gas emissions. The country currently imports 61 percent of its energy, often from places with unstable regimes. The energy transition has reduced such imports. But the growth of renewables has not significantly decreased emission levels. This is partly because Germany produces far more electricity than it needs; in 2016 it exported around 9 percent of the power it produced.

About 40 percent of the electricity generated comes from burning coal, a very carbon-intensive source. The 100-or-so coal-fired power plants in Germany emit about one-third of the country's total emissions. Therefore, phasing out coal is important if the country is to meet its national climate targets. But as things stand, it will miss its goal of a 40 percent reduction in emissions by 2020.

Renewables have overtaken nuclear in all parts of the energy system – but they still have to catch up with fossil fuels

Germany's geographical position in the centre of Europe has been a boon: it can fall back on its neighbours as a flexible back-up. Whenever Germany does not produce enough power because of a lull in the wind or cloudy skies, it can resort to imports. As a result, the country has never itself had to invest in flexibility in generation or storage. Coupling with the heating, cooling and transport sectors means that policymakers will have to work out how to orchestrate a truly sustainable energy system of the future. This is particularly true for vehicles, which are still a long way from being decarbonized.

Much of the public debate sees the energy transition positively, in part because of the citizens' involvement in the Energiewende. Around 334,000 people are directly employed in the renewable energy sector – far more than in fossil fuels. But this positive perception could change if the energy transition appears to benefit large corporations rather than ordinary citizens. ●

NEIGHBOURS

POWER TO ALL OUR FRIENDS: THE INCONSISTENCY OF POLICIES

The tier of countries to the east and south of the European Union are a source of energy imports as well as a potential source of instability. The EU neighbourhood policy wants to contribute to carbon emission reduction. But large-scale investments in new pipelines undermines these goals.

Despite progress with renewables, the European Union still imports 54 percent of its energy needs, including 90 percent of its crude oil and 69 percent of its natural gas. This import dependency comes at a high price. In 2013, the EU spent 403 billion euros for fuel imports, falling to 261 billion euros in 2015. This drop does not reflect lower demand but a fall in world market prices – indicating the EU’s vulnerability to price volatility.

Another worry is overreliance on a few energy exporters. The EU imports 28 percent of its crude oil from Russia, 11 percent from Norway, 8 percent from Nigeria and another 8 percent from Saudi Arabia. Russia (29 percent) and Norway (26 percent) are the two biggest sources for gas imports, followed by Algeria (9 percent) and Qatar (6 percent). For both these types of fuels, more than half comes from just four countries. That raises security and dependency concerns.

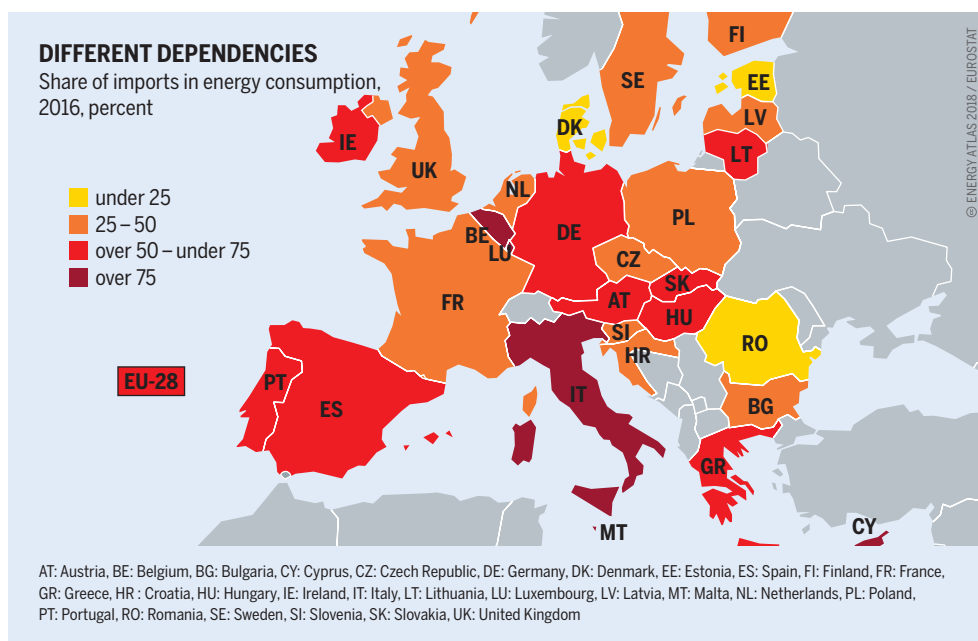
Some of the EU’s neighbours already enjoy close ties (such as Norway and Switzerland) or are candidates for accession (such as the countries of the western Balkans). The EU manages its relationships with its other neighbours (ex-

cept Russia) through the European Neighbourhood Policy, which focuses on the promotion of democracy, the rule of law and the free market. Energy issues are only one element of this policy.

The Neighbourhood Policy consists of two parts: the Eastern Partnership and the Union for the Mediterranean. The Eastern Partnership covers relations with Belarus, Moldova and Ukraine in eastern Europe and Armenia, Azerbaijan and Georgia in the southern Caucasus. It encourages economic development in these countries but puts a lot of emphasis on energy security and on ensuring natural gas supplies from Russia, via Ukraine, to EU member states. The main aim is to maintain and secure fossil-fuel imports – a strategy that perpetuates the EU’s dependence on these energy sources.

In terms of renewables, the Eastern Partnership promotes the development of clean energy sources in accordance with the EU’s internal market. Other energy-related aspects include promoting energy efficiency, increasing interconnectivity, reducing emissions and adapting to climate change. In contrast, the Union for the Mediterranean emphasizes regulatory and market liberalization issues. Energy and climate action are one of six strategic priority areas, and unlike the Eastern Partnership, the Union focuses less on energy security issues per se. The development of solar and wind power in the hot, dry countries around the Mediterranean represent an economic stimulus, supporting the democratization of the region’s societies through sustainable economic development.

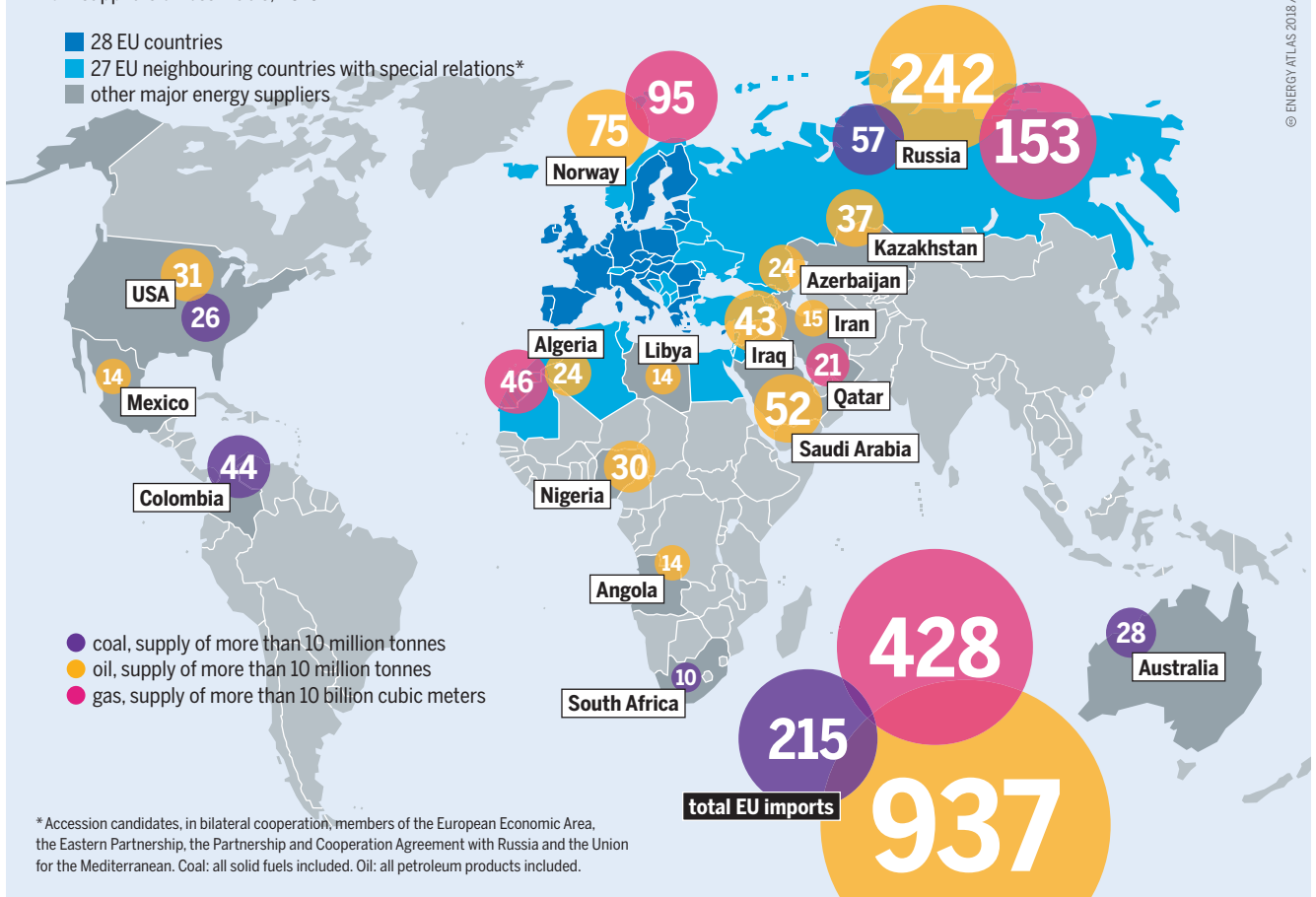
The EU still sees the diversification of gas and oil supplies, including structural changes in the gas market, as essential



Energy security is a concern of all EU countries – but they are affected to very different degrees

WHO SUPPLIES EUROPE? THE GLOBAL CONCERNS OF EU ENERGY IMPORTS

Main suppliers of fossil fuels, 2016



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to increasing its energy security in the short and medium term. Liquefied natural gas (LNG) has turned the gas trade into a global market. LNG does not need pipelines; it can be shipped. By 2016, LNG accounted for one eighth (48.7 billion m³) of total EU gas imports. As many as 17 countries are LNG exporters, freeing importers from being held hostage by a single, dominant gas supplier. LNG makes it possible to create a global, not regional, or local gas market, which results in more competition between exporters.

But attempts to diversify supplies and reduce the share of gas from Russia collide with numerous political obstacles. Investments in gas infrastructure such as the Nord Stream II pipeline between Russia and Germany threaten to perpetuate reliance and lock in carbon-intensive infrastructure; this basically undermines the goals of achieving energy security and reducing the carbon footprint of the energy sector. The goals of the Neighbourhood Policy are thus inconsistent with the EU's commitments under the Paris Agreement to cut its CO₂ output.

The interests of the rapidly changing eastern members of the EU and its older western members often diverge, as do the geopolitical conditions and long-term common interests of member states. A solution lies in improving energy

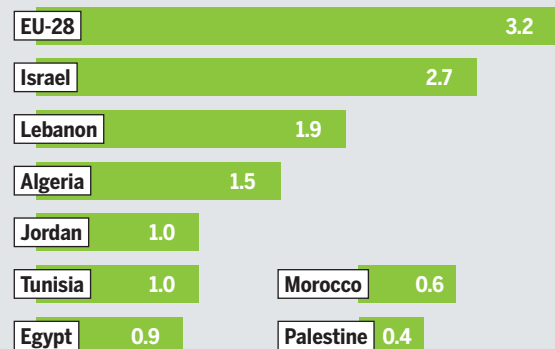
Most of Europe's southern neighbours consume little energy. Europe can help them develop their renewable energy sources

An evident dependence on Russian energy is a crucial challenge for EU foreign and security policy

efficiency and developing renewables so as to reduce dependency on imports. At the same time, the EU can help its eastern and southern neighbours develop their own renewable energy sources, improving their energy efficiency and building interconnections that enable them to trade power and even out bumps in supplies. ●

NORTH-SOUTH DIVIDE

Energy consumption in the EU and in neighbouring Mediterranean countries, tonnes of oil equivalent per inhabitant, 2015



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GLOSSARY

CAPACITY MARKET

Refers to payments that owners of power plants receive to ensure the availability of adequate generation capacity. Capacity payments are often considered as subsidies for the most polluting and uneconomic power plants.

CAPACITY FACTOR

Describes the relationship between a generator's rated capacity (in kilowatts) and the amount of energy produced (in kilowatt-hours). Under ideal conditions, a wind turbine with a rated capacity of 1.5 megawatts could theoretically produce a maximum of 36 megawatt-hours a day (1.5 MW x 24 hours), equivalent to a capacity factor of 100 percent – the turbine then generates its maximum output all the time. In practice, an onshore wind turbine has a capacity factor closer to 25 percent in good locations, so a 1.5 MW turbine would run at 0.375 megawatts on average, producing nine megawatt-hours a day.

COGENERATION

Cogeneration through combined heat and power (CHP) is the simultaneous production of electricity with the recovery and utilization of heat. Cogeneration is a highly efficient form of energy conversion: it can achieve primary energy savings of approximately 40 percent compared to the separate purchase of electricity from the national grid and a gas boiler for onsite heating. Combined heat and power plants are typically situated close to the end users, reducing transport and distribution losses and improving the overall performance of the electricity transmission and distribution network.

COMMUNITY POWER

A bottom-up approach to self-sufficient energy supply. The key idea is that citizens, through ownership of supply, have more control over how energy is generated and consumed. Generally speaking, community power promotes democratic decision-making, sharing of costs and benefits through collective responsibility, and community solidarity.

DEMAND-SIDE MANAGEMENT

Since electricity cannot easily be stored, the exact amount consumed generally has to equal the amount generated. Until recently, power supply systems were designed so that the supply side was managed to meet demand; large central power plants ramp up and down as electricity demand increases and decreases. With intermittent renewables, however, power supply can no longer be adjusted easily, so demand will have to be managed. Digital solutions, such as smart meters and grids, will help to manage demand.

DISTRIBUTED ENERGY SYSTEM

Electricity produced by a large number of small generators (solar roofs, wind turbines, etc.), as opposed to a centralized power supply based on large power stations (nuclear and fossil-fuel plants, utility-scale photovoltaic power plants and large wind farms).

DISTRICT HEATING

A system for distributing heat generated in a central location for residential and commercial requirements such as space heating and water heating. The heat is often obtained from a cogeneration plant burning fossil fuels or, increasingly, biomass. Heat-only boilers, geothermal heating, heat pumps and central solar heating are also used. District heating plants can provide higher efficiencies and better pollution control than localized boilers. According to some research, district heating with combined heat and power (CHP) is the cheapest method of cutting carbon emissions, and has one of the lowest carbon footprints of all fossil-fuel generation plants.

EUROPEAN NETWORK OF TRANSMISSION SYSTEM OPERATORS

Also known as ENTSO-E, it represents 43 electricity transmission system operators (TSOs) from 36 countries across Europe. It was established and given legal mandates by the EU's Third Package for the Internal Energy Market in 2009, which aims at further liberalizing the gas and electricity markets in the EU.

EUROPEAN UNION EMISSIONS TRADING SCHEME

Also known as EU ETS, this is the first and largest greenhouse gas emissions trading scheme in the world. It was launched in 2005 to fight climate change and is a major pillar of EU climate policy. Under the cap-and-trade principle, a cap is set on the total amount of greenhouse gases that can be emitted by all participating sectors and installations. Allowances for emissions are then auctioned off (or allocated for free), and can subsequently be traded. If an installation's emissions exceed what is permitted by its allowances, it must then purchase allowances from others. Conversely, if an installation has performed well at reducing its emissions, it can sell its leftover credits. In theory, this would allow the system to find the most cost-effective way of reducing emissions without significant government interference. Unfortunately, the EU ETS remains largely ineffective due to the overallocation of allowances and a subsequent low price per tonne of emissions.

FEED-IN TARIFF

A policy instrument designed to accelerate the investment in renewable energies by providing a stable investment climate. The tariff on every kilowatt-hour of electricity that is generated from a renewable energy source is fixed above the wholesale (spot market) rate of electricity.

FLEXIBILITY OPTIONS

The electricity system's ability to adapt to dynamic and changing generation or demand conditions, for example through storage. It may entail balancing supply and demand by the hour or the minute, or deployment of new generation and transmission resources over a period of years. It makes sure that the necessary electricity is available to meet demand at all times.

GENERATION CAPACITY

The maximum output a generator can produce under specific conditions. For instance, a single wind turbine may have a rated capacity of 1,500 kilowatts, but it will only produce that amount of power in strong winds.

GREENHOUSE GAS

A gas that absorbs and emits radiant energy within the thermal infrared range. This process is the fundamental cause of the greenhouse effect. The primary greenhouse gases in the Earth's atmosphere are water vapour, carbon dioxide, methane, nitrous oxide, and ozone. Without greenhouse gases, the average temperature of Earth's surface would be about -18°C . Human activity has produced a 40 percent increase in the atmospheric concentration of carbon dioxide since the industrial revolution. The vast majority of anthropogenic carbon dioxide emissions (i.e. emissions produced by human activity) come from the combustion of fossil fuels, principally coal, oil, and natural gas, with comparatively modest additional contributions from deforestation, changes in land use, soil erosion, and agriculture.

GRID

see Smart grid

GROSS ENERGY VS. FINAL ENERGY

Gross energy includes energy consumption within the energy sector along with distribution losses. Final energy is the energy that reaches your doorstep as fuel or electricity. It does not include losses in production and transport.

KILOWATT VS. KILOWATT-HOUR

A kilowatt is a unit of power, while a kilowatt-hour is a unit of energy (the amount of power used in one hour). 1,000 watts is a kilowatt; 1,000 kilowatts is a megawatt; 1,000 megawatts, a gigawatt; and 1,000 gigawatts, a terawatt. A hair dryer that has "1,000 watts" written on its label consumes a kilowatt of electricity when it is on full blast. If it runs for an hour, it has consumed a kilowatt-hour. Likewise, an appliance that consumes 2,000 watts when it is on will consume 1,000 watt-hours (or a kilowatt-hour) when it runs for 30 minutes.

OVERCAPACITY

Overcapacity can hamper a smooth energy transition to renewable energy sources. It is a challenge that characterizes the energy transition as fossil-fuel utilities are not necessarily required to switch off or reduce their generation as larger generation capacity from renewables enters the electricity system.

PRIMARY ENERGY

The amount of energy put into a supply system, as opposed to the "useful energy" that the supply system outputs to consumers. For instance, the tons of coal fed to a coal plant are considered primary energy, whereas the electricity that leaves the plant is considered secondary energy. A coal plant with an efficiency of 40 percent consumes 2.5 times more primary energy (coal) than it produces in the form of electricity (secondary energy). For wind and solar, there is no difference between primary and secondary energy.

PROSUMER

A person who both produces and consumes a certain product. In the energy system, the growing phenomenon of decentralized community energy has led to ordinary citizens becoming prosumers: they both produce and consume electricity, especially solar. Prosumers may generate large amounts of renewable energy, and in doing so may disrupt the centralized energy system.

QUOTA SYSTEMS

Minimum shares of renewable energy in the energy or electricity mix. Unlike feed-in tariffs, quota systems tend to incentivize investments in the cheapest technology available.

RETAIL MARKET

Typical retail power consumers include households and small businesses. These power purchasers have low-voltage grid connections and consume relatively little electricity. They also generally pay the highest prices because they have been "captive" up to now, meaning that they have had no affordable alternatives to electricity from the grid. The growth of renewables – and in particular solar with storage – is changing that situation worldwide.

SECTOR COUPLING

Connecting among different types of energy end-users: buildings (for heating and cooling), transport, and industry. The power sector is also often included because of the importance of electricity. Connecting these sectors will be crucial for a successful energy transition.

SMART GRID

An electricity grid that includes a variety of operational and energy measures, including smart meters, smart appliances that run at optimal times, renewable energy sources, and measures to use energy efficiently. Digital controls permit flexibility in the production, distribution and pricing of electricity. Smart grids lie at the heart of the energy transition; they will require a fundamental restructuring of the electricity system.

STRUCTURAL CHANGE

A shift or change in the basic ways a market or economy functions or operates. A carbon-intensive energy system is not sustainable for the climate. This means fundamental changes are needed in the system, from production through generation to consumption. Regions that have been dominated by coal or oil production have to find other ways of thriving economically. This perhaps is the most severe challenge to the renewable energy transition as entire regions have to reinvent themselves economically.

WHOLESALE MARKET

In a wholesale electricity market, competing generators trade their electricity output with each other and with electricity retailers, financial intermediaries and large-scale end-users (such as big factories). The retailers then market the electricity to small-scale consumers (such as households) through the retail market. Consumers buying electricity directly from generators is a relatively recent phenomenon.

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Fostering democracy and upholding human rights, taking action to prevent the destruction of the global ecosystem, advancing equality between women and men, securing peace through conflict prevention in crisis zones, and defending the freedom of individuals against excessive state and economic power – these are the objectives that drive the ideas and actions of the Heinrich Böll Foundation and its worldwide network with currently 30 international offices.

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Heinrich-Böll-Stiftung
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Friends of the Earth Europe is the largest grassroots environmental network in Europe, uniting more than 30 national organisations with thousands of local groups. We are the European arm of Friends of the Earth International which unites 74 national member organisations and over two million supporters around the world.

We campaign on today's most urgent environmental and social issues. We challenge the current model of economic and corporate globalization, and promote solutions that will help to create environmentally sustainable and socially just societies. We work towards environmental, social, economic and political justice and equal access to resources and opportunities. Our vision is of a peaceful and sustainable world based on societies living in harmony with nature.



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The Green European Foundation (GEF) is a European level political foundation funded by the European Parliament. It is linked to, but independent of, other European Green actors such as the European Green Party and the Green Group in the European Parliament. Our mission is to contribute to the development of a European public sphere and to foster greater involvement by citizens in European politics.

GEF strives to mainstream discussions on European policies and politics both within and beyond the Green political family, and seeks to encourage cross-border cooperation and exchanges. The foundation therefore acts as a platform to discuss Europe's shared challenges, by bringing diverse actors together, from European to national foundations, think tanks, academics and NGOs.



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EUROPEAN RENEWABLE ENERGIES FEDERATION (EREF)

EREF is the federation of national renewable energy associations from EU Member States, representing sectors such as wind, solar, small hydro, bio-energy, tidal, wave, and geothermal. Our objective is to defend the interests of independent power, fuel and heat production from renewable sources and to promote non discriminatory access to the energy market. The federation is striving to create, maintain and further develop stable and reliable framework conditions for renewable energy sources. EREF continuously advocates for ambitious and legally binding targets for all renewable energy sectors beyond 2020.

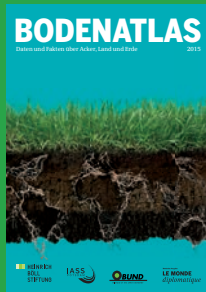
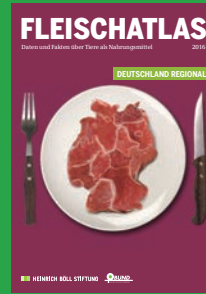
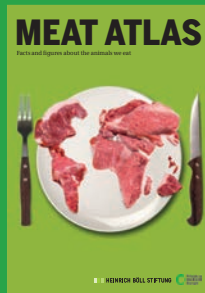
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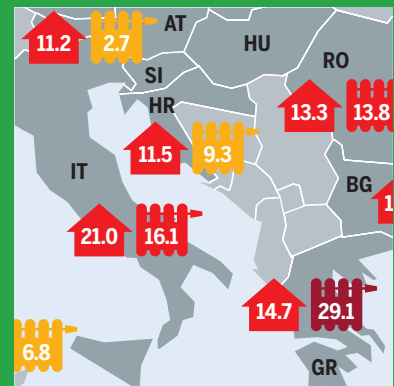
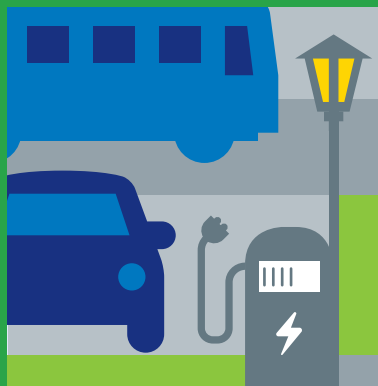
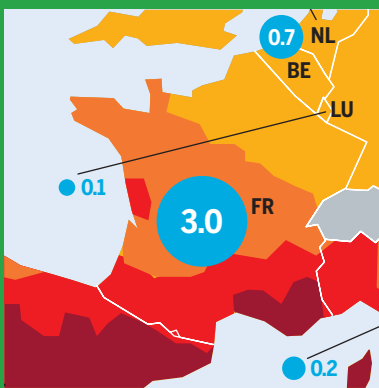
generates and provides evidence-based knowledge and analysis of policies as well as facilitates co-operation and networking.

EREF is supporting the renewable energy industry by legal action in the European institutions as well as in Member States. To survive the mounting and varied pressure and tactics by the incumbent industry, the industry needs the capacity and competence to use all existing rules and to create and maintain an overall political and regulatory atmosphere which enables further independent growth and substance. It needs a strong and loud voice as producers in Europe.

European Renewable Energies Federation
Avenue Marnix 28, 1000 Brussels, Belgium, www.eref-europe.org

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Countries that advance solar and wind power, smart grids and energy storage will be one step ahead.

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