

COAL ATLAS

Facts and figures on a fossil fuel

2015



HOW WE ARE
COOKING
THE CLIMATE

■■■ HEINRICH
BÖLL
STIFTUNG

 Friends of
the Earth
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IMPRINT

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INTRODUCTION

We have borrowed the Earth from our children.” This early environmental movement slogan uses simple words to express a central tenet of responsible, forward-looking policies: we must preserve the basis for the livelihood of future generations. We must leave a better world to our children than the one that we inherited.

Today, this principle compels us to do everything in our power to stop climate change and the damage it is causing. This means that by the middle of the century, we will have to decarbonize our economy and society. A milestone on this road is the phasing out of coal-burning. That is a huge challenge: coal was, and still is, the fuel of industrialization and global economic growth. Switching to renewable energy and a more efficient economy requires nothing less than a worldwide energy revolution.

A look at the statistics shows that global demand for coal is still rising. Growth will average a rate of 2.1 percent annually through 2019. Just over half the world’s usage takes place in China, which is by far the biggest consumer and importer. King Coal also generates 43 percent of Germany’s total energy. Even so, renewables have overtaken lignite, an especially climate-damaging type of coal, as a power source in Germany in 2014. The International Energy Agency predicts that the use of coal to produce energy will decline in the medium term. Even in China, there are signs that consumption has peaked.

” **By the middle of the century, we will have to decarbonize our economy and society.**

The coal boom has negative consequences for humans and nature that outweigh its economic benefits. Coal does not just kill the climate. In coal mines, terrible working conditions are rife. Accidents are commonplace. The environmental and health costs linked to the use of coal to generate electricity are enormous. Turning away from fossil (and nuclear) fuels towards renewable energy can offer huge economic and social opportunities. It would create jobs and cut costs. A shortage of power can best be overcome by the decentralized generation of energy from renewable sources.

A multilateral, binding climate agreement must give a clear signal to phase out fossil fuels. Companies that have made huge profits from fossil fuels should be made legally and financially responsible for the damage they have caused, and continue to cause. To speed the transition, a reasonable price must be set for CO₂ emissions.

We hope that this publication will spur the international campaign to phase out the use of coal. We are particularly pleased with the efforts of many of our offices abroad to produce editions of this atlas in local languages. We hope you will find this stimulating reading.

Barbara Unmüßig and Ralf Fücks
Board, Heinrich Böll Foundation

Coal contributes more to climate change than any other energy source. Burning coal is the largest single source of carbon dioxide emissions in the world. Its extraction, processing and burning are inescapably dirty: the entire coal-to-energy process generates pollution and destructive impacts for communities, workers and the environment. “Clean coal” is simply impossible.

Thousands of people die in mining accidents each year. Digging up coal often involves the displacement of communities, with little or no compensation. The health impacts from burning coal are severe, producing pollutants that cause numerous health problems: bronchitis, emphysema, asthma, heart attacks and premature death, to name a few.

Yet governments and corporations all over the world are recklessly supporting the expansion of coal mining and the construction of new coal-fired power stations. Often the countries bearing the greatest historical responsibility for polluting the atmosphere are tying development aid and even climate finance to coal deals.

Investment in coal-fired power diverts much-needed investment away from renewable energy, locking countries into destructive, high-carbon energy infrastructures, increasing the risk of runaway climate change, and generating devastating local impacts.

Many Friends of the Earth (FoE) groups are tireless in their resistance to coal. In South

” Investment in coal-fired power diverts much-needed investment away from renewable energy.

Africa, Friends of the Earth South Africa fights against air pollution and health problems caused by coal companies. FoE Indonesia and FoE Japan lobby against northern-financed coal plants in southern countries. Friends of the Earth members in Mozambique, Australia and Nigeria fight the social impacts of coal on local communities. In Colombia and Croatia, our members are working to close the Cerrejón mine in Colombia, which feeds Croatian coal plants. In France, FoE France challenges French banks like BNP Paribas and Credit Agricole that fund coal abroad. Our member group in Denmark pushes for energy efficiency and renewable energy and fights carbon capture and storage, with the aim of cutting the 40 percent share of the country’s energy which currently comes from coal.

Coal workers are rightly concerned about the transition from polluting to clean energy and what it means for them. Their livelihoods must be part of what we call the “just transition”, a shift away from our current unsustainable and unjust energy system into one that is community-led, climate-safe, and just. To realize this vision, we must make coal history.

Jagoda Munic

Chairperson of Friends of the Earth International

12 BRIEF LESSONS

ABOUT COAL AND THE WORLD

1 Millions of years of solar power are stored in coal. This energy is released through burning. In the process, large amounts of both carbon dioxide and heavy metals are also released into the atmosphere. This is **HARMFUL** to the climate and environment – and to our health too.

2 The impact of digging coal is tremendous. Whether in open-cast or underground mines, mining coal **DESTROYS** nature, **POLLUTES** water, **DAMAGES** homes and forces the relocation of entire villages.

3 Coal-fired power plants are not very efficient. Most of the energy is **LOST** as heat.

Nevertheless, coal remains the second-most **IMPORTANT SOURCE** of energy in the world, after oil.

5 Emissions from burning coal are increasing in Europe despite its climate policies. Germany, Britain and Poland are the biggest **CULPRITS**.

Our governments have committed themselves to protecting the climate. If global warming exceeds 1.5° Celsius, it will be impossible to manage the **CONSEQUENCES** of climate change.

Despite all warnings, coal continues to be **SUBSIDIZED**. EU member states continue to support coal projects with taxpayers' money.



6

8

9

Private banks finance coal projects worldwide; but in the hope of fighting poverty, development banks also invest **PUBLIC FUNDS** in coal.

7

To reach the climate target, 88 percent of all known coal reserves must **REMAIN IN THE GROUND**.

10

The coal industry is well-connected and uses lobbying, generous campaign donations and well-paid climate sceptics **TO SLOW** the switch to renewable energies.

11

Worldwide opposition to open-cast mining and other coal projects is growing. **PROTEST** takes many forms – human chains, blockades, demonstrations and online campaigns.



12

Creating economies that rely on renewable energy rather than fossil fuels is a major challenge of our time. **SOLUTIONS** are being sought around the world. They will radically change societies.



SUBTERRANEAN FORESTS

Coal is formed from vegetation at high temperatures and pressures, cut off from the air. The older the coal, the more carbon and energy it contains. Deposits are located in all continents.

Coal is a brownish to black sedimentary rock made up of organic material. It was formed in the Carboniferous, a period that lasted 60 million years and spans from about 359 million to 299 million years ago. The name “Carboniferous” comes from “carbo”, the Latin word for coal, because so much of this type of rock dates from this period. The Latin in turn comes from the presumed Indo-European word **ker*, meaning “burn”.

The climate was generally warm in the Carboniferous, and the atmosphere was richer in oxygen – 35 percent, compared to just 21 percent today. That stimulated the growth of plants. Vast forests spread over the land surface. A now-extinct tree known as lepidodendrales (from the Greek for “scale tree” after the appearance of their trunks) grew up to 40 metres tall.

Relatives of horsetails, now inconspicuous plants that grow on the edges of fields, reached 20 metres in height. Giant ferns formed massive swamp forests. All these plants accumulated large amounts of biomass. They used chlorophyll, the substance that makes leaves green, to use the energy from sunlight to convert carbon dioxide and hydrogen into organic material. They absorbed enormous quantities of greenhouse gases and turned them into lignin, resins and proteins.

When the vegetation died, the process of coal formation began. Many dead plants sank beneath the water, where they did not rot because of the lack of oxygen, but formed

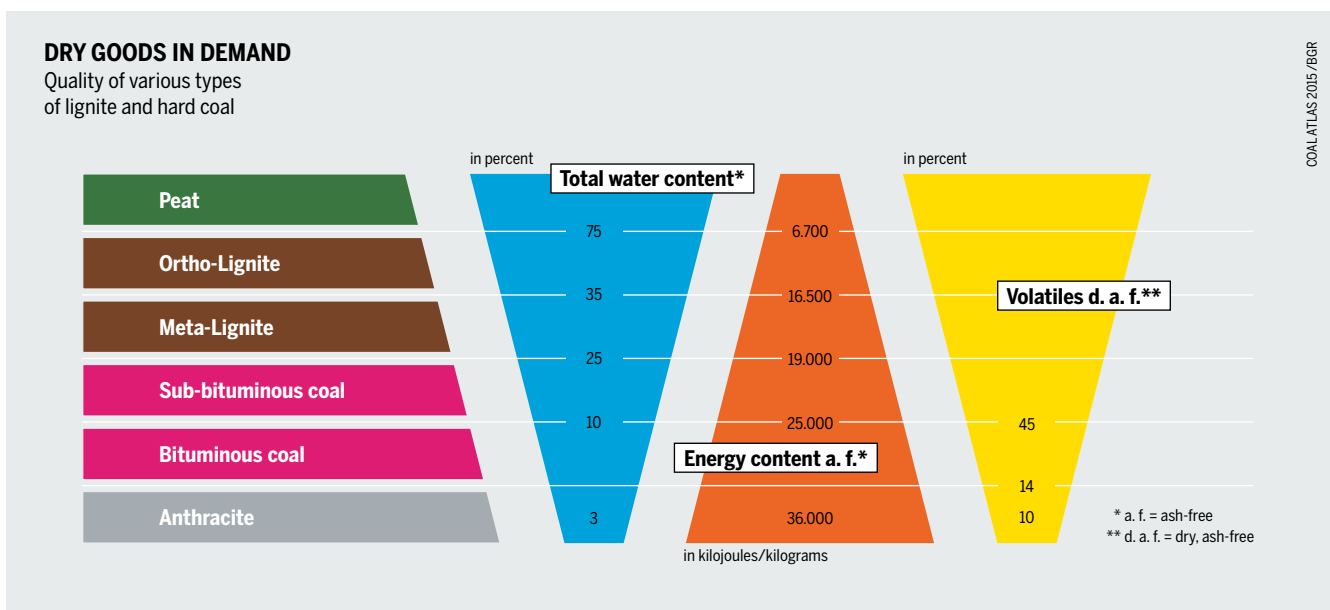
peat. Sediments such as clay or sand were deposited on top, raising the pressure and heat and squeezing out the water.

As the carbon content of the organic layers increased, the peat turned into denser, firmer lignite, or brown coal. Most deposits of this type date from 40 to 50 million years ago, from the Palaeogene period, formerly known as the Tertiary. Lignite has a moisture content of 45 to 60 percent. The remains of vegetation, such as roots, can still be seen in some pieces of lignite. Hard coal is much older – around 250 to 350 million years old. Lumps of this coal still bear the imprints of past vegetation. Most hard coal has a moisture content of 15 to 20 percent.

The more carbon coal contains, the more energy and the higher its calorific value – its value as fuel. So hard coal is preferable to brown coal. The best type is known as anthracite, which contains very little water or other ingredients. The only minerals that have more carbon are graphite and diamond, which are both usually of volcanic origin.

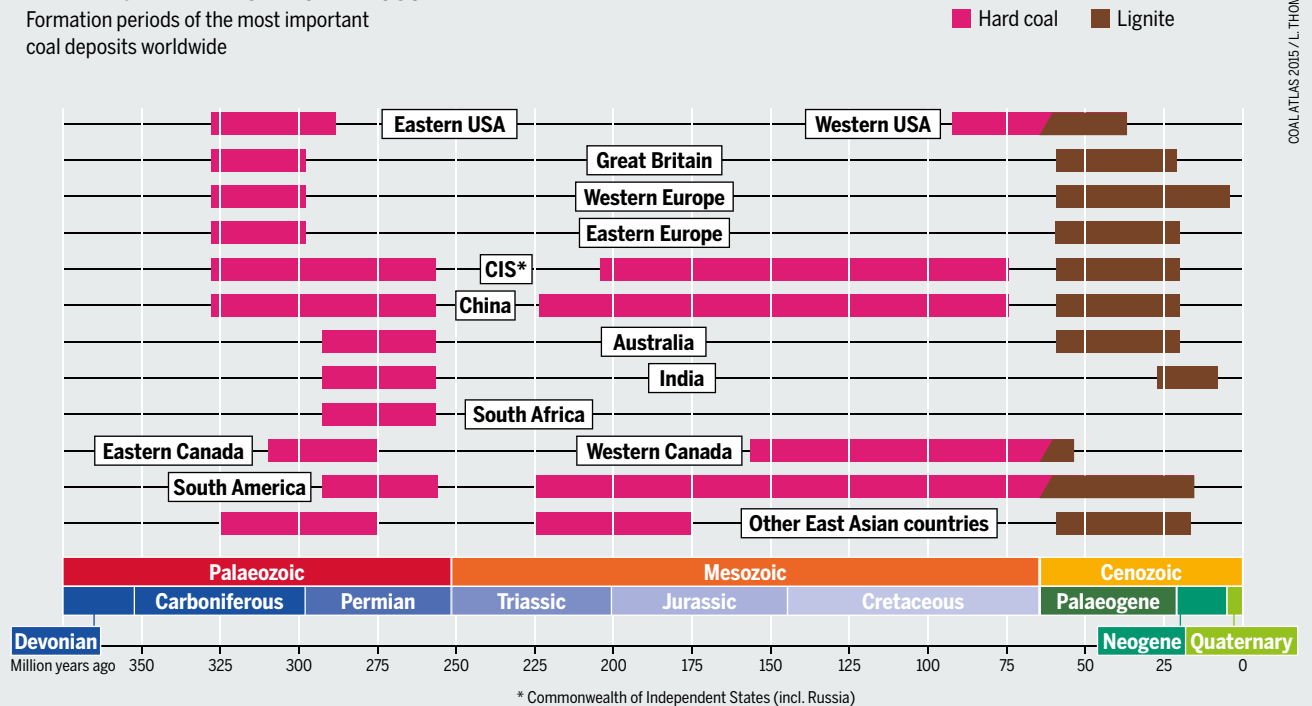
Ultimately, coal is energy from the sun, preserved in the form of plant remains. The historian Rolf Peter Sieferle refers to coal as a “subterranean forest”. Along with oil and natural gas, lignite and hard coal are fossil fuels. The term “fossil” indicates that they were formed from organic materials in the geological past. Coal and lignite come from vegetation; oil and natural gas are the remains of tiny organisms that were deposited on the sea floor. They were formed between 400 and 100 million years ago – at around the same time as hard coal. More recent deposits, such as those in the North Sea, were, like lignite, formed in the Palaeogene.

Heavy industry loves anthracite. It can contain more than 90 percent carbon



IT ALL BEGAN IN THE CARBONIFEROUS

Formation periods of the most important coal deposits worldwide



COAL ATLAS 2015 / L. THOMAS

The German Federal Institute for Geosciences and Natural Resources estimates the world's coal reserves at 968 gigatonnes (968 billion tonnes). It classifies reserves as deposits that can be exploited economically and profitably using current technology. In 2013 alone, humankind mined and burned 8 gigatonnes, or 253 tonnes every second. In addition to the reserves, the Earth has vast deposits of coal that have been proven but are currently uneconomic to exploit. Altogether, it is estimated that global deposits of lignite and hard coal may amount to 22,000 gigatonnes.

The largest deposits of the economically more important hard coal are found in Asia, Australia, North America and the Commonwealth of Independent States, an organisation of former Soviet Republics. The United States has the biggest reserves of hard coal and anthracite, with 223 gigatonnes. China comes next, with 121 gigatonnes, followed by India, with 82. In 2013, China dug up 3.7 gigatonnes of hard coal, more than half the world's total output. The United States followed with 12 percent, and then India, with 8 percent. About 20 percent of the world's hard coal output is traded internationally.

Lignite, on the other hand, is difficult to transport and contains less energy, so it is used as fuel only in the immediate vicinity of the open-cast mines where it is extracted. Some 37 countries around the world exploit lignite, but only eleven account for 82 percent of worldwide production. The biggest producer in 2013 was Germany, with 183 million tonnes, followed by China and Russia. Germany's lignite production has risen sharply after the country's move away

Once upon a time, a map of coal deposits reflected natural wealth. Now it shows where problems may lie

Hard coal takes a mere 60 million years to form – a brief period on a geological timescale

from nuclear power. This has significantly worsened its carbon footprint. In 2014, renewables overtook lignite as Germany's most important source of energy, but only by a small margin.

Unlike oil, there is no official shortage of coal. In the long term, output will decline because the atmosphere can absorb only so much carbon dioxide. However, the Energy Watch Group, an international network of specialists, thinks that official estimates of coal reserves are too high. The global estimates are continually being revised downwards – between 1980 and 2005 by about half, despite higher figures for India and Australia. The group expects we will reach peak global coal production as soon as 2020. ●

BURSTING AT THE SEAMS

Deposits of hard coal and lignite



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HISTORY

THE BEDROCK OF INDUSTRY

Coal is the fuel that powered the Industrial Revolution and the transformation of economies and societies over the last two centuries. Its benefits have been huge – while the damage it has wrought was ignored for too long. A switch to cleaner fuels now heralds the end of the coal era.

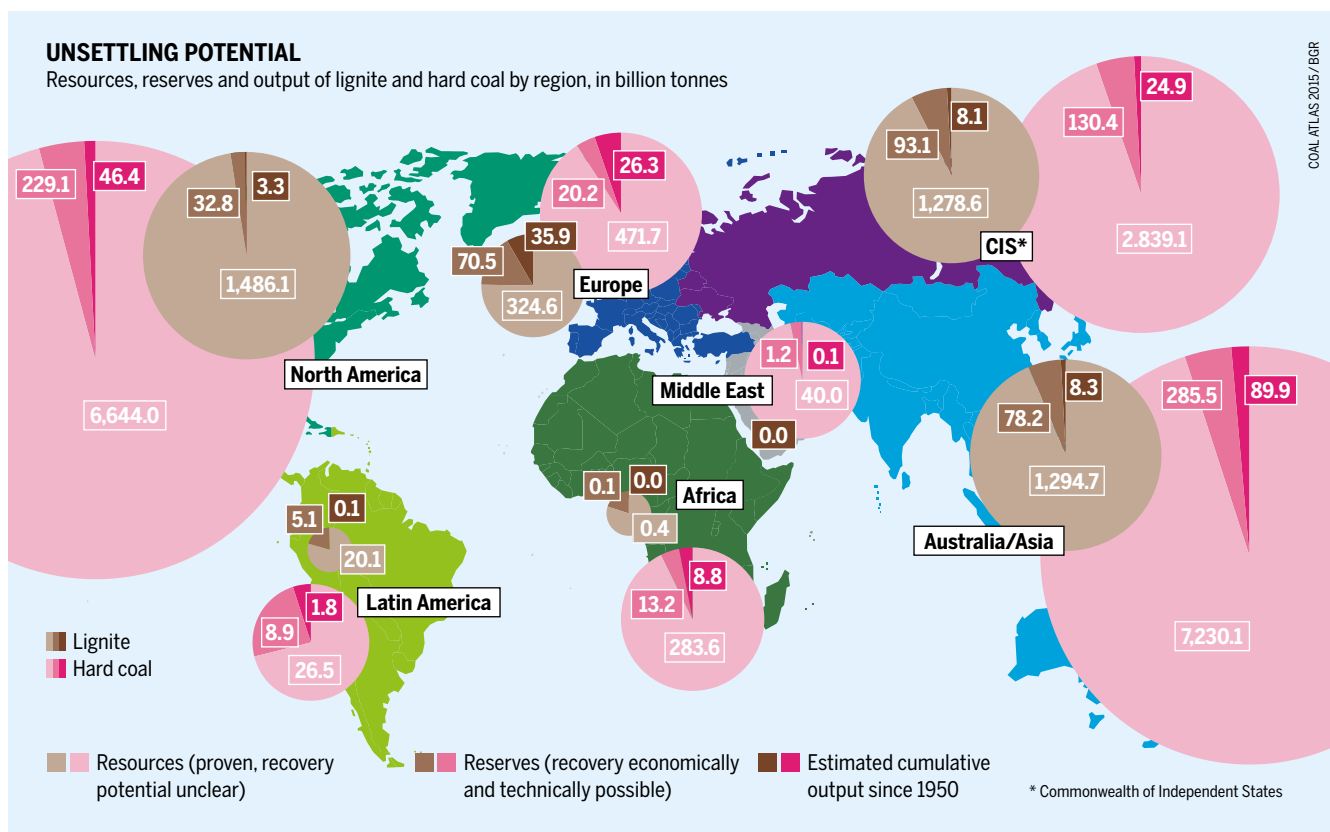
Hardly any shift in human history has changed society as much as the Industrial Revolution. Coal was the fuel that powered this economic and social upheaval. The Romans mined coal in Britain, and the Chinese used it as a source of energy in the 13th century. In the Ruhr area of Germany we have evidence of deliveries of coal to blacksmiths in the 14th century. But for the most part, humanity relied rather on biomass, mostly wood. In the pre-industrial era, huge areas of forest were cut down to smelt iron and steel. But then in the 17th century, Great Britain, the home of the Industrial Revolution, discovered a cheap and energy-rich alternative fuel in the form of coal.

Burning coal made iron production so cheap that machines and factories could be built on a larger scale. The steam pump, invented in 1705, made it possible to pump water out of ever-deeper mines. The Scottish instrument-maker, James Watt, improved the early pump designs, and in 1774 opened the world's first factory to make steam

engines. His coal-powered engines were a huge success, and they began to replace human and animal muscle power in ever more tasks. Entirely new types of production emerged. At the same time, railways and steamships started to play an increasing role. As the costs of production sank and factories multiplied, the way was open for the mass production of goods.

In the 19th century, industrialization took hold in other countries. On the European continent, where coal, wood and animal power had long been used alongside each other, the use of coal grew in the Prussian coal basins in the Ruhr, Silesia and the Saarland. From the middle of the century, German heavy industry took shape, creating an economic and technological complex based initially on coal, iron and steel, railways and machinery, with chemicals added later to the mix. Coal production in Silesia expanded markedly in the 19th century, making it one of Europe's leading industrial centres and spearheading the industrialization of Poland. As iron and steel production developed further, mines and steelworks were established, new cities sprang up, and railways spread across the land. Between 1850 and 1874, the coal output in Upper Silesia rose from 975,000 to 8.2 million

The world still has huge coal reserves. The energy industry wants to burn as much as possible



tonnes. In what is now the Czech Republic, coal mining grew considerably too, and along with the spread of steam power, led to the transition from crafts to industrial manufacturing.

The new forms of industrial production changed the entire structure of society. First in Britain and then in much of Central Europe and the United States, an industrial proletariat emerged in the rapidly growing cities. The impoverished working class often lived and worked in appalling conditions. Mine workers formed unions to fight against the harsh and dangerous working conditions. In many countries the leaders of socialist or left-leaning political movements emerged from such organizations. Their work underground forged close ties between miners, and coal influenced the culture of whole communities. Today's witnesses to this include statues to honour miners, guilds and clubs, as well as songs and art created by miners.

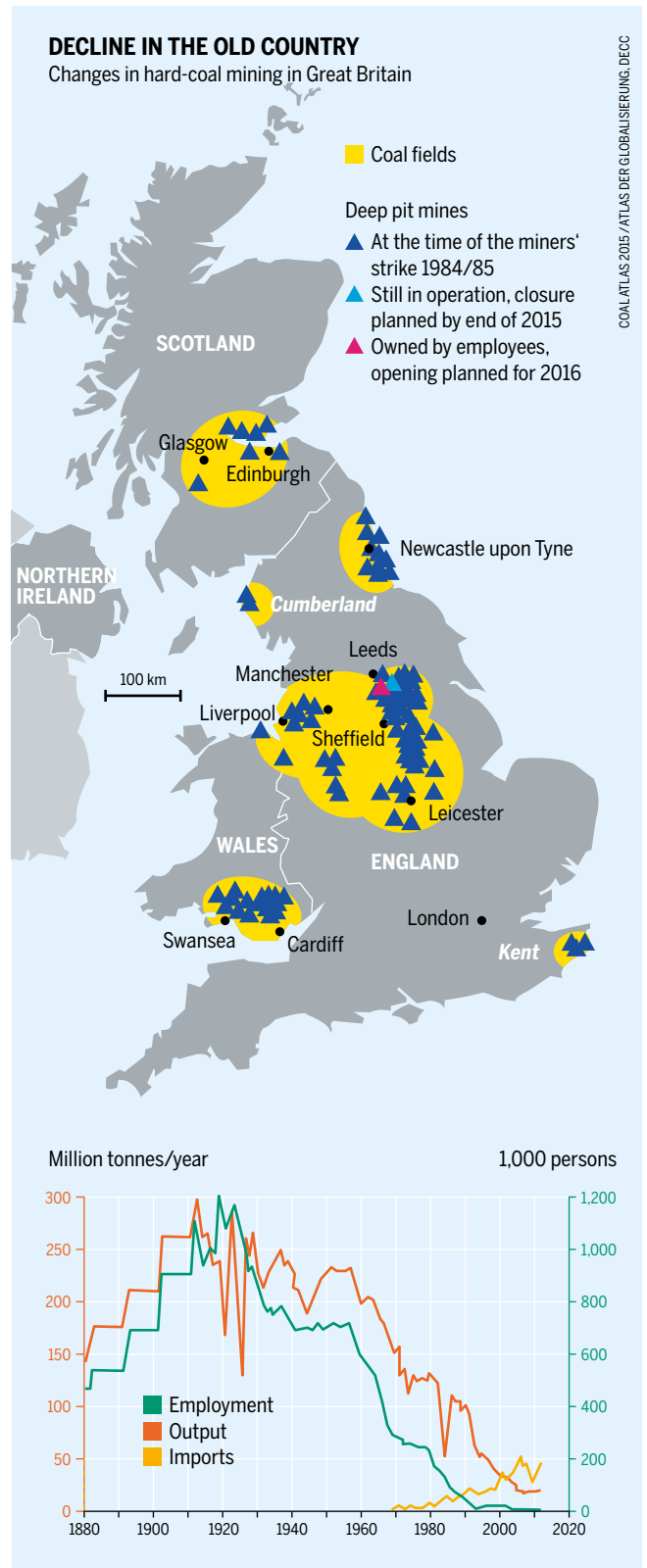
In Canada, coal mining began in the late 1830s when a group of English investors obtained a monopoly in the province of Nova Scotia. They imported the latest mining technology, including steam-driven pumps. Coal delivered the energy needed by the growing network of railways and steamships, fuelled steel production and was the source of heating for the burgeoning cities. Output grew from 3 million tonnes in 1890 to 17 million tonnes in 1942.

The economic development of Australia, which started out as a British penal colony in 1788, is closely tied to coal mining. The discovery of gold in the mid-19th century sparked the exploration for raw materials, including coal. A long-time exporter of raw commodities, Australia developed its manufacturing industry mainly after the Second World War. It is now the second-biggest coal exporter in the world, after Indonesia.

Since 2000, coal consumption has declined slightly in the OECD, a club of industrialized countries. But it has risen by 123 percent in non-OECD countries. Most of this increase has been in China, which accounts for half of the worldwide consumption. However, China is no longer pushing for the unrestricted development of coal-fired power stations to quench its thirst for energy.

No such trend can yet be seen in other industrializing countries such as India and Indonesia; their coal consumption has doubled since 2004, or in the case of Indonesia, nearly tripled. Such countries are trying to combat energy shortages by building coal-fired power plants. The economic development of these countries and the consequent rise in energy use rely on producing goods for the rest of the world. If the developed world increases its consumption of goods from these countries, carbon-dioxide emissions there rise. For instance, exports are now responsible for one-third of China's emissions, most of them from burning coal. The Potsdam Institute for Climate Impact Research calculates that between 1990 and 2008, the production of consumer goods in developing countries has resulted in five times more emissions than the industrialized countries have saved through their climate-change programmes.

South Africa obtains almost 90 percent of its electricity and 77 percent of its primary energy needs from coal. Alongside electricity generation, coal is used as a raw material in the petrochemicals industry. Unique in the world, the Sasol company converts large amounts into liquid fuel, a process that involves substantial energy losses.



Beginning in 1985, the British government closed most of the country's coal mines. Strikes were pointless. Nowadays Britain has few miners left

Some developing countries have decided to use renewable energy sources rather than fossil fuels, at least for part of their economic development strategy. An example is Morocco, which hopes to use wind and solar energy to reduce its dependence on imported fuels. ●

GREENHOUSE GASES

SPOILING THE CLIMATE

Digging up coal and using it to generate electricity churns out emissions that intensify the greenhouse effect. Coal is one of the biggest sources of climate change.

Greenhouse gases occur naturally in the atmosphere. They absorb part of the energy from the Earth's surface and from clouds, preventing heat from escaping into space. Without this so-called greenhouse effect, the Earth would be a lot colder than it is. But since the Industrial Revolution, we have added sharply to the amount of carbon dioxide, methane and other greenhouse gases in the atmosphere: levels of CO₂ in the air have gone up from 288 to 395 parts per million. Such concentrations boost the greenhouse effect.

The average global temperature has risen by 0.85 degrees Celsius since temperature records began. That may not sound like much, but the effects on our climate are considerable. Extreme weather such as droughts and heavy downpours are increasing. The mean sea level has risen by 19 cm since 1901. The Arctic ice pack is dwindling, the Greenland ice sheet has lost considerable mass, and glaciers worldwide are shrinking.

No other source of energy contributes as much to greenhouse gas emissions as coal. In 2014 it was responsible for emitting 14.2 gigatonnes of CO₂. That is 44 percent of all energy-related carbon dioxide emissions, and more than one-quarter of all greenhouse gas emissions.

The 35 biggest coal producers have been responsible for one-third of the global emissions since 1988. This was the year the Intergovernmental Panel on Climate Change was founded, and the Toronto climate conference requested governments to set targets for reducing their emissions. The coal industry could no longer deny the harm its product was causing. Private companies, state-owned enterprises and government-run industries have made huge profits from

producing and selling coal. But they have not been held accountable financially or legally for the loss and damage they have caused, and continue to cause, around the world.

The majority of coal is burned to produce heat and electricity. That releases a lot of carbon dioxide, along with smaller quantities of methane (CH₄) and nitrous oxide (N₂O). Different greenhouse gases have a different impact on the climate; converting them to a "CO₂ equivalent" measure makes them comparable.

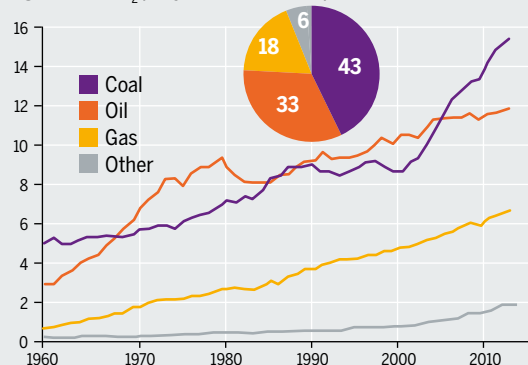
The amounts of CO₂ and other greenhouse gases that escape into the atmosphere for each kilowatt-hour of electricity produced depend on the carbon content of the coal and the efficiency and operations of the power station. Only about one-third of the heat generated from burning is converted into electricity by turning water into steam that spins a turbine. A critical question is whether the power plant uses the residual warmth for heating purposes, or whether it merely releases it into the environment. In general, generating electricity from coal damages the climate most; gas-powered plants emit only half as much CO₂ as modern coal-fired power stations.

The carbon footprint of coal is further enlarged by emissions of mine gas. This is created during the formation of the coal, and consists mainly of methane. In 2010, mines added the equivalent of another 500 million tonnes of CO₂ to the atmosphere. In addition, hard coal often has to be transported long distances. That involves energy and contributes to the climate damage. Burning coal, whether in a power station, furnace or stove, releases soot particles that also fuel the greenhouse effect. Mining and transporting lignite produces fewer emissions. But using it to generate electricity still harms the climate more than hard coal. This is because lig-

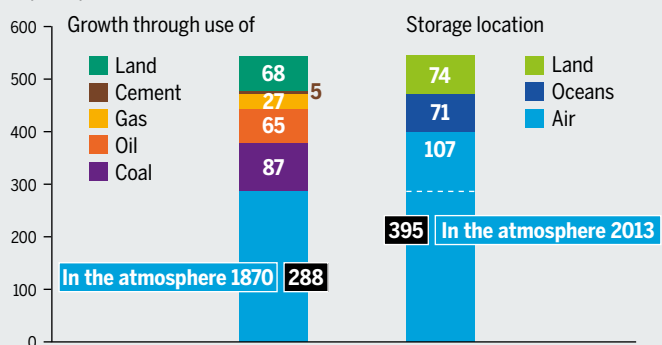
With its voracious appetite for energy, global industry is overburdening the atmosphere

THE CARBON DIOXIDE DISASTER

Emissions from the combustion of fossil fuels
Gigatonnes CO₂ per year 2013, in percent



Growth and destination of all CO₂ emissions since 1870, in parts per million

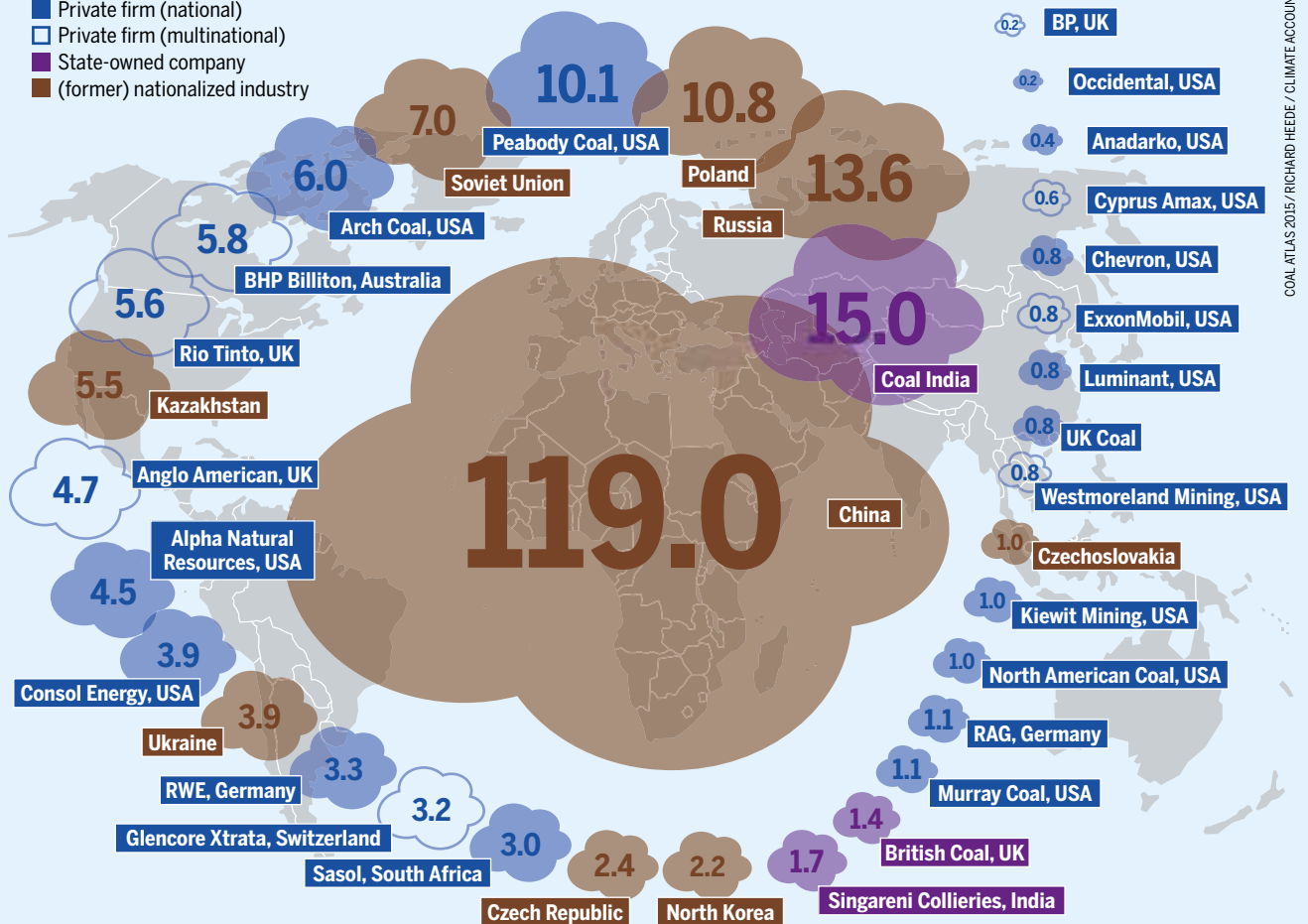


COAL ATLAS 2015 / GCP

LIKE THERE IS NO TOMORROW

The world's 35 largest private or state-owned coal producers by carbon dioxide and methane emissions, cumulative 1988-2013, in billion tonnes of CO₂-equivalent*

- Private firm (national)
- Private firm (multinational)
- State-owned company
- (former) nationalized industry



* The climate damage caused by methane is converted to CO₂ equivalent. Soviet Union 1988-1991, Russia, Ukraine and Kazakhstan since 1992. Czechoslovakia 1988-1992, Czech Republic since 1993

nite is less compact: it contains less energy - more has to be burned to produce the same amount of power.

Coal does not just feed power plants. It also goes into the blast furnaces of the iron and steel industry where it is converted into coke, which acts both as a fuel and a reducing agent to remove the oxygen from the iron oxide in the ore. This process also releases CO₂.

With enough energy, coal can be transformed into a liquid or gas that can be used as a raw material in the chemicals industry or as a fuel-oil substitute. This is economically feasible only if oil prices are very high and coal prices very low. Only China, India and South Africa currently use this climate-damaging technology on a large scale.

There are already enough greenhouse gases in the atmosphere to raise the Earth's average surface temperature by 1.5 degrees Celsius. This figure should not be exceeded, say scientists, nongovernment organisations and the nations that will be most affected, because doing so would jeopardize lives and livelihoods in many parts of the world.

If the temperature rises above that limit, the climate could cross a critical threshold. The permafrost at high latitudes could thaw, releasing the methane that it holds.

1988 is a key year. The Intergovernmental Panel on Climate Change is founded, and the damage caused by CO₂ can no longer be denied. But the coal producers are not too worried

The West Antarctic ice cap might melt. Such temperature thresholds are known as climate "tipping points". Beyond the tipping point, the climate would not return to its current state, but would undergo further changes that are impossible to predict.

At the Climate Change Conference in the Mexican city of Cancún in 2010, the international community agreed to limit temperature change to 2 degrees Celsius above pre-industrial levels. To have a 50 percent chance of keeping under this limit, the CO₂ content of the atmosphere must be kept under 450 parts per million. That means that humanity must emit no more than 1,000 gigatonnes of CO₂ by 2050. That is possible only if 88 percent of the currently confirmed coal reserves stay in the ground, along with one-third of the mineral oil and half the natural gas reserves. Our consumption of coal will have to fall sharply, from 1.07 tonnes per person today to only 80 kilograms in 2050. ●

A CONTAMINATED FUTURE

Open-cast mining destroys the landscape of both the pit and the surrounding area. Efforts to restore these areas often fail and the surface above the underground mines sinks.

Coal extraction has huge impacts on the environment. In open-pit mining, which accounts for about 40 percent of global coal production, the entire overburden has to be removed to reach the coal seams underneath. The landscape is completely destroyed. Communities are removed, plants and animals are eliminated, and the living soil is shovelled away. Excavators dig enormous craters, hundreds of metres deep. Appalachia, in the United States, has a particularly extreme form of open-pit mining: to get at the coal, entire mountaintops are blasted away and the rubble is dumped in the valleys.

Our planet is littered with thousands of coal mines. The largest mine in the world, measured in terms of reserves, is the North Antelope Rochelle Mine in Wyoming, in the western United States that is estimated to hold some 2.3 billion tonnes of coal. It produces over 100 million tonnes annually from a vast open pit covering 250 square kilometres. The second-largest operation is the Haerwusu Mine in Inner Mongolia in China. This mine has an estimated 1.7 billion tonnes of reserves and an annual output of 20 million tonnes. It covers over 67 square kilometres. Other mega-mines can be found in Australia, Colombia, Indonesia, Mozambique, Russia and South Africa.

The ecological consequences are similar across countries, though standards for mining, restoration and legal enforcement differ widely. Mining means digging up and shifting huge amounts of earth. In some types of soil, iron and sulphur compounds can oxidize to iron and sulphate when they come into contact with the air. After extraction ceases the groundwater levels rise again and sulphuric acid is produced. As a result, the flooded pits and groundwater acidify. Adding alkaline materials such as limestone can reduce the level of acidity but cannot prevent it completely. Some of the iron that is set free is converted to iron hydroxide, or limonite. This rust-coloured mineral clogs pipes and pumps, blankets the spawning grounds of fish, and smothers their food supply.

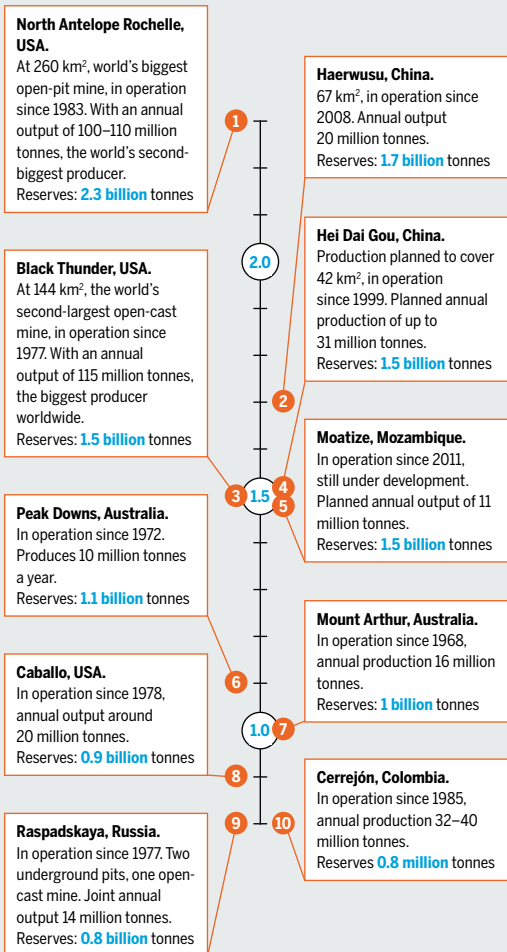
Pumps are used to lower the water table and prevent the pits from filling up with water. This has severe consequences for the groundwater. In Germany’s largest open-pit mine, at Hambach, this will require pumping out almost 45 billion cubic metres of groundwater over the next 60 years the mine is expected to be in operation. Keeping a mine dry disrupts the hydrology of the neighbouring areas: lowering the water table by as much as 550 metres dries up the springs that feed rivers, kills trees, desiccates wetlands and reduces biodiversity. This pumping, or what the experts call “mine dewatering”, may also dry up wells, endangering drinking water supplies. It can take a hundred years for the groundwater level to regain its previous level.

Mozambique’s Tete province used to be famous for its beautiful baobab trees, many over 1,000 years old. But coal-mining companies have destroyed vast numbers of them, ignoring their importance for the environment, local culture and peoples’ diets. Such trees may take hundreds of years to regrow. Clouds of coal dust, polluted water and soil contaminated by acid drainage from mines also harm local communities. None of the companies operating in Mozambique have published environmental management plans, leaving the public ignorant of the environmental consequences of their operations.

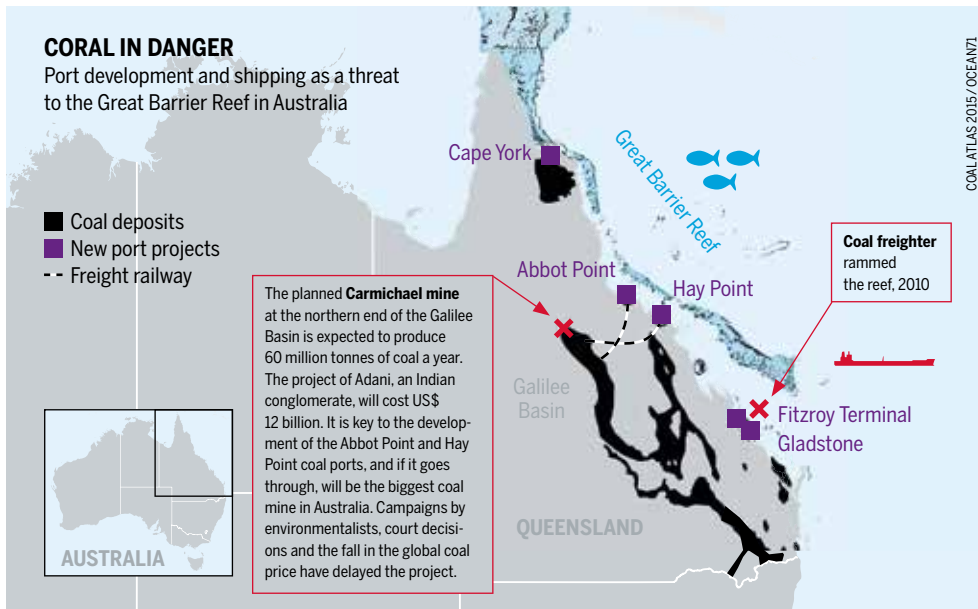
Fast eaters. The largest coal fields in the United States will be depleted in around 20 years

MASSES OF FUEL

The world’s ten biggest open-cast mines by reserves, in billion tonnes



COAL ATLAS 2015 / MINING TECHNOLOGY



More mines, more ports – Australia wants to ship more coal to China and India

In Nigeria, the government has signed a memorandum of understanding with the Chinese firm HTG-Pacific Energy to exploit coal in Enugu, in the southeast of the country. But no environmental impact assessment has been made – though this is required by law – and the right of affected communities to be involved in the project development has been ignored.

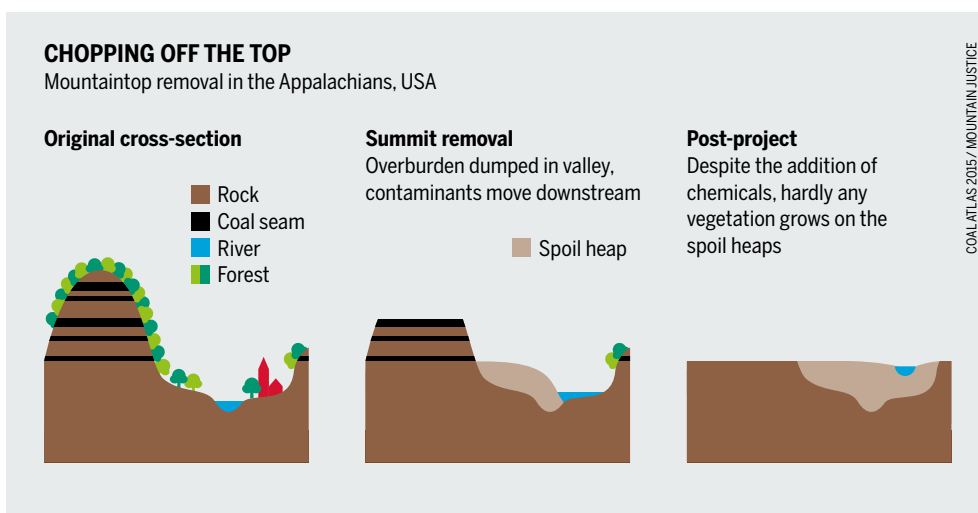
Cerrejón, a massive open-cast mine in Colombia, has impoverished the surrounding soils and contaminated or dried up water sources, with devastating impacts on farming and livestock keeping. The whole mining complex here extends over 69,000 hectares. Ninety percent of Cerrejón’s hard coal is shipped abroad to fuel power plants, mainly in Europe and the United States.

While becoming the world’s largest coal exporter, Indonesia has destroyed vast areas of rainforest and deprived local people of their land and homes. In Borneo, the indigenous Dayak people are fighting against mining companies’ activities, particularly against the mining giant, BHP Billiton. The Dayak are trying to stop a series of large coal mines and railways that would decimate primary rainforest, pollute water sources, displace indigenous peoples and

endanger orangutans. This project would destroy the headwaters of 14 major rivers that provide clean water to 11 million people.

Coal mining leaves its mark on the landscape in other ways too. Lethal landslides can occur in open-cast pits decades after mining operations have ceased. Underground mines cause surface subsidence that damages buildings and roads. These “inherited liabilities” will continue to be a burden to future generations. In the Ruhrgebiet, a mining and industrial area in western Germany, water has to be pumped out of abandoned underground pits to stop the water table from rising too high, and in some areas continuous pumping is needed to prevent entire neighbourhoods from being flooded.

The ash from power plants also gives cause for concern. Landfills that store this toxic by-product of coal burning are often inadequately secured, allowing the ash to leak out. A particularly serious case occurred in 2008 in Tennessee, in the eastern USA. A retaining dam next to the Kingston coal-fired power station collapsed. Four million cubic meters of ash sludge containing heavy metals were released, carpeting the surrounding areas and polluting a nearby river. ●



Mining leaves behind a lunar landscape. It is next to impossible to reclaim such areas for farming.

FINE DUST, FAT PRICE

Smoke and fumes from coal-fired power plants make us ill. They are responsible for hundreds of thousands of deaths worldwide each year. Atmospheric and environmental pollution from coal costs billions in health expenses.

Mining and burning coal harm human health both directly and indirectly. The European Pollutant Release and Transfer Register, a database of emissions, lists 53 pollutants released by coal-fired power stations into the air, water, and the soil. Burning a kilogram of hard coal, releases more pollutants than burning a kilogram of lignite. But then again, you need three times as much lignite to produce the same amount of energy. That is why lignite is regarded as the dirtier fuel.

According to the World Health Organization (WHO), air pollution is one of the major health risks. In 2012, the WHO estimates that worldwide, 3.7 million people died prematurely as a result of diseases attributed to outdoor air pollution. The smog in Asia's cities is caused mainly by vehicle exhaust and burning coal.

Estimates of the number of victims worldwide due to coal-fired power vary widely. A study conducted by the Chicago School of Public Health reveals that coal combustion in China accounts for 250,000 deaths per year in the country. The researchers base this number on an estimated 77 deaths per terawatt hour from a coal-fired power plant. Detailed figures for Europe come from the Health and Environment Alliance (HEAL), a coalition of 65 European non-governmental organisations. They blame coal power for 18,200 deaths in the European Union annually. The coalition says that

8,500 people are diagnosed with chronic bronchitis a year because they come into contact with pollutants from coal plants. If power plants in Croatia, Serbia and Turkey are included, the number of deaths in Europe rises to more than 23,000 a year. HEAL calculates that the health costs add up to almost 43 billion euro a year. These high health costs ought to be included when comparing the prices of various sources of energy.

The amounts of emissions depend on the filtering systems the power plant uses. Although these have improved considerably in recent decades, coal-fired plants are still responsible for releasing 70 percent of the EU-wide emissions of sulphur dioxide – a particularly important class of fine particles – along with half of the industrial mercury emissions.

When fine particles are inhaled, they penetrate the lungs and bloodstream, causing various harmful effects on the body. They can cause chronic inflammation of the lungs, impair the pulmonary reflexes, and reduce the functioning of the lungs. That can lead to diseases such as asthma, chronic bronchitis, and in the long term, lung cancer. Another effect is reduced blood flow to the brain because the blood coagulates faster and can carry less oxygen. High blood pressure, irregular heartbeat and heart attacks may result. There is no official limit below which fine particles are considered harmless.

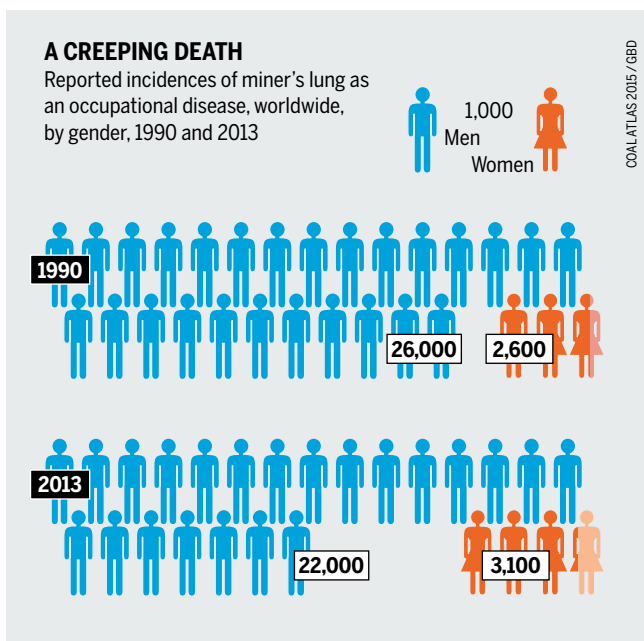
Children are especially susceptible to the harmful effects of heavy metals in emissions: lead, mercury, cadmium and arsenic. If their lungs are damaged early in life, they may be permanently weakened. While still in their mother's wombs, children who are exposed to large amounts of lead or mercury risk developing cognitive disorders and often have lower IQs. They may also suffer irreversible organ damage.

Measurements show that power stations with especially high carbon dioxide emissions also emit many other toxic pollutants. If less CO₂ is released, the emissions of sulphur dioxide, nitrogen and fine particles also fall. That is why the American Lung Association supports President Obama's climate change plan, which aims to reduce the emissions from new power stations by around one-third.

But the burning of coal is only one health hazard; mining is harmful too. People living near open-cast mines are exposed to high levels of particulate matter, which can lead to respiratory diseases or allergies. Mine tailings contain heavy metals and other toxic substances that can enter the groundwater and air.

Radioactivity is another problem. Lignite contains uranium, thorium and potassium-40. In the Rhineland, Germany's largest open-cast mining area, 100 million tonnes of lig-

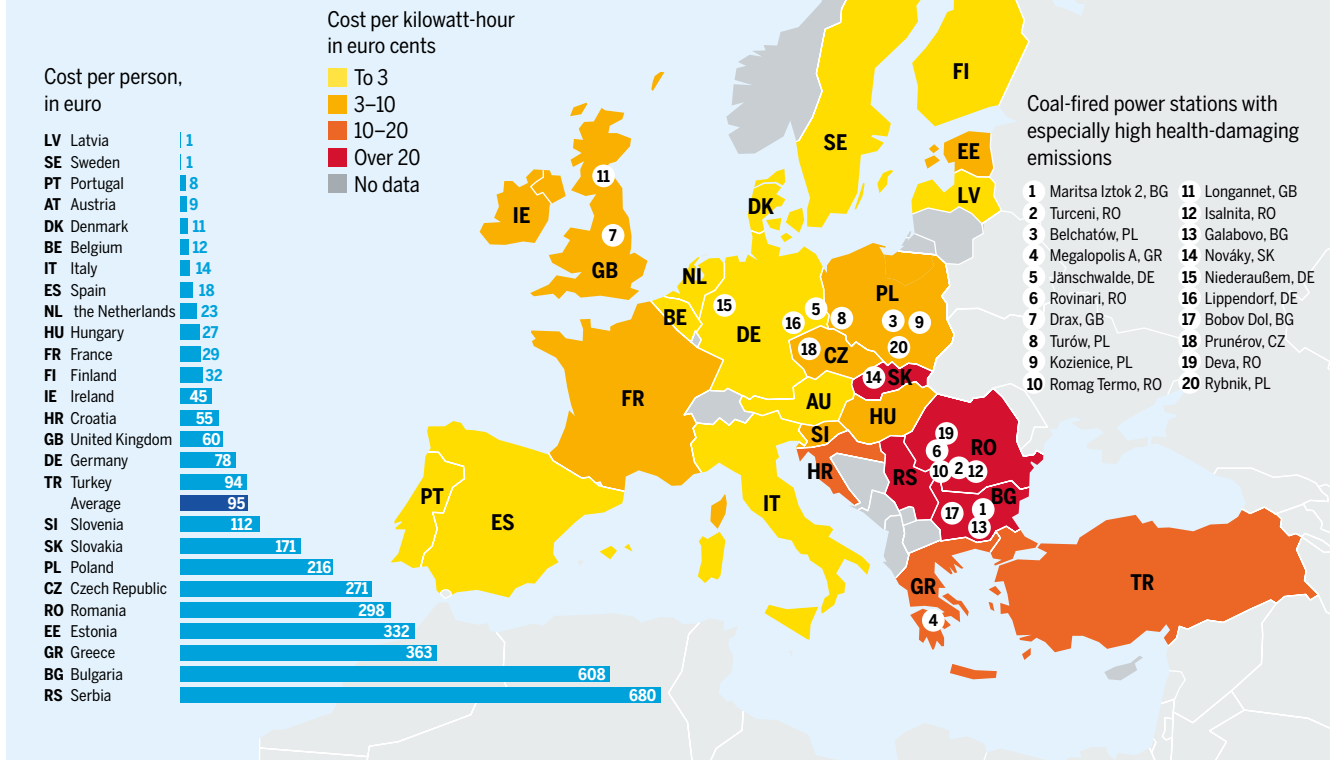
More and more women are working in coal mines. More are dying from miner's lung, while fatalities among men are declining



COUGH, PLEASE

Health costs resulting from electricity generation by coal and lignite power plants, 2009, and location of the 20 dirtiest coal-fired plants in the EU

COAL ATLAS 2015 / HEAL



nite and 460 tonnes of overburden are excavated each year. Friends of the Earth Germany estimates that this includes 388 tonnes of uranium. These radioactive substances are also present in the airborne dust and find their way into people's lungs – with incalculable consequences to their health.

Such health problems are particularly evident in the Mpumalanga Highveld coal-mining area in South Africa, home of 12 of the largest coal-fired power stations in the world. Toxic substances and waste water from the open-cast mines contaminate the limited amounts of drinking water in the area. Local people have little choice but to consume it. Research by Friends of the Earth South Africa indicates that coal is responsible for half of the deaths caused by respiratory and cardiovascular diseases in the region. Respiratory problems such as asthma and whooping cough are widespread among local people. Children and elderly people are especially at risk. Most of the power plants do not have to comply with national clean air standards – for cost reasons.

The permissible limits for pollutants vary widely from country to country. The United States has significantly stricter mercury and sulphur dioxide limits than the European Union. As a result, many coal-fired power plants there have been closed or retrofitted.

Climate change caused by using coal is an indirect threat to human health. In June 2015, a Lancet Commission

Almost 30 million cases per year: the frequency EU citizens experience lung problems caused by coal

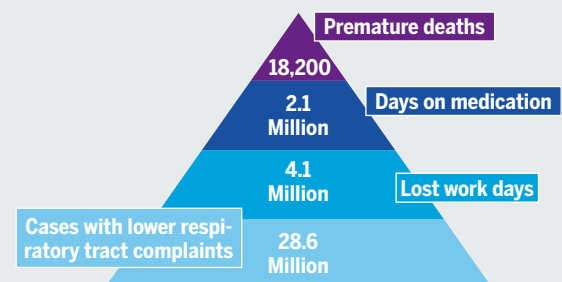
43 billion euro in health costs should be added to the price of coal in the EU alone

of international health experts warned about the health consequences of global warming. The last five decades of development and health advances could be nullified. The commission pointed at the dangers posed by air pollution, rising temperatures and extreme weather. This included increasing heat stress, the spread of infectious diseases such as malaria and dengue, threats to food security, malnutrition, and a rising number of refugees and armed conflicts. ●

SHORTER LIVES

Annual health consequences caused by coal-fired power plants in the EU*, 2009

COAL ATLAS 2015 / HEAL



* 27 countries (without Croatia). Serbia and Turkey included in study but not reported here

LABOUR

DIRTY JOBS IN A DIRTY INDUSTRY

Although coal production is still on the rise, the sector is employing fewer people. Structural change has spread to all continents. Nevertheless, mining underground remains one of the most dangerous occupations worldwide.

In 2012, an estimated seven million people were employed in the coal industry, most of them in coal and lignite mining. That number is likely to be lower in 2015, with employment falling especially in China. The world's largest coal producer is beginning to exploit its reserves more efficiently, however, it still needs many more workers than the United States, where modern equipment and optimized operations enable about 90,000 people to mine 0.9 billion tonnes, mainly in open-cast mines. In China, 5.7 million people are needed to dig out 3.7 billion tonnes, mainly from underground mines. In the United States 10,000 jobs were lost in 2013 alone, partly because the shale-gas boom has made coal production less profitable.

Fewer workers are needed in countries where productivity is rising quickly. For example, the Chinese government has closed thousands of small, inefficient mines. India also needs fewer workers to produce the same amount of coal. Coal India, the state-controlled producer, slimmed its employee rolls from 500,000 in 2005 to 350,000 in 2014. In the same period, its output rose by one-third. Moreover, both India and China have invested in Australian mines to boost their own supplies. These extensive coal imports mean that Australia is one of the few countries where employment in the coal sector was rising in the last decade.

The European Union is also cutting thousands of jobs every year. In 2008, 342,000 miners worked above and below ground; in 2013 the number was only 326,000. In the Czech Republic, which relies heavily on coal, there has been a decrease in employment in the coal sector. After a delay, structural change is now starting in Poland, which obtains most of its energy from coal. Britain has almost completed the transition: by 2016 only two pits will still be in operation, an old mine and a new one, both owned by their workforces.

In 1950, almost 540,000 people worked in Germany's hard coal mines, and 360,000 of them underground. Today the figure is 12,100, and by 2018 there will be no miners underground. In the country's lignite mines, the number of people directly employed in digging out the rock and transforming it into electricity has fallen from 130,000 in 1990 to 21,000 today.

While coal is declining as a source of employment around the world, renewables are growing in importance. In 2013, 6.5 million people were employed in this sector, 800,000 more than in the previous year, according to the International Renewable Energy Agency. This organization

estimates that the coal and renewables sectors now employ a similar number of people worldwide. In Germany and the rest of the European Union, jobs in renewables have overtaken those in coal. In developing countries and emerging markets, however, employment figures cover only the coal industry itself, and do not include the related project development, transport and power-plant operations.

Despite such uncertainties, it is still possible to discern some trends. China is the leading power in renewable energy, employing 2.6 million people in 2013. Most jobs can be found in the production and installation of renewable-energy plants. Brazil follows with around 900,000 jobs, the USA with 600,000 and India with 400,000. Germany is fifth. Its employment in renewables has doubled since 2004; by 2013 it had reached 370,000. By comparison, the German lignite industry directly and indirectly employs 70,000 people.

Working conditions in the renewables sector are generally better than in coal, although the renewables still entails risks, as in the chemicals companies that make solar cells. But workers in coal mines are subject to much greater risk to life and limb. And to their lungs, where the coal dust settles causing chronic diseases. Mining accidents are often dramatic, claim many lives, and attract a lot of publicity. With 150 years of experience underground, the coal industry has a deep understanding of the risks, and has detailed regulations to prevent accidents. If accidents occur, they are usually due to safety precautions that have been ignored in order to save costs, to negligence, or to equipment failure.

The situation in China, which accounted for 80 percent of worldwide deaths in coal mining, is improving. The small mines that are being closed are also the most dangerous. In the 1990s, 5,000 to 7,000 miners died every year. In 2010 the figure was 2,400, and 930 in 2014, according to governmental data.

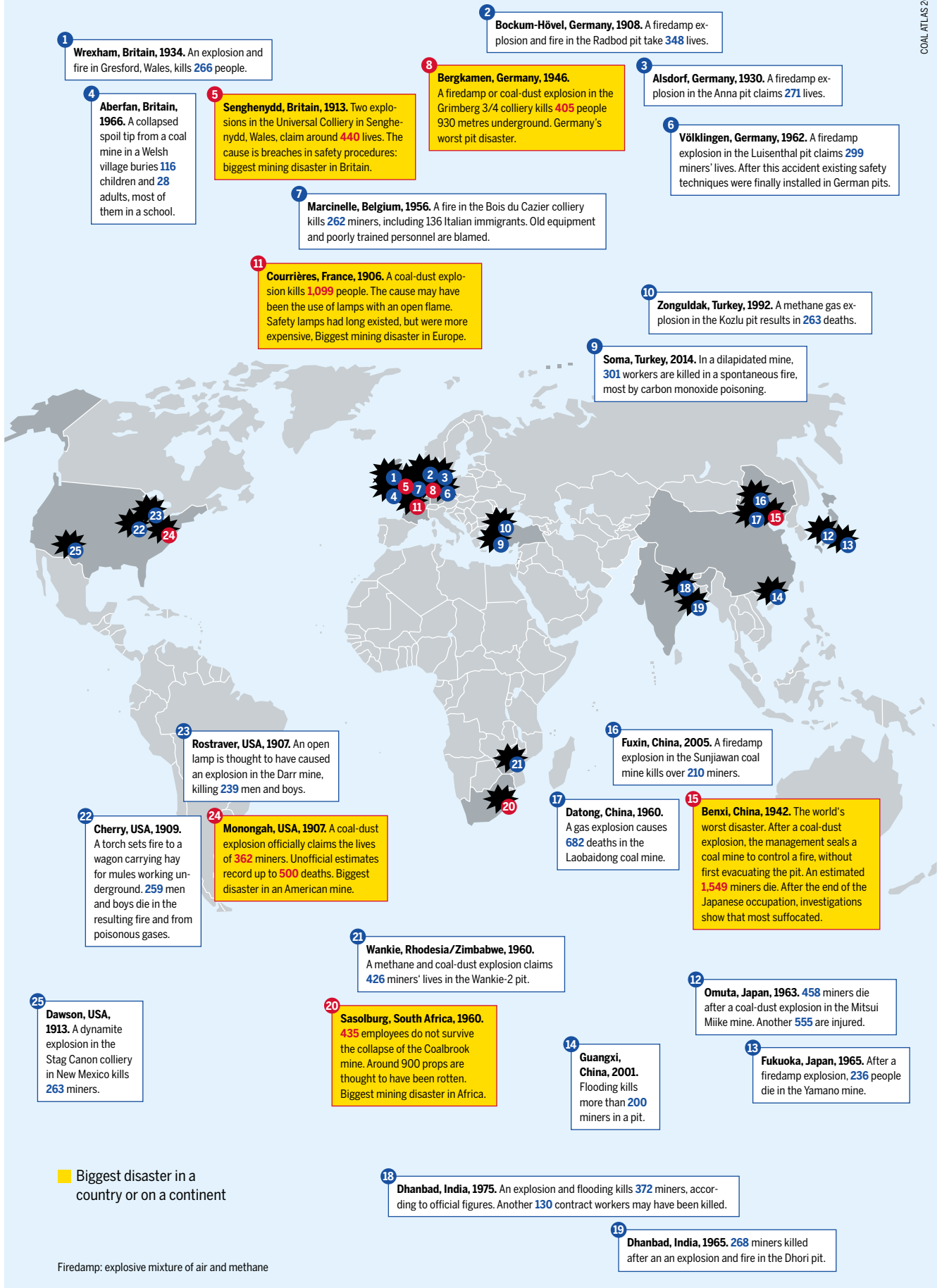
In the western world, the image of a miner is still one of a hard-working, soot-covered man. And indeed, in Europe or Canada – and also in India – women still account for less than 20 percent of the workforce. In the ex-socialist countries, however, more women go underground. In many parts of the world it is not easy for women to find work in the coal industry. And if they do land a job, they are usually paid less than men and have to fear sexual assault in the mine.

According to a Greenpeace study, the coal industry will shed another two to three million jobs by 2030. The renewables sector is growing fast enough to compensate for these losses. In 2014, the Ibbenbüren mine in Germany recruited 56 maintenance trainees. It was the last such hiring. ●

Many mining accidents happen because the operators do not comply with the safety rules

DISASTERS DEEP DOWN

Accidents in coal mines with over 200 deaths, 1900–2014



HUMAN RIGHTS

PUSHED DOWN AND DRIVEN OUT

When the coal firms arrive, local people can expect forced removal and repression. Voluntary standards are of little help.

Mining companies are accused of violating human rights more often than firms in other industries. John Ruggie, who served as the United Nations Special Representative for Business and Human Rights from 2005 to 2011, revealed that 28 percent of all complaints received by his office were directed against mining and oil/gas companies. Underground coal mines are particularly prone to safety lapses and poor working conditions. Open-cast mines violate the human rights to food and water, says Ruggie, and residents are often forcibly relocated.

Open-cast mines eat into farmland, pastures and hunting areas. In Mozambique, coal companies from Brazil and Britain resettled more than 2,000 households between 2009 and 2012. These people were moved to barren, arid areas

where they now find it hard to grow food. Worse still, the Indian company Jindal operates an open-pit coal mine without resettling the local communities, leading to serious health problems for residents who still live just one kilometre away. Water pumped out of mines is often discharged without adequate treatment. The dissolved toxic substances and waste oil it contains make it completely unusable. They pollute the groundwater and surface water of surrounding areas.

The Alta Guajira area in northern Colombia is very dry, but the Cerrejón coal mine there uses 17 million litres of water daily. In a region where people are faced with scarcity of water, the abundant use of water in the mine is regarded with disapproval. The United Nations recommend between 50–100 litres of water per person a day for personal and domestic use.

In northwestern Bangladesh, a planned coal mine at Phulbari threatens 130,000 people with relocation. Some 220,000 people fear losing their supply of clean water. Residents have been demonstrating against the mine ever since the plans were announced. In 2006, the Bangladesh Rifles, a paramilitary force, killed three people and wounded over 100 others. Each year, activists meet in memory of the victims. In 2012, the government tried to prevent this commemoration by banning gatherings of more than four people.

Companies in Colombia, Indonesia, Mozambique and South Africa have been accused of using brutal security personnel to protect their facilities. They use force against protesting workers, trade union activists and local residents. Resistance has been criminalized to weaken the protests and reduce support for them. In one example, paramilitaries murdered three trade unionists in Colombia in 2001. The victims' relatives have accused Drummond, an American mining company, of employing the perpetrators as guards. Drummond denies responsibility and in early 2015 sued the victims' lawyer in the United States.

Indigenous peoples are frequently affected by mining. The Dayak, an indigenous tribe in Indonesia, are fighting coal mining in their territories on the island of Kalimantan. Some communities there have been forcibly relocated more than once by mining activities. Colombia's Cerrejón mine impacts a region where 45 percent of the population are indigenous people and 7.5 percent are descended from Africans. In Australia, coal mines are often found in Aboriginal territories. In Russia, open-cast mines surround the settlements of the Teleuts and Shors, Siberian Turkic peoples. The resulting dust and waste water have destroyed their hunting and fishing grounds. In Colombia, the Gunadule are now struggling against the same fate: the government has awarded a South Korean firm concessions to extract coal in their area, without consulting the local people.

Even if consultations are held before a mining project goes ahead, the agreements cannot be trusted. Many an undertaking to restore the land proves to be hollow. In Jharkhand, in India, where hard coal is mined in open pits,

THE BURDEN ON WOMEN

Problems after their families had been resettled in four coal-mining projects in Jharkhand, India, interviews with affected women. 2001–2009, qualitative analysis

Financial

Compensation for the complete loss of land and housing goes to the men in the form of savings accounts and motorbikes. However women in this tribal culture are not used to being dependent on their husbands; it hinders their social relations and lowers their self-esteem.

Housing

Many families now live in worse conditions than before. Uncertain of their future income, they have not added to, or repaired their houses. Very few have toilets. Lengthy stays with relatives are stressful.

Common property

It was mainly the women who used community land for grazing, small-scale cropping and to collect water. There has been no compensation for the loss of this land.

Livestock raising

It is not possible to produce enough meat because there is no land to keep large animals.

Work

Women can no longer grow crops or go into the forest to gather fruit, flowers, herbs or firewood for family use or to sell. They have no option but to work at home.

Hygiene

The ponds and springs have been destroyed. Many of the new bathing and washing places are further away and take more time to reach. The loss of woodland makes it harder for almost two-thirds of the women to defecate in private.

Health

The relocation means that it is further to the hospital. Access to free public health facilities has deteriorated, so half the women now pay to visit private clinics. Between two-thirds and three-quarters of the families have increased their use of traditional healers.

Trauma

Many women suffered from shock after losing most of their possessions. They suffer from a sense of uncertainty at home and at work. Alcoholism and domestic violence at the hands of men are on the rise. The men used to stay at home and drink small amounts of home brew made by their wives; they now go elsewhere and drink more.

Paid work

Many of the men work for the mining company, but about one-third do not. Very few of the women have jobs with the company.

Money management

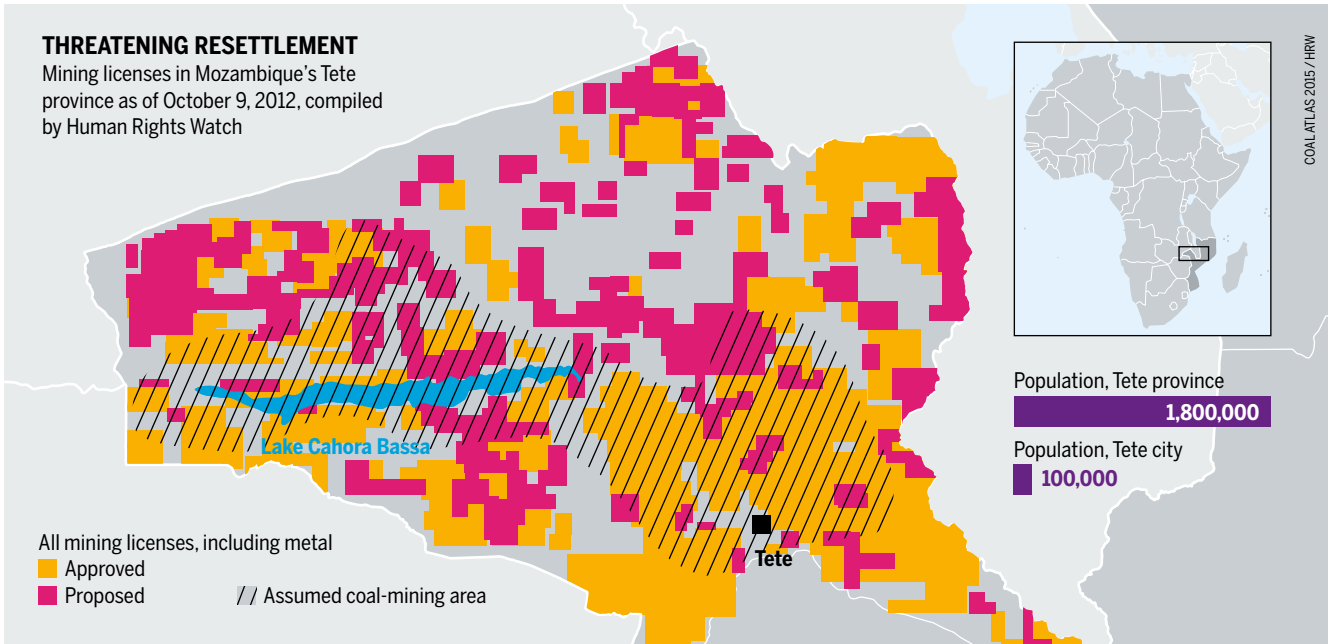
The men have cash: from the financial compensation and wages from their jobs in the mines. But they do not spend it to support their families. Traditionally, the women are not supposed to work for money.

Social bonds

The villagers used to maintain close social contacts; they supported each other and had ways to resolve disputes. These traditional mechanisms have broken down.

■ Jharkhand

COAL ATLAS 2015 / AHMAD LAHIRI DUTT



the overlying soil was stockpiled so it could be reused. But six years later, it had lost its fertility.

Most deaths in coal mining occur because safety and labour standards are ignored – itself a violation of human rights. Although the mining industry accounts for only about one percent of the global workforce, it accounts for eight percent of fatal accidents at work. In addition not all deaths are recorded officially, especially in the illegal coal mines of China, Colombia and South Africa.

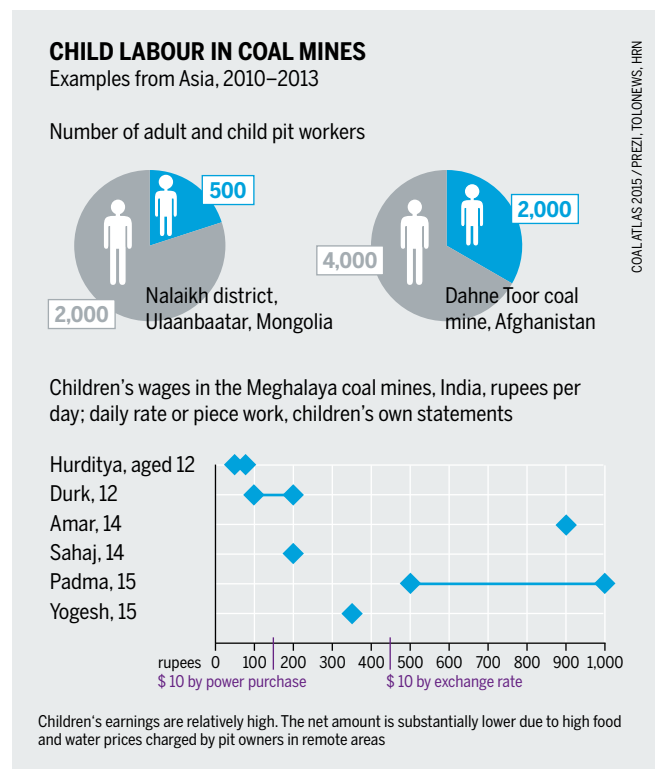
Pneumoconiosis, or “miner’s lung” is an internationally recognized occupational disease, but Russia, India and South Africa do not publish data on the number of victims. In China, though, the Ministry of Health revealed that there were 23,812 new cases in 2010, half of them a result of coal mining. An international research team examined 260,000 cases of people who had died of the disease worldwide; 25,000 deaths could be linked to coal mining. Even if the disease does not kill, it can cause severe suffering. Patients can no longer work, thus condemning their families to poverty. They may have the right to claim compensation from the mining company, but a doctor must confirm their claim. Furthermore, payments are often delayed or insufficient.

Many mining areas are among the poorest parts of a country, even in the industrialized world. In the Appalachians, a mountain range in the eastern United States, poverty and mortality rates are significantly higher in coal-mining areas than elsewhere. Studies in several countries reveal that mining mainly benefits a small, mostly urban class, while rural people suffer. If coal is extracted for export, local people hardly benefit at all; on the contrary they are usually left with the toxic remains. Poverty also leads to child labour in coal mines. Around 400,000 children are working in the Indian state’s 15,000 mines in Jharkhand, many of them under often inhumane conditions.

Not all areas will eventually be covered by mining operations. But conflicts over land and water use and water resource management are looming

Mining companies do respond to such accusations. The International Council on Mining and Metals, an association of 23 of the world’s leading mining companies, has published guidelines for respecting human rights and the rights of indigenous peoples. Some companies are improving health-care services and infrastructure. But the governments in many countries lack the will or ability to guarantee mining workers and local people the most important protection – that of the law. ●

While child labour in coal pits has been significantly reduced in Latin America over the last decades it is still very common in Central and South Asia.



PROTESTS

A BROAD ALLIANCE WITH STAYING POWER

Around the world, people are fighting back against the coal industry. They face repression, harassment and violence – but sometimes they are successful.

International environmental organizations have been protesting for 30 years against the exploitation of nature and the mining of coal. At the grassroots level, local communities are fighting back, too. The Wayúu community in Tamaquito is struggling against Cerrejón, a huge open-cast coal mine in Colombia. Locals have mounted a health campaign against two urban coal-fired power plants in Chicago. In Shenzhen, China, the city council rebelled against a 2,000 megawatt plant.

The most visible protests can be found in the developing world, where the use of coal is rising quickly. All around the

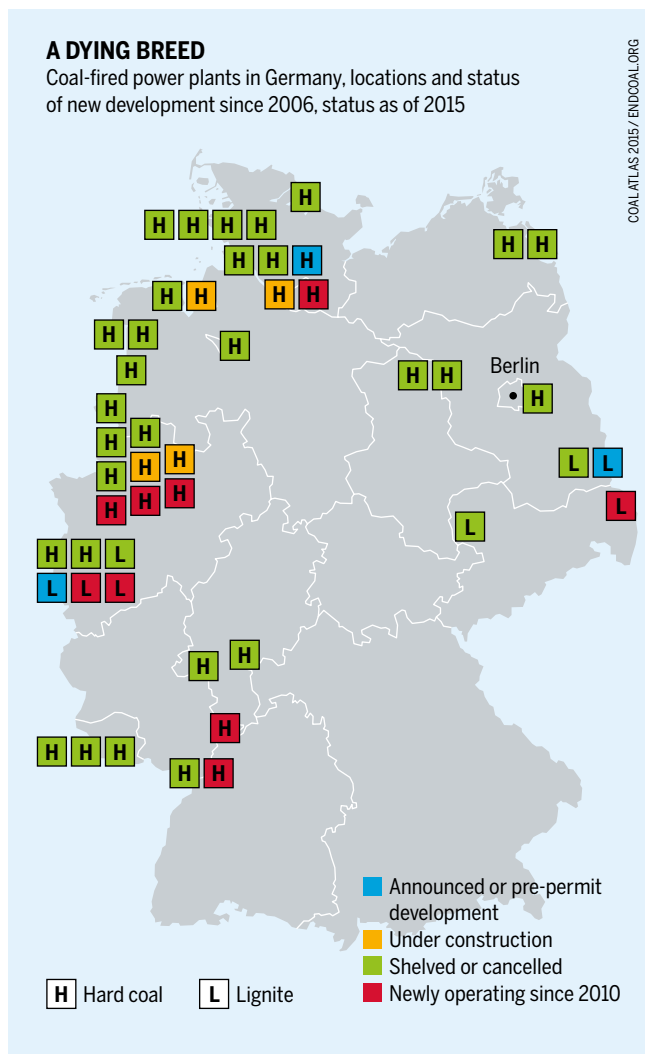
world, people are taking to the streets: in Australia, Bangladesh, China, Croatia, Finland, France, Germany, India, Malaysia, Mozambique, the Philippines, Sri Lanka and South Africa. Farmers in Inner Mongolia, China's biggest coal region, have risked their lives by blocking coal transports. In the big cities, people demonstrate against the smog.

Communities affected by coal in Mozambique have repeatedly protested by blocking the Sena railway line that carries coal to the port of Beira. India's government is expanding the use of coal more than any other country; a national alliance has responded with hunger strikes and protest marches. The activists have been ordered about, imprisoned and threatened. Despite adverse conditions in Colombia, communities are working together to expose the truth about coal mining. Their actions include holding popular tribunals against mining, visits to sacred sites, and autonomous public hearings.

In Australia, the world's second-biggest coal exporter, an alliance of Aboriginal communities, farmers, churches, doctors and environmentalists wants to halt the construction of new port infrastructure and the expansion of existing ones in Queensland. These facilities are intended to serve new or expanded mines to be sited across the Galilee Basin. The alliance uses a variety of tactics, including strategic legal action, lobbying, divestment campaigns, public education and non-violent direct action. It has secured significant victories. For example, Friends of the Earth Australia helped establish Lock the Gate, a powerful alliance that is active throughout Australia. Also, Market Forces, a campaigning organization, has helped shift many millions of dollars in investment away from destructive fossil-fuel projects.

In the United States, environmental organizations have been fighting to phase out coal. Thanks to the efforts of a broad coalition, a total of 200 coal-fired power plants – some 40 percent of the country's total – have been retired since 2010. Such successes are based on a wide-ranging set of arguments: climate change, health threats and environmental damage. In 2014, mass protests against the discharge of toxic waste from mines into rivers took place in West Virginia and North Carolina. Hundreds of thousands of people had been left without drinking water for weeks.

Friends of the Earth Korea works with local communities who have long fought against the expansion of coal-fired power plants. Plans to expand the Yeongheung plant were cancelled recently as a result of protests against air pollution. In an unusual move, the provincial government backed health research in Dangjin, site of a 4,000 megawatt plant.

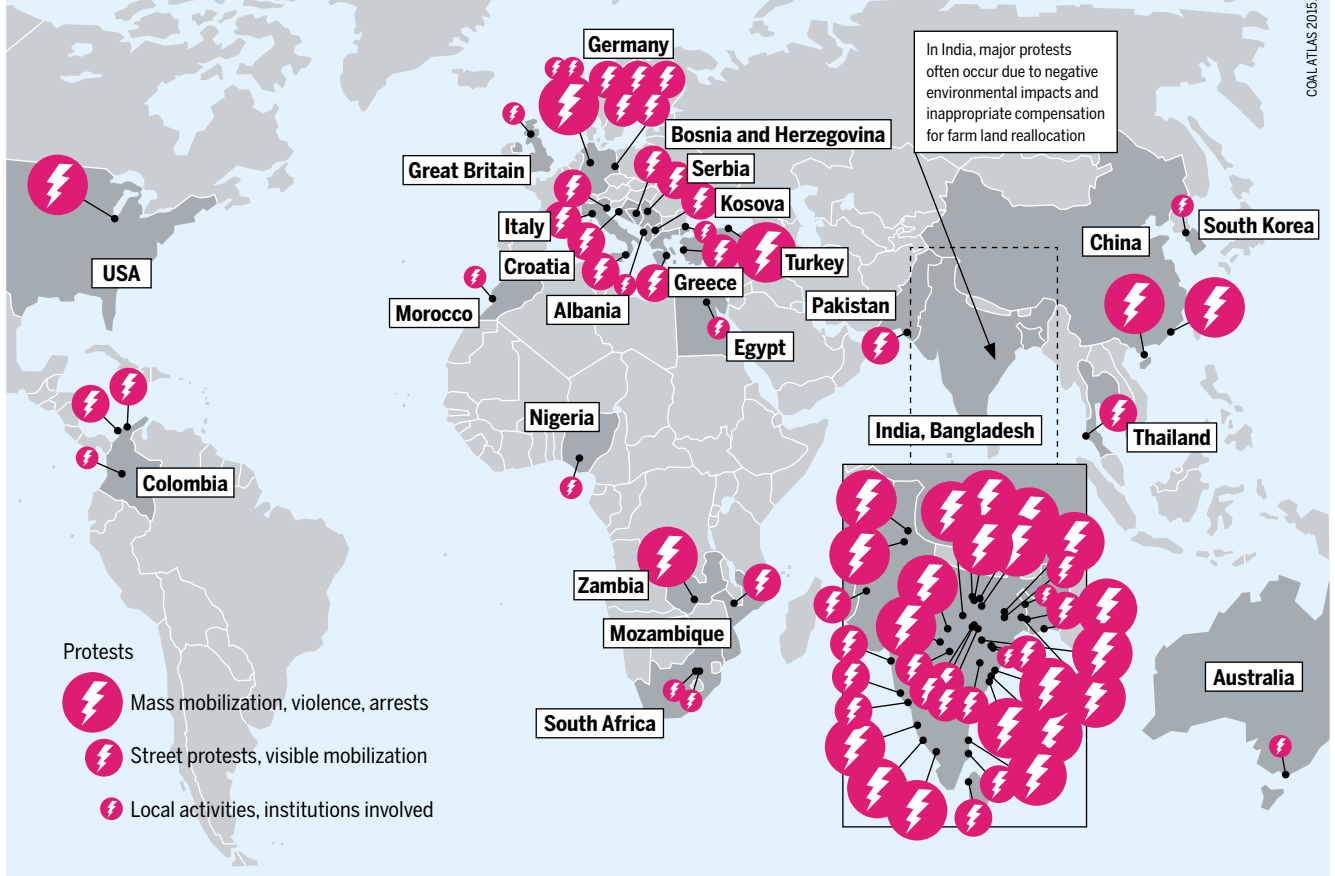


Of 41 power plant projects registered, 32 were prevented; 13 are under construction or in operation

WORLDWIDE MOBILIZATION

Intensity of protests against coal mines, coal harbours and coal-powered plants according to the Environmental Justice Atlas (ejatlas.org)

COAL ATLAS 2015 / EJATLAS.ORG



This study revealed high levels of hazardous heavy metals and other toxins on people living near the plant.

In Europe, protesters in countries ranging from Denmark to Italy, Croatia and Turkey have undertaken various actions against new coal power plants. They draw attention to the environmental and social costs, the need to protect the climate, and the goal of making energy supplies renewable. The United Kingdom was one of the first countries where such protests gained visibility. The first “Camp for Climate Action” was set up near the Drax power station in Yorkshire in 2006. In a highly symbolic action, some 600 activists tried to break into the plant to disrupt its operations. In the Thames estuary, Greenpeace activists repeatedly blocked access roads to the highly polluting Kingsnorth coal-fired plant over a period of three years.

When the operator abandoned the site, Greenpeace claimed a major victory. Although the British anti-coal movement lost steam during the economic and financial crisis, the approaches it pioneered live on. Climate camps, with their mix of actions, information and discussions, have spread to Belgium, Germany, the Netherlands, Scandinavia, South Africa, and the United States.

In Germany, campaigns against coal have been held for decades, though they have been only local or regional in scope. Around 2006, however, protests grew louder after investors announced plans for 38 new coal-fired power plants. Climate Alliance Germany was formed in 2007. This broad coalition includes churches and development organisations

Not all protests against the coal industry are registered in the Environmental Justice Atlas. But many are, revealing major areas of conflict

such as Bread for the World and Oxfam, which added coal to their campaign agendas. The alliance launched an anti-coal movement in 2008. In the following years, environmental groups such as Friends of the Earth Germany and Deutsche Umwelthilfe tried to stop the projects, in part through the courts. They were successful: 22 new plants were stopped and many more delayed. The court orders have been accompanied by public pressure questioning the role of coal in climate and energy policies, and pointing out the plants’ lack of economic viability.

Since 2011, the German lignite mining areas have also seen a range of protests: both local rallies and big, international actions. In 2014, environmental NGOs organized a human chain stretching several kilometres through Lusatia, with 7,500 people from all over Europe. In 2015, 6,000 people formed another chain in the Rhineland. There, in August of the same year, about 1,500 protesters took part in the largest act of civil disobedience seen in Germany for decades. Under the banner “Ende Gelände” (Here and no further) they climbed into the Garzweiler mine, forcing it to shut down for nearly a day. The mine’s operator, German coal giant RWE, has taken legal action against 800 demonstrators. Nevertheless, activists consider the event a huge success for the climate movement. ●

SUBSIDIES

HIDDEN PAYMENTS, UNPAID BILLS

The coal industry uses taxpayers' money to keep its prices low – and it does not compensate for the costs of climate change or disease. A brief look at the scale of the problem.

Supporters often say that coal produces cheap energy. But things are not quite as simple as the industry suggests. The real cost depends on what is included in the reckoning, and who pays for that. The price of power reflects the costs incurred by the energy producer, along with taxes and levies.

However, some factors are not included in the price and never show up on an electricity bill. These are the so-called external costs. These externalities occur when a market actor (in this case, the coal company) affects the welfare of others but does not compensate them. In other words, the person or organization that causes a problem does not pay fully for its consequences. It pulls in a profit but passes part of the costs on to third parties, or to society at large.

Mining and burning coal involve enormous external costs. The most significant costs are government subsidies, environmental damage and harm to human health. Taking this into account, coal becomes an expensive commodity. The International Monetary Fund has revealed that post-tax subsidies for coal amounted to 3.0 percent of global GDP in 2011, rising to 3.9 percent in 2015. This is largely due to the high environmental costs associated with coal consumption.

Those costs include greenhouse gas emissions and air pollution. It is impossible to put hard numbers on these; instead, we have to rely on estimates and judgement. Some types of damage cannot be reversed. In addition, costs are

not based on the intrinsic value of ecosystems harmed by climate change, for example, but on the economic losses. The costs of repairing damage after a major accident are included, but only to a limited extent, to avoid forcing the business concerned into bankruptcy if damages are claimed.

These considerations mean that any figures – such as those provided by the British consulting firm Trucost to the United Nations Environment Programme – are politically tinged. The numbers should be treated with caution, but they are huge, even if they are just the tip of the iceberg. According to Trucost, the external costs of using coal to generate power in 2009 amounted to \$452 billion in East Asia alone. These costs were mainly attributed to greenhouse gas emissions and air pollution. In the same year, the costs in North America reached \$316 billion.

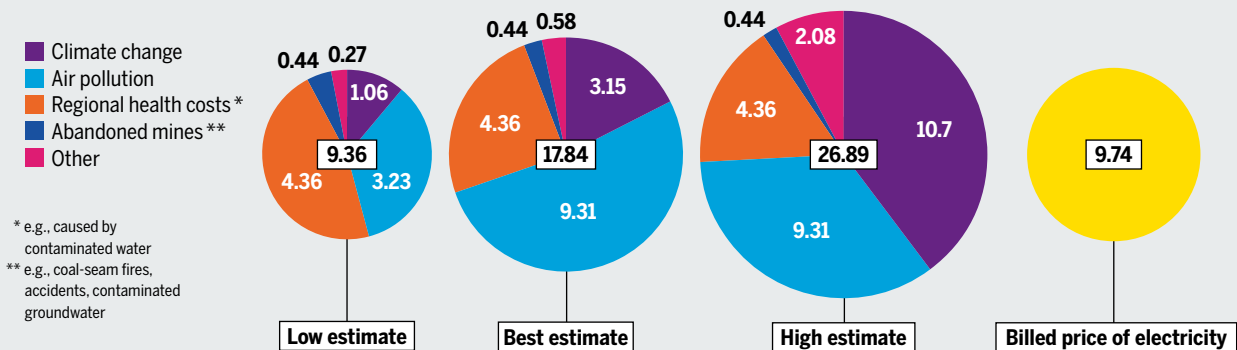
In Germany, air pollution and greenhouse gases added up to more than 28 billion euros – exceeding what was spent to support renewable energy. For lignite, the German Federal Environment Agency puts the environmental costs at around 11 euro cents per kilowatt-hour; for hard coal, the figure is 9 cents. If these costs were reflected in the energy price, electricity bills would rise. In the USA, researchers estimate that a coal-fired kilowatt-hour would have to cost between 9 and 27 US cents more than the customary 10 cents appearing on the electricity bill. If the coal companies were to internalize these external costs, coal would barely be competitive and would be displaced from the market as a result.

A more realistic price would not automatically compensate people harmed by climate change or those suffering

If climate, environment and health damage by coal power production were properly taken into account, the electricity bill would look radically different

THE FLIP SIDE OF THE ELECTRICITY BILL

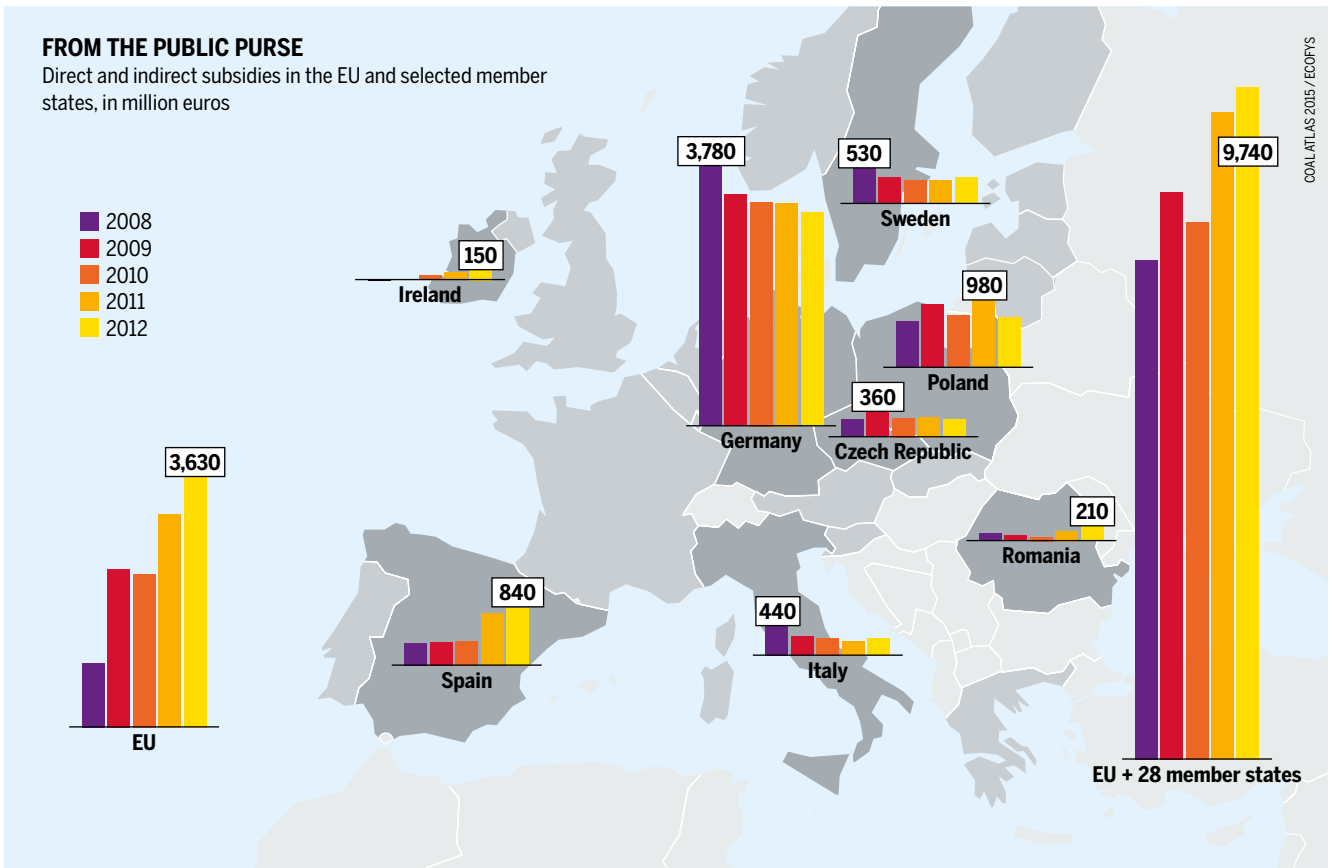
Environmental and health costs not included in electricity bills in the Appalachian coal-producing area, USA, calculations for 2008, and billed average electricity price in 2008, in US cents per kilowatt-hour



COAL ATLAS 2015 / EPSTEIN ET AL.

FROM THE PUBLIC PURSE

Direct and indirect subsidies in the EU and selected member states, in million euros



COAL ATLAS 2015 / ECOFYS

from air pollution. The coal companies should have to take on the legal as well as the financial responsibility. A public admission of guilt and an apology to the victims would be appropriate. Both are taboo for the industry.

The apparent cheapness of coal is also a result of subsidies from the taxpayer, both current and in the past. Energy producers are still profiting from the support they received in the past. In 2014, the German consulting firm Ecofys put together some impressive numbers for the European Commission. Between 1990 and 2007, the current 28 members of the European Union subsidized the expansion of coal-related infrastructure to the tune of 200 billion euros. Only nuclear power got more support, with 220 billion euros. Aside from 100 billion euros spent on hydropower, renewables were not directly subsidized.

Government support has ensured that locally produced coal stays competitive. Between 1970 and 2007 this support cost the EU countries a total of 380 billion euros. Germany leads in the subsidy race. One source of funding is the 1.2 billion euros that the German government contributes directly to the hard-coal mining industry.

Between 1974 and 2007, the EU governments as a whole spent around 87 billion euros on fuel research and development. Nuclear power got the biggest chunk, at 78 percent. Another 12 percent went to renewables, and 10 percent to fossil fuels – with coal getting more than oil and gas. In 2012, the member states of the EU handed out a total of 13.4 billion

Every year, the coal industry in the EU receives nearly 10 billion euros of taxpayers' money. Germany contributes the biggest amount

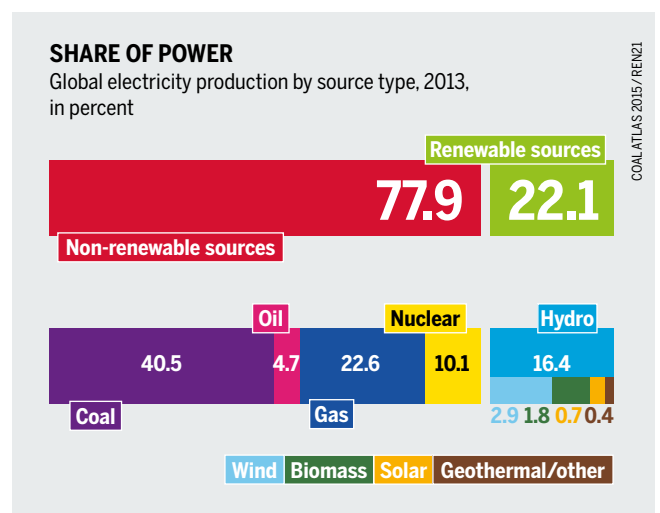
euros to the fossil-fuel industry. Outside the EU, coal subsidies are huge, too. A study by the Global Subsidies Initiative found that in Turkey, for example, they amounted to \$730 million. The OECD puts the figure for Australia at over \$125 million in 2011.

In 2009, the governments of the G20 group of major economies committed themselves to phase out subsidies for fossil fuels in the medium term. The worldwide shift to renewable energy will gather pace if they put their promises into action. ●

Subsidies make sense if they improve the energy mix. But coal is part of the problem, not part of the solution

SHARE OF POWER

Global electricity production by source type, 2013, in percent



COAL ATLAS 2015 / RENZI

BIG PLAYERS BEHIND THE SCENES

Digging mines, building power plants and providing infrastructure cost billions. Many countries cannot afford the investments; credit agencies and multilateral and private banks are glad to step in.

For a foreign contractor, building a coal-fired power station in a developing country entails substantial financial risks – even for prominent firms like Bilfinger, Siemens, Alstom or ThyssenKrupp. Construction is expensive – a big power plant can easily cost over a billion euros – and requires huge investments up front. It can take years for a contractor to get paid. The client, who may be a government-owned or private power generator, may run into financial difficulties. Political crises may halt construction.

To cut the risks for the contractors and their banks, many governments have established export credit insurance. In addition, loans from development banks support the export of mining equipment and power plants. By hedging their risks and availing themselves of lower interest rates, the contractor can offer lower prices. But support for coal projects is a controversial aspect of development cooperation.

On the one hand, new coal-fired power plants are supposed to combat poverty and boost energy supplies in developing countries. On the other, burning fossil fuels alters the climate, pollutes the air and water, and hinders the development of renewable energy. In addition, coal mining is often accompanied by environmental destruction, violations of human rights and exploitative working conditions.

Developed countries support their exports generously. Between 2007 and 2014, more than \$73 billion – or over \$9 billion a year – in public finance was approved for coal. Nearly half (47 percent) of the total international finance for coal came through export credit agencies in countries that are members of the Organisation for Economic Co-operation and Development (OECD). Japan, an OECD member, led the pack, with \$20 billion. China (nearly \$15 billion) was followed by two more OECD members, South Korea (over \$7 billion) and Germany (\$6.8 billion).

The largest recipient countries of coal finance by export credit agencies from 2007 to 2014 are Vietnam (more than \$4.5 billion), South Africa (almost \$4.5 billion), India (more than \$4 billion) and Australia with \$4 billion in total. Nearly one-quarter of coal funding from OECD export credit agencies went to High Income Countries. In this period, the total greenhouse gas emissions related to international public finance for coal amounts to almost half a billion tonnes of CO₂ per year, or, to put this number in context, the total annual emissions of Italy.

Most of the money goes into building power plants. However, countries such as Russia, Canada and Italy use export credits mainly to finance the digging of new coal mines. Led by the United States and Japan, around \$12.9 billion have been used for this purpose from 2007 to 2013. Even though

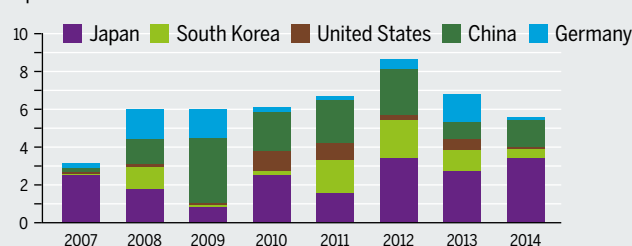
Donor countries provide cheap credit so they can boost their own export industries

TAX MONEY FOR EXPORTERS

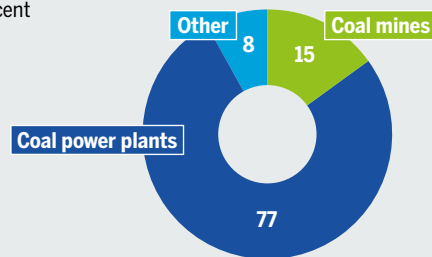
Subsidies for the sale of coal-fired power stations and mining facilities, 2007-2014, in billion US dollars



Top 5 countries' bilateral finance



Public finance for project type, in percent



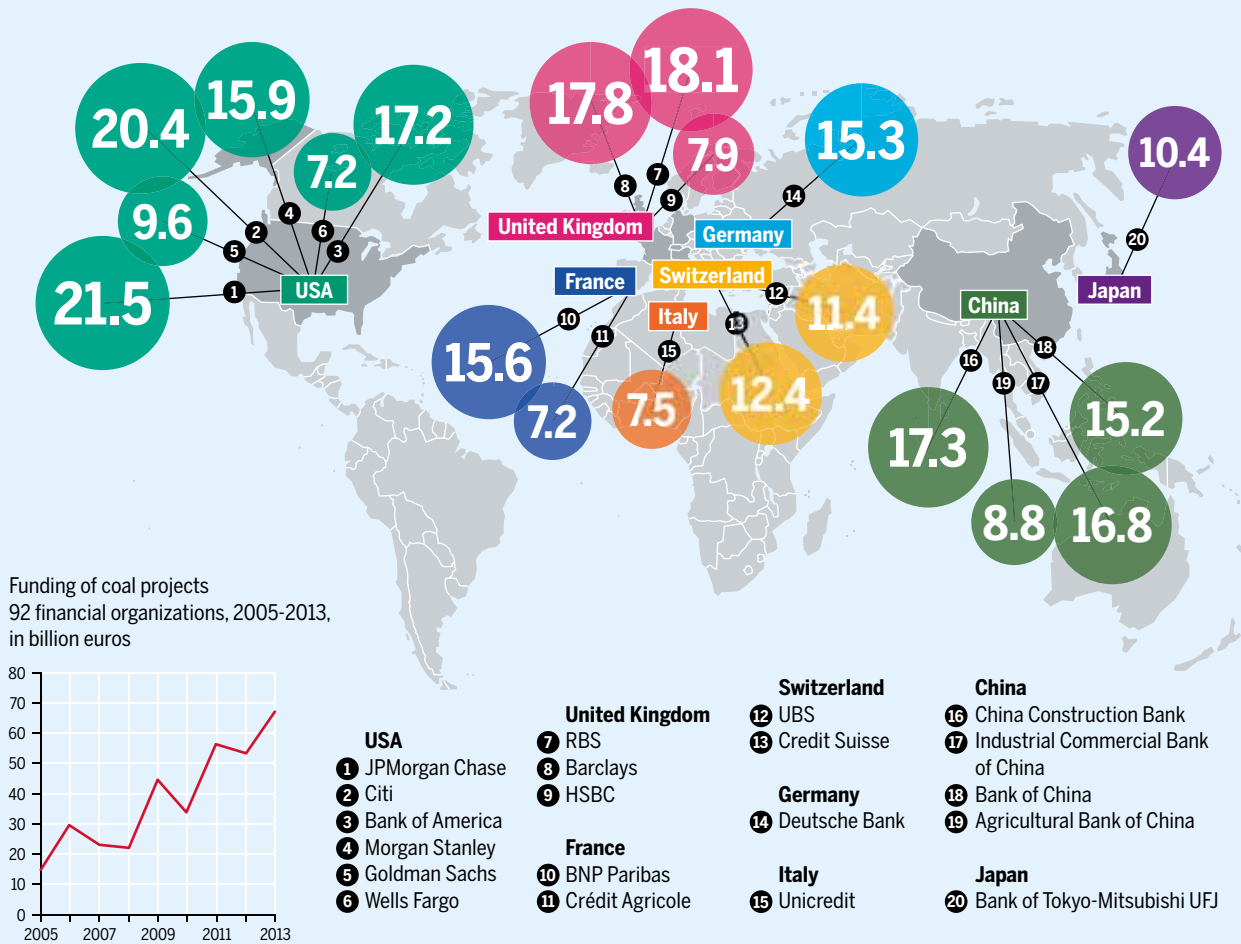
In millions of tonnes of CO₂ equivalent



* OECD member countries ** latest year available

BIG MONEY, SMALL FUTURE

The 20 largest banks funding coal, January 2005 to April 2014, in billion euros



export credits were initially intended to reduce business risks in uncertain markets, they have also recently been used to develop coal mines in politically stable countries such as the United States and Australia.

Multilateral development banks also play an important role alongside the national credit agencies. Between 2007 and 2013 they supported coal projects with subsidies worth \$13.5 billion. The biggest donor was the World Bank, at \$6.5 billion; the biggest regional donor was the African Development Bank, with \$2.8 billion in support. About 90 percent of this money went to build new power plants; the rest went on mining and on modernising older plants.

Faced with persistent criticism, financial support for coal projects has declined sharply since 2010. Since 2013, three development banks – the World Bank, the European Bank for Reconstruction and Development and the European Investment Bank – have decided not to support any more coal projects, or to do so only in exceptional circumstances. Individual governments are also pulling back. Since 2013, the Export-Import Bank of the United States has discontinued support of coal-fired plants – with a few exceptions.

In Europe, France, the Netherlands, the United Kingdom and several Scandinavian countries have also announced they will do the same, though they are still discussing possible exceptions. Germany is struggling to phase out of

Banks finance mines, transport systems and power plants - good business, as long as the politics are supportive

supporting coal. KfW, a government-owned development bank, has ended its longstanding practice of subsidizing new coal-fired power stations. But its private sector subsidiary, IPEX, will continue to support coal projects if the recipient country has a climate-change policy.

Commercial banks, whose day-to-day operations are beyond government influence, play an even bigger role than the public sources of funding. Between 2005 and 2014, financing for coal projects added up to 500 billion dollars. Together, the 20 leading banks gave 73 percent of the loans.

The member states of the OECD have divergent views on tightening environmental and social standards that they should apply when offering export credits. The biggest issue is the financing of coal projects. The United States and some other countries demand that these types of credits for coal projects be stopped – more transparency is needed in this regard. Export credit agencies seldom make their business information available to the public. Critics demand that in future the agencies should announce promptly whom they are supporting, and in what way. ●

PROFITABILITY

DEFLATING THE CARBON BUBBLE

Successful climate policies mean that coal is becoming a less valuable resource. This affects the companies that dig it up.

In 2009, a team of researchers at the Potsdam Institute for Climate Impact Research published a ground-breaking study calculating the size of the global carbon budget. That is the amount of CO₂ that can be emitted if the rise in the Earth's surface temperature is to be held below 2 degrees Celsius. A key finding: if we continue pumping out as much greenhouse gas into the atmosphere as we have so far, we will have used up the budget in just 14 years – and the temperature will rise more than 2°C. In addition, it means that the carbon budget sets a limit to the amount of coal, oil and

gas we can burn. All the fossil energy sources beyond this limit are “unburnable carbon” – a phrase coined by the Carbon Tracker Initiative that has become an important measure in global climate policymaking. The Carbon Tracker Initiative calculates that 2,795 gigatonnes of CO₂ are stored in oil, gas and coal reserves in private and government hands and listed on stock exchanges. Compare that to the global carbon budget of 565 gigatonnes. In a nutshell: four-fifths of the reserves are “unburnable carbon”.

Two scientists at University College London have worked out what these calculations imply for the use of individual fossil fuels in different locations. They published their findings in the journal *Nature* at the beginning of 2015: to keep within the 2°C limit, we can burn only about 12 percent of current global coal reserves, two thirds of the oil and about 50 percent of the natural gas reserves. The restrictions would be even tighter if we are to keep within a 1.5°C rise, as recommended by climate science.

Policy decisions and lower market prices for energy, partly as a result of advances in renewable energy, could leave most fossil-fuel investments as “stranded assets”. Against investors' expectations, such assets would bring in no profit; on the contrary, they would have to be written off as more or less worthless. The Carbon Tracker Initiative calls this misinvestment problem the “carbon bubble”; named after the speculative peaks in the world of finance, such as the property bubble that sparked the economic crisis in 2008. The phenomenon is not restricted to coal: oil and gas reserves are also affected.

Despite this, private and government financial institutions continue to invest in the companies affected, or to grant credit on the basis of the previous policy situation. Fossil-fuel reserves are included in the trading value of companies: the production licenses of mining companies, the generation capacity of power producers, and the investments by banks in these firms. If the bubble bursts, these companies will see their value crash.

A study commissioned by the European Greens looked into the risks in 2014 for 43 of the EU's biggest banks and pension funds. It identified a total of over one trillion euros. The good news: some funds have already started to divest themselves of these holdings in order to avoid a crisis if the investments in coal and oil become “stranded”. In June 2015, the Norwegian parliament voted to remove coal firms from the investment portfolio of the country's pension fund. This is the biggest divestment so far by a single investor, which is also Europe's largest pension fund.

Many governments are concerned about the financial risk represented by the carbon bubble. Divesting from coal now is necessary to prevent disastrous climate change and

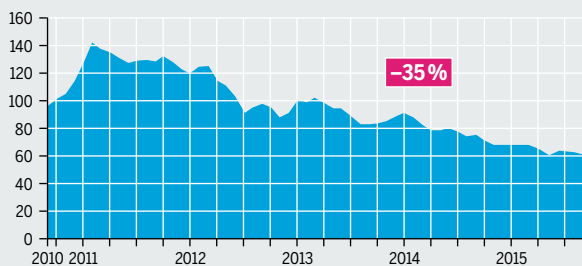
Pressure on global energy policies will put further pressure on coal share prices

GOING DOWNHILL

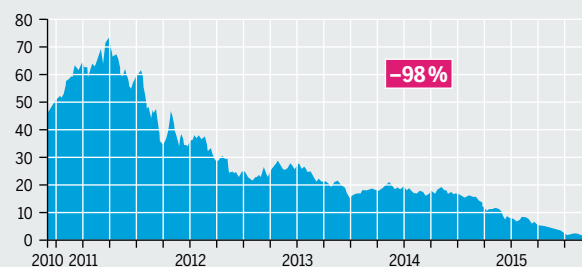
Financial crises in the coal sector, three examples, August 2010 to August 2015

Prices for exported Australian coal, in US dollars per tonne

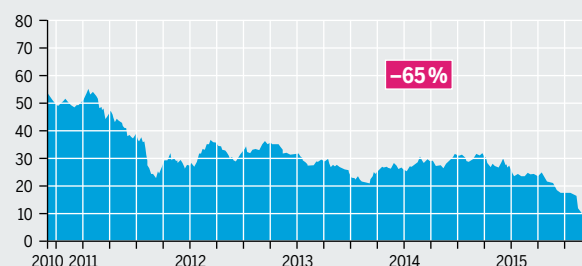
Percentage loss in 5 years



Share prices for Peabody Energy, biggest US coal producer, in US dollars



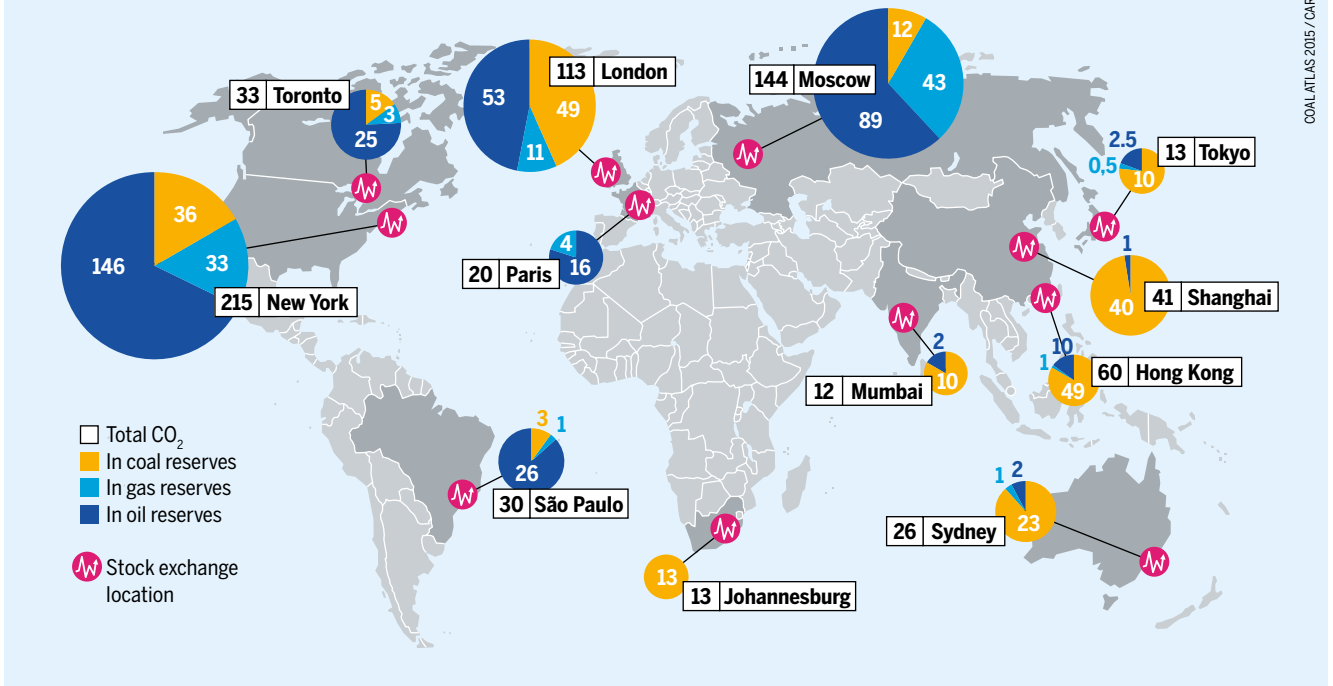
Share prices of RWE, largest German power generator, in euros



COAL ATLAS 2015 / INDEX MUNDI / YAHOO FINANCE

TODAY'S INVESTMENT IN TOMORROW'S POLLUTION

The 12 stock exchanges with the biggest coal, oil and gas reserves of listed companies, expressed as CO₂ content of the reserves, 2013, in billion tonnes of CO₂



COAL ATLAS 2015 / CARBON TRACKER

a global financial crisis. The big coal producers at least partly recognize the sign of the times. E.ON, Germany's biggest power firm, is splitting in two. One part of the firm will focus on renewable energy and power services, while the rest will be responsible for conventional power plants. Rio Tinto, a mining multinational, has hived off its coal investments into a separate firm while signalling it will move away from this type of mining. Its competitor, BHP-Billiton, has also parted coal investments into a separate firm, thereby halving its coal activities.

These actions are late. In Europe, power firms have lost touch with developments because they have not changed their strategy quickly enough. Only eight percent of German investments in renewables came from power suppliers like E.ON and RWE. In 2014, the French energy giant GDF Suez had to write off stranded assets to the value of 15 billion euros. The power firms did not take the EU's goal of reducing emissions by 2020 seriously. They assumed that energy efficiency and renewables would be long in coming, if they arrived at all.

The coal industry is now waking up. Low prices on the world market are putting revenues and profitability on hold. In 2014, coal consumption in China, the biggest consumer, fell for the first time on record. In an effort to reduce air pollution, the country is consuming significantly less. Demand in the United States and Europe is also declining; rising consumption in India cannot make up the difference. As a result, coal prices have halved from a peak in 2011, and are now as low as during the global financial crisis in 2008. Low

The end of coal exploitation does not have to trigger a stock-market crisis – if investors change course

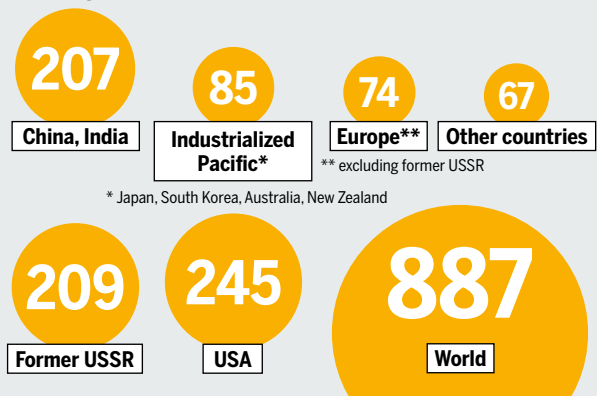
A decline in the value of fossil fuel reserves translates into a fall in the share price of the firms that own them

world prices affect the Chinese market too, bringing losses to coal producers there. In mid-December 2014, Glencore, a mining giant, shut its 20 mines in Australia for three weeks and told 8,000 workers to take their annual leave – a sign of the depth of problems faced by the industry.

Investors should perhaps regard some coal producers themselves as “stranded assets”. Political moves to reduce carbon emissions and develop alternative technologies send the right signals to chief financial officers. More important still, companies in the fossil-fuel sector are also getting a clear message; they should not waste any more money looking for new reserves. ●

IT'S BEST TO LEAVE IT IN THE GROUND

Coal reserves that are “unburnable” with a 2-degree limit to global warming, in billion tonnes



COAL ATLAS 2015 / MGLADE/EKINS

CHINA

BLACK FUEL, IN THE RED

Change is under way for the world's biggest coal consumer; consumption in 2014 was down. Renewables are up. Coal-fired power plants are working at less than full capacity.

China burns more coal than any other country. In the 15 years since it became the workshop of the world and developed a booming domestic market, its consumption of coal has doubled. Between 2010 and 2014 alone, China built new coal-fired power plants capable of generating 228 gigawatts – three times more than Germany's total electricity consumption. Because of its dependence on coal, China now emits significantly more carbon dioxide than the long-time number-one climate offender, the United States – though it still churns out less of the greenhouse gas per person. Counting the cumulative emissions since 1990, China is now on the verge of overtaking the USA.

But 2014 was different. For the first time in over three decades, China burned less coal than in the previous year. Consumption declined by 2.9 percent, and imports slumped by around 11 percent. Not long ago, the International Energy Agency predicted that both figures would continue to rise until 2020. Despite the decline in coal, power consumption was up by 3.8 percent, and the gross domestic product rose by more than 7 percent. It is unclear whether this decoupling is a blip or a turning point.

The decline in consumption did not just happen. The government wants to reduce the use of coal for various reasons. The most important reason is the smog that blankets Chinese cities causing asthma and boosting the risk of cancer. The Chinese people, and especially the emerging middle class, are becoming increasingly irritated. Released in 2015, the documentary "Under the Dome" by journalist Chai Jing, focuses on widespread air pollution, and has attracted attention. Over 150 million Chinese watched this film within just three days. It has since been censored by the authorities.

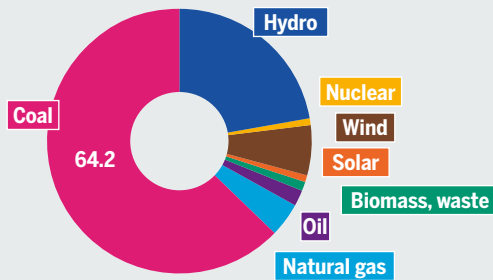
In the face of widespread dissatisfaction, cities have been switching off their older coal power plants and dozens of provinces have decided to reduce their consumption. A planned national market for CO₂ pollution rights strives to support such efforts. These may make the goal of the "Energy Development Strategy Action Plan", which aims to reduce the share of coal in the total energy mix to below 62 percent by 2020, down from today's official 64.2 percent, possible.

The national government is also pushing for the rapid expansion of renewable energy. By 2020, non-fossil energy

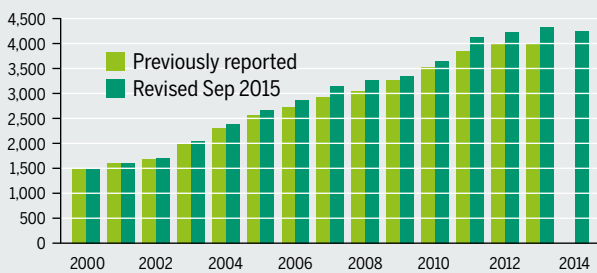
New data released in 2015 revealed China had used 14 percent more coal than previously thought. Even so, 2014 saw a slight drop

UPS AND DOWNS IN CHINESE COAL USE

Installed electricity capacity share by fuel, mid 2014, in percent

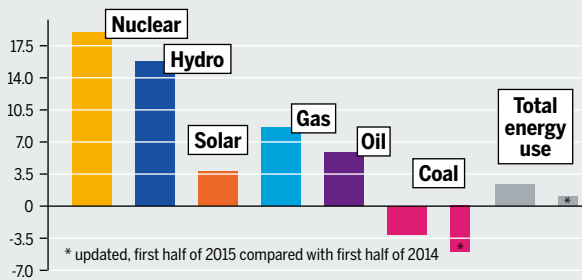


A coal plateau? Raw coal production, old and new data, million short tons* per year



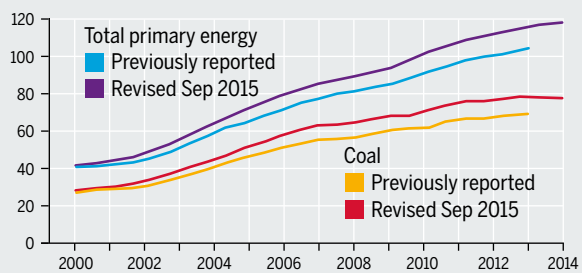
* short ton: in the US, 907.2 kilograms

Less coal, more nuclear and hydropower: changes in energy use, 2014 to 2013, in percent



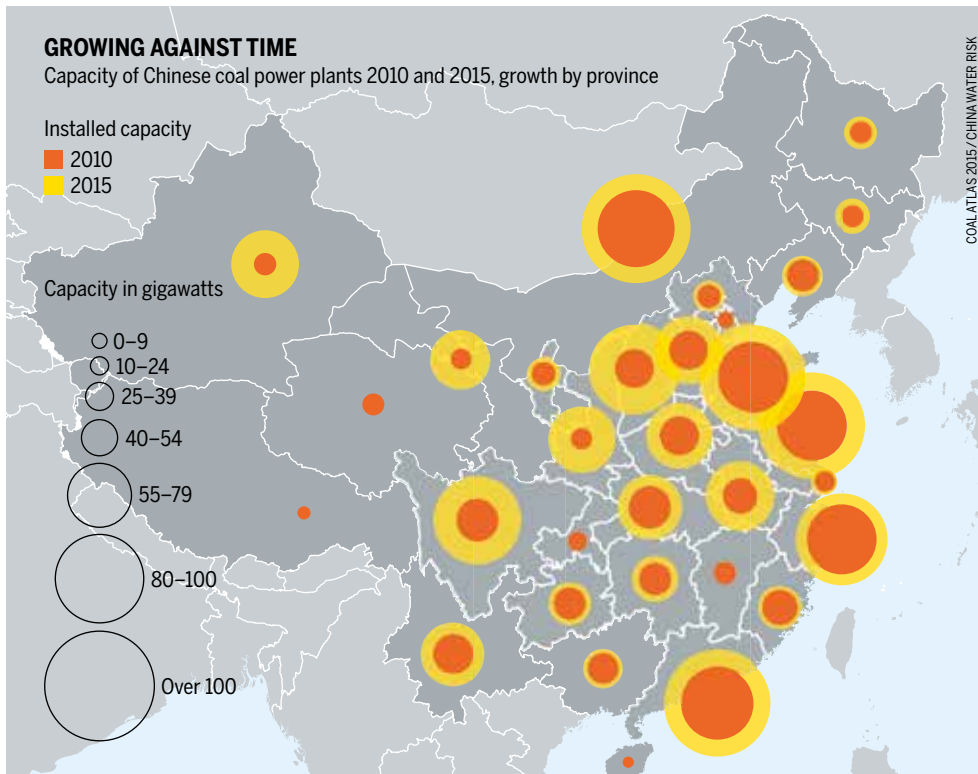
* updated, first half of 2015 compared with first half of 2014

Ever higher: energy consumption, old and new data, quadrillion Btu* per year



* Btu: British thermal unit, a non-metric unit, 1,055 joules

COAL ATLAS 2015 / EIA, CARBON BRIEF, IEA



If China's demand for coal continues to decline, many power stations will be superfluous

sources, including nuclear, will account for 15 percent of primary energy consumption; by 2030 their share should rise to at least 20 percent. Meanwhile, no other country is investing as much in hydro, wind and solar power; in 2014, China spent about \$90 billion on these power sources. Such investments are not without controversy. Big hydropower projects have been criticized for their negative impacts on the environment and for serious human rights violations. The construction of the Three Gorges dam alone forced the resettlement of almost 1.5 million people. Compared with the previous year, China boosted its installed wind capacity by 26 percent and solar capacity by 67 percent.

That has led to a decrease in coal production. In 2014, the coal-fired plants produced 1.3 percent less power than in the previous year; on average they are now only running at 54 percent capacity, the lowest level for three decades. China's coal sector is now suffering from serious overcapacity. That is one reason why several planned coal projects have been halted in recent years.

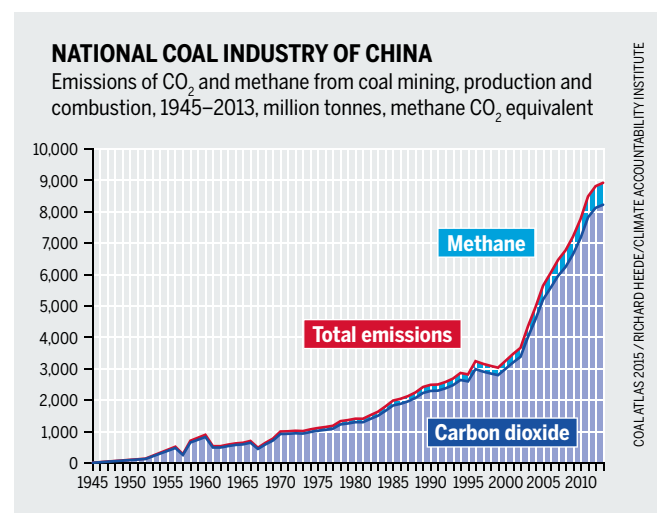
Falling prices, a ban on especially dirty types of coal, and more stringent environmental requirements have depressed the profits of mining outfits. Three out of four Chinese coal firms have reported losses recently. In the last four years, almost 6,000 coal mines have had to close down. By the end of 2015 another 2,000 mines will padlock their gates. Yet as mining companies are yielding to financial and political pressures, other firms are still planning new coal-fired power plants.

Experts warn of an investment bubble caused by an overcapacity in power generation, because still more new

Emissions from the Chinese state coal industry have doubled in a decade. It will take a long time to reverse that trend

plants are being planned that might go unneeded. The value of companies with extensive coal reserves will undergo a correction on the stock markets as their reserves lose value. That will have knock-on effects on related sectors, on major investors, and on banks that have invested in coal firms or have outstanding loans to them. If the Chinese coal bubble bursts, it will threaten not only the country's own financial situation but also the rest of Asia. The big Australian and Indonesian coal exporters, which are oriented entirely to the Chinese market, will quickly feel the pain.

The Chinese government has started to treat coal critically and is ushering in an era of renewable energy. That is a strong signal for the rest of the world. Because China stimulates the mass production of modern facilities, their cost will fall. Strange as it may seem, it is the country with the world's worst pollution that is leading the global energy turnaround. ●



INDIA

RICH IN COAL BUT POOR IN ENERGY

Coal is an important part of India's energy mix, and consumption is rising quickly as the economy expands. Local production is not enough: strong demand is attracting imports from Australia and elsewhere. However, India has huge potential for renewable energy, especially solar and windpower.

Of the 1.2 billion people worldwide without access to electricity, over 300 million live in India. Two-thirds of the 80 million households affected are located in villages that are nonetheless connected to the electricity grid. "Energy poverty" – the lack of modern, non-polluting forms of power – harms lives in numerous ways. Daily power shut-downs, known as "load shedding", increase business costs, reduce efficiency and stop farmers from pumping irrigation water. Burning firewood, cow dung and kerosene pollutes the air indoors and causes respiratory problems, especially among women who do the cooking. Poor lighting means schoolchildren cannot do their homework in the evenings.

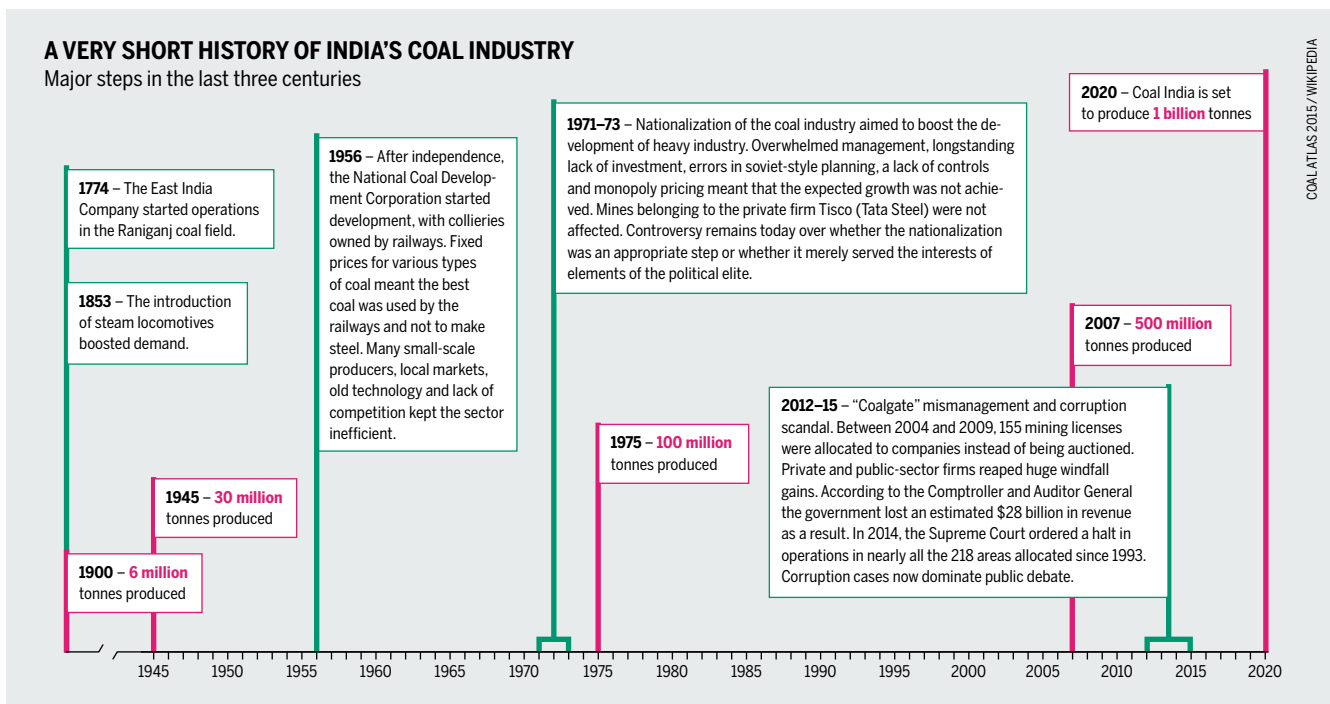
India has been able to reduce poverty alongside a massive expansion of coal use over the last two decades. Power production and the amount of coal consumed to produce it nearly quadrupled between 1990 and 2013. The percentage of the population living below the poverty line fell by about one-third, while the proportion of the population with access to electricity rose from half to more than three-quarters. Coal has alleviated India's energy access problem and contributed to poverty reduction – though at substantial health,

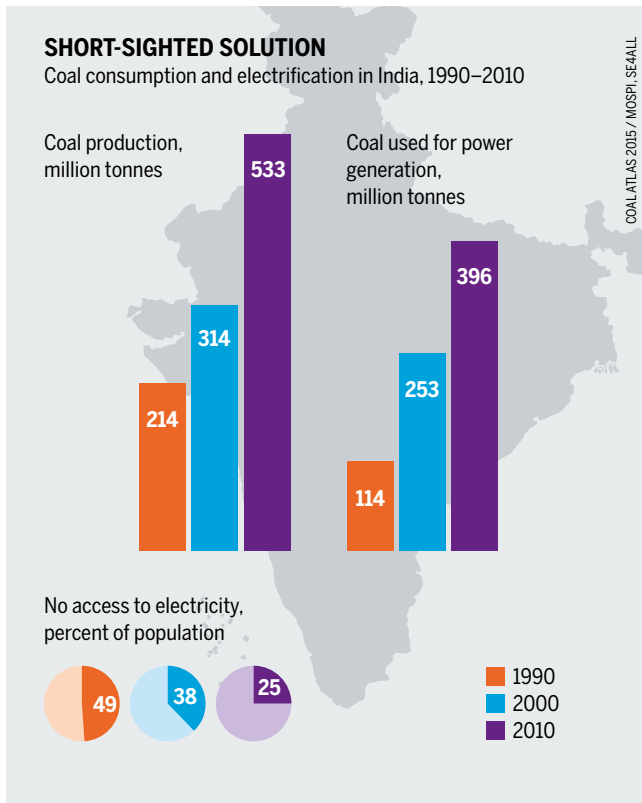
social and environmental costs. And yet each Indian consumes the equivalent of only 0.47 tonnes of oil a year: less than a third of the world average.

Coal provides more than half of India's total primary energy, a share that is projected to decline only slightly by 2030. In 2013–14, the country consumed 740 million tonnes, more than 70 percent of it to produce power, and much of the rest to make steel and fertilizer. The government has targeted a coal consumption of 1 billion tonnes for 2020. Current consumption makes India the world's second-biggest coal consumer, and number three in terms of total CO₂ emissions, even though its per capita emissions of around 1.7 tonnes per person a year remain by far the lowest among the BRICS countries.

Much of India's coal mining and many of its coal-fired plants, often situated directly on the mining sites, are located in forest areas inhabited by indigenous groups called Adivasi. Living on the fringes of India's mainstream society, they are among the poorest communities in India, while bearing the brunt of the environmental destruction and pollution caused by the extraction of coal and other minerals. Large-scale coal mining and power plants in the Singrauli area in Madhya Pradesh have displaced local people and led to land grabs, the loss of forests and numerous health issues, including mercury pollution. Here, local protests recently stopped plans to expand mining in the Mahan forest. In the

For more than half a century, state-ruled Indian coal production and disposition has not succeeded in becoming efficient





open-cast mining areas of Jharia, Jharkhand, uncontrolled underground coal fires have burned continuously for nearly a century. Also in Jharkhand, Maoist guerrillas fight the government; while claiming to defend local communities they themselves thrive on their own coal operations and on protection money paid by coal companies.

India has enormous coal reserves of 300 billion tonnes that could provide the country with energy for hundreds of years at current consumption rates. State-owned, Coal India is the single largest coal company in the world, with over 350,000 employees in 2013 and producing close to half a billion tonnes of coal in 2014–15. Together with numerous state-owned coal power plants and Indian Railways (which derives nearly half of its freight earnings from transporting coal) they constitute a veritable pro-coal lobby within India’s government institutions.

Still, national coal production lags behind official expectations, because of local resistance, outdated production techniques and the cancellation of licences for private mine operators after corruption allegations (known as “Coalgate”). Twenty-five years ago, nearly all the coal used in India was produced locally. Today, nearly one-quarter is imported, most of it from Indonesia, Australia and South Africa. In 2014–15, the import share was 19 percent higher than in the preceding year, and India may overtake China as the world’s biggest coal importer in 2015. To supply the growing import market, Indian companies have gone global. For example, the Adani company, which operates a coal power plant and India’s largest coal port in Mundra, Gujarat,

Government-owned India Coal’s greenhouse-gas emissions have risen steadily for half a century. Only global economy crises caused some delay

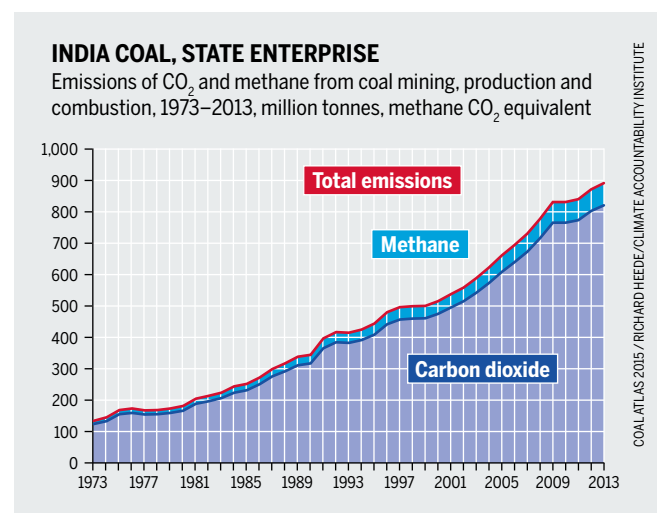
India is the last big country where coal is supposed to promise growth and modernization

wants to invest in large-scale mining in the Galilee Basin in Queensland, Australia. To handle exports to India, the company has leased the Abbot Point port and plans to expand it, endangering the Great Barrier Reef, a World Heritage Site.

India’s government views anti-coal and divestment campaigns as threats to national energy security and inimical to the country’s strategy of rapid economic growth. The government acts against local groups as well as international NGOs such as Greenpeace that advocates a rapid end to the use of coal worldwide. Other NGOs, such as the Centre for Science and Environment, argue that coal has to be phased out in the longer run, but may be required as a cheap energy option in the meantime. They lobby for increased efficiency and higher pollution reduction standards. A “green rating” environmental audit undertaken in 2014 revealed that many of the country’s coal-fired power plants perform very poorly. Even the best did not achieve more than “average” ratings.

Coal is likely to remain prominent in India’s power mix, but alternatives are being pursued as well. There are plans to build several additional nuclear power plants, as well as numerous dams especially in the Northeast; but they meet substantial opposition, particularly at the local level. India has a huge potential for solar energy, and in 2014, the government announced an ambitious plan to expand solar-generated capacity to 100 gigawatts by 2022, about three times the total current solar installations of countries such as China or Germany. From April 2015, the tax on coal was doubled to 200 rupees (about €3) per tonnes, and the proceeds will be used to promote renewables.

Energy poverty provides a potential for technological leapfrogging. Today nearly 97 percent of India’s 600,000 villages have a grid connection, however, due to poverty or erratic power supply, 43.2 percent of rural households still relied on kerosene for lighting in 2011. This is why businesses and NGOs see opportunities to establish small-scale solar installations and off-grid or micro-grid solutions based on solar power or small hydroelectric plants. ●



UNITED STATES

PAST ITS PRIME

The US coal industry is losing market share to gas and renewables. The nation's dirtiest fuel is giving way to cleaner alternatives.

In mid-July 2015, a major Midwest power company made a momentous announcement: five of its pollution-heavy coal-fired power plants in Iowa will soon undergo transition to natural gas or shut down entirely. Iowans were shouldering an estimated \$15 million in healthcare costs from the plants' air pollution, and the state, which already gets one-third of its power from wind, is now closer to a clean-energy future. Even though gas is not a renewable energy, most of the time it is still marginally cleaner than coal and other fossil fuels.

But the phase-out also marked a historic national milestone: it was the 200th coal plant shutdown announced since 2010 – meaning that 40 percent of all US coal plants are now headed for retirement. The American coal industry is suffering, knocked down by market forces that have given a decisive edge to natural gas and renewables. These are the result of the technology known as hydraulic fracturing, or “fracking”, which has led to vast new quantities of natural gas, a rapidly declining price of renewable energy, and innovations in financing for renewable energy.

Electricity utilities are moving away from coal power, and coal companies are heading towards bankruptcy. In July 2015, Walter Energy and Alpha Natural Resources were the most recent in a long list of companies filing for Chapter 11 bankruptcy. The companies that are still operating are not faring much better. Peabody Energy reported a net loss of over \$1 billion for the quarter ending in June 2015. This is a gargantuan economic shift.

Throughout the 20th century, coal was the undisputed champion of American energy, providing well over half the power consumed nationwide. Starting in the mid-2000s, that share began to tumble, and today coal is down below 40

percent of the nation's power mix. In April 2015, for the first time in US history, more of the country's electricity came from natural gas than from coal.

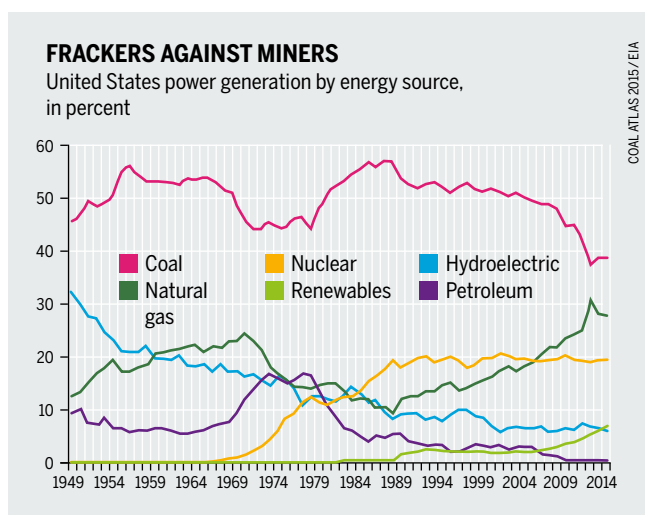
Coal's decline is a sign of vital progress. Coal-fired power plants are the nation's top source of carbon dioxide emissions, accounting for nine percent more CO₂ emissions than all vehicles. In other words, the United State's capacity to slow global warming is largely contingent on its ability to curb coal consumption.

That fact is a central tenant of President Obama's climate policy, embodied in a new set of regulations that will likely form a key barrier to any prospect of a domestic coal resurgence. Known as the Clean Power Plan, the regulations will empower the Environmental Protection Agency, using authority from the Clean Air Act, to limit CO₂ emissions from the power sector for both new and existing sources. Ultimately, the plan aims, by 2030, to reduce emissions from the nation's existing power plants to levels that are 30 percent beneath those of 2005. The rules dictate to each state a unique target for reductions in its carbon intensity (i.e., emissions per unit of energy produced). States are free to meet the target any way they wish; some choose to retire coal plants.

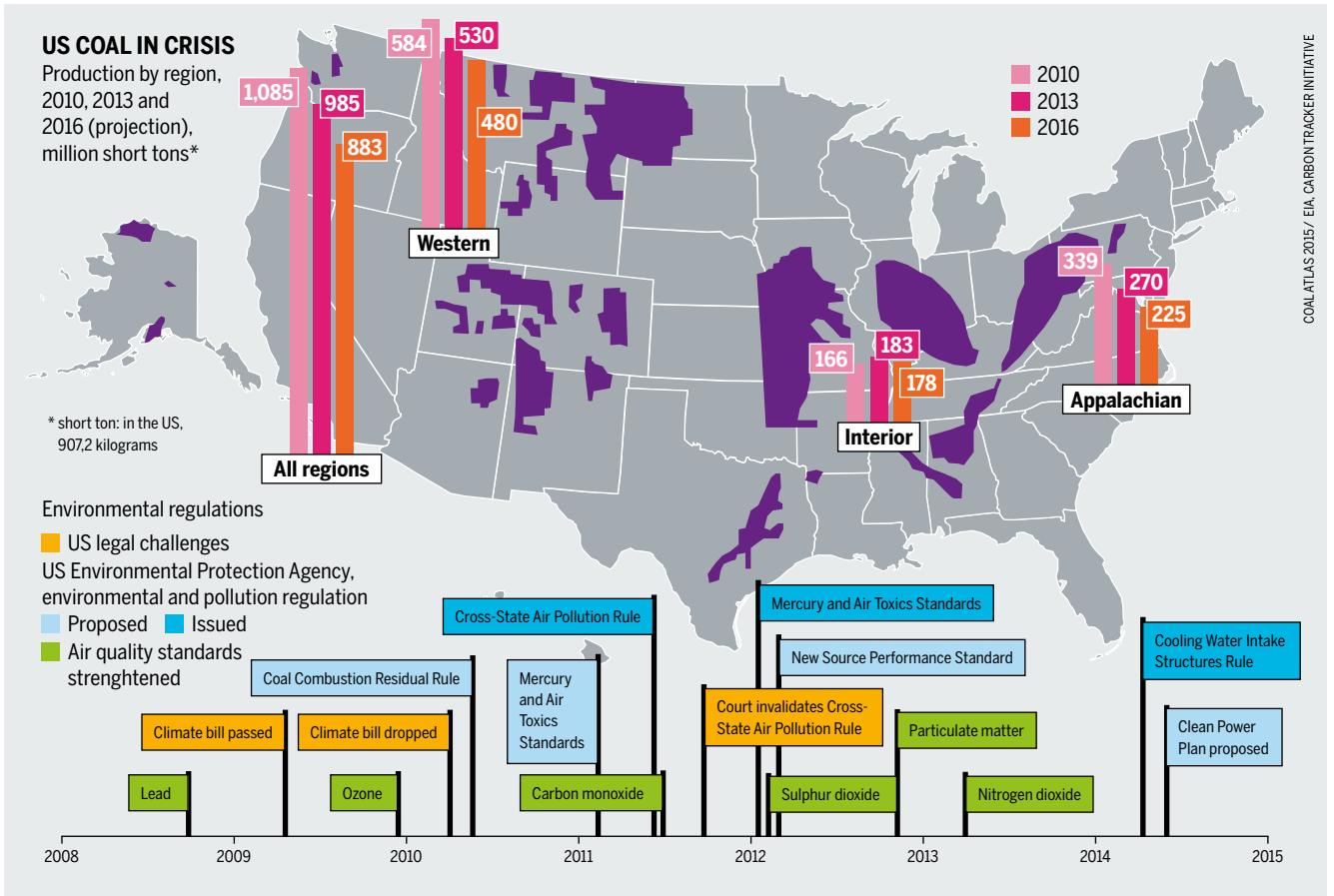
Larger trends in the US energy market are ushering coal out the door, regardless of the president's opinions about climate change. Another development is the failure of carbon capture and sequestration to materialize as an economically viable option. In 2015, the Department of Energy cancelled two large-scale carbon capture and sequestration projects despite having spent huge amounts on them.

Conceived by President Bush in 2003, one of these projects, known as FutureGen, was intended to be the world's first zero-emissions coal facility. Originally projected to be finalized by 2012, the project might end up costing taxpayers over \$1 billion. While still going forward, the Kemper coal plant in Mississippi has been equally troubled. It is currently billions of dollars over budget and years behind schedule.

The coal industry has been in trouble even without a price on carbon. An important court decision in Colorado could help pave the way for a price to be put on coal. A federal district court stopped the expansion of a coal mine due to the federal government's failure to quantify the costs of greenhouse-gas emissions. The court found the Bureau of Land Management and the Forest Service had arbitrarily based their approval to expand mining exploration in the Sunset Roadless Area solely on the estimated economic benefits of the project; they had ignored the social costs of its potential contribution to global climate change. The court found the agencies violated the National Environmental Policy Act, which mandates that federal agencies take a



War on coal: the chief antagonists are the vast natural gas industry and the rising renewables



“hard look” at the potential environmental impacts of a proposed project prior to making a decision. This could lead to the government being required to consider the social cost of carbon when approving leases.

Since 2007, production of natural gas from shale exploded thanks to the controversial extraction method known as fracking. According to federal statistics, since 2000, the volume of shale gas produced nationwide has grown over 1,800 percent. In spring 2012, gas prices hit an all-time low, and as a result, consumption of electricity from natural gas has grown 58 percent since 2000. Most of that growth – 90 percent, according to one recent analysis – has directly replaced coal. At the same time, renewable sources like wind and solar continue to surge as well, thanks to falling costs and tax incentives at local, state, and federal levels.

As the market for coal falls, coal production is also on a downward slope. In 2008, it entered its first long-term decline in history, and as of spring 2015 coal production was down to levels not seen since 1989. Meanwhile, since the beginning of that decline the coal-mining industry has shed at least 50,000 jobs, and now employs fewer than half the number of people who work in the US solar power industry.

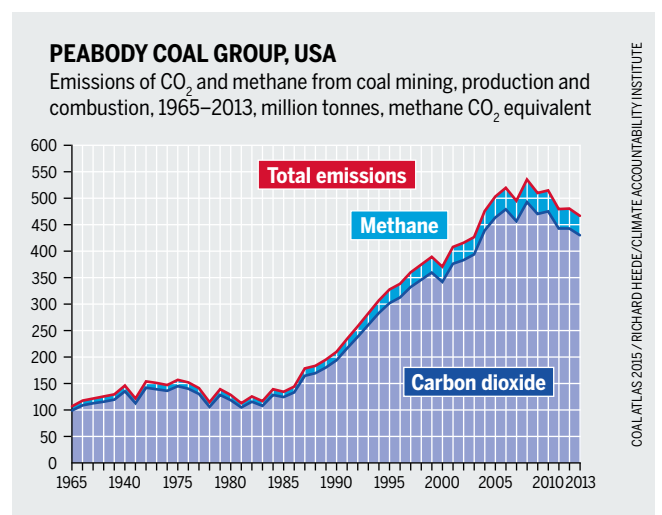
One important upshot of these trends is that US CO₂ emissions from the power sector are on the decline, falling 12 percent since 2008. Another is that US coal producers are increasingly looking to sell their product abroad. Coal ex-

The sector is faced with mine closings, power plants switching to cheap natural gas, and stricter environmental regulations

ports are at record highs, with shipments bound mostly for Europe, Asia and Brazil. That trend has fuelled a new battle with environmental activists, who are campaigning aggressively against planned coal-export terminals in the Pacific Northwest.

The US coal industry isn’t dead yet; official projections show it playing a central role for decades to come. Still, it’s safe to say that the heyday of America’s dirtiest energy source has come and gone. ●

Peabody Coal, the largest private-sector coal company in the world, is also the world’s biggest private polluter



RUSSIA

THE LAND WITHOUT DOUBT OR DEBATE

Coal is one of the dirtiest industries in Russia. Apart from hydropower, renewable energy is practically non-existent. Civil society groups that might push for more sustainable sources of power are few and far between.

The Russian Federation has the world's second-largest coal reserves, and coal is produced in 25 of its constituent territories. Over half (52 percent) comes from the Kuznetskiy basin, and another 12 percent from the Kansk-Achinsk basin. The Pechora basin contributes 5 percent, while the East Donets and South Yakutsk fields contribute 3 percent each. The Kuznetskiy basin, or Kuzbass, in the Kemerovo Region of Western Siberia is the most important coal supplier, and Russia's rising production over the past ten years have been due mainly to new production capacities in this region.

Seventy percent of Russia's coal is currently produced from open-cast mines. The industry, which is composed entirely of privately owned companies, employs around 150,000 people. Among the largest producers and exporters are SUEK, Kuzbassrazrezugol, SDS, Mechel, and KTK.

Over 170 power plants in Russia run on coal. More than 80 percent of these plants are over 20 years old, and some have an electrical efficiency of only 23 percent. New coal-fired plants abroad can achieve 46 percent efficiency.

In 2013, Russia was the world's third-largest coal exporter, after Indonesia and Australia. It ships coal to nearly 50

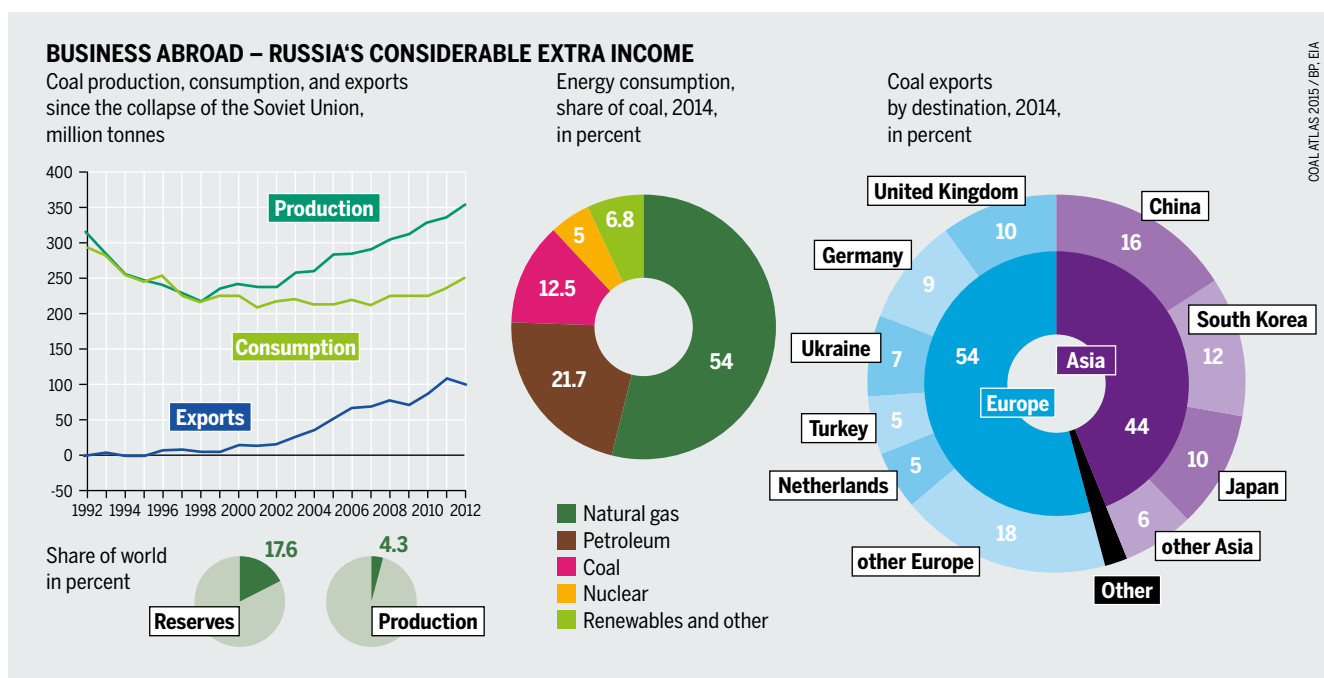
countries. Germany and the United Kingdom are its biggest customers in Europe.

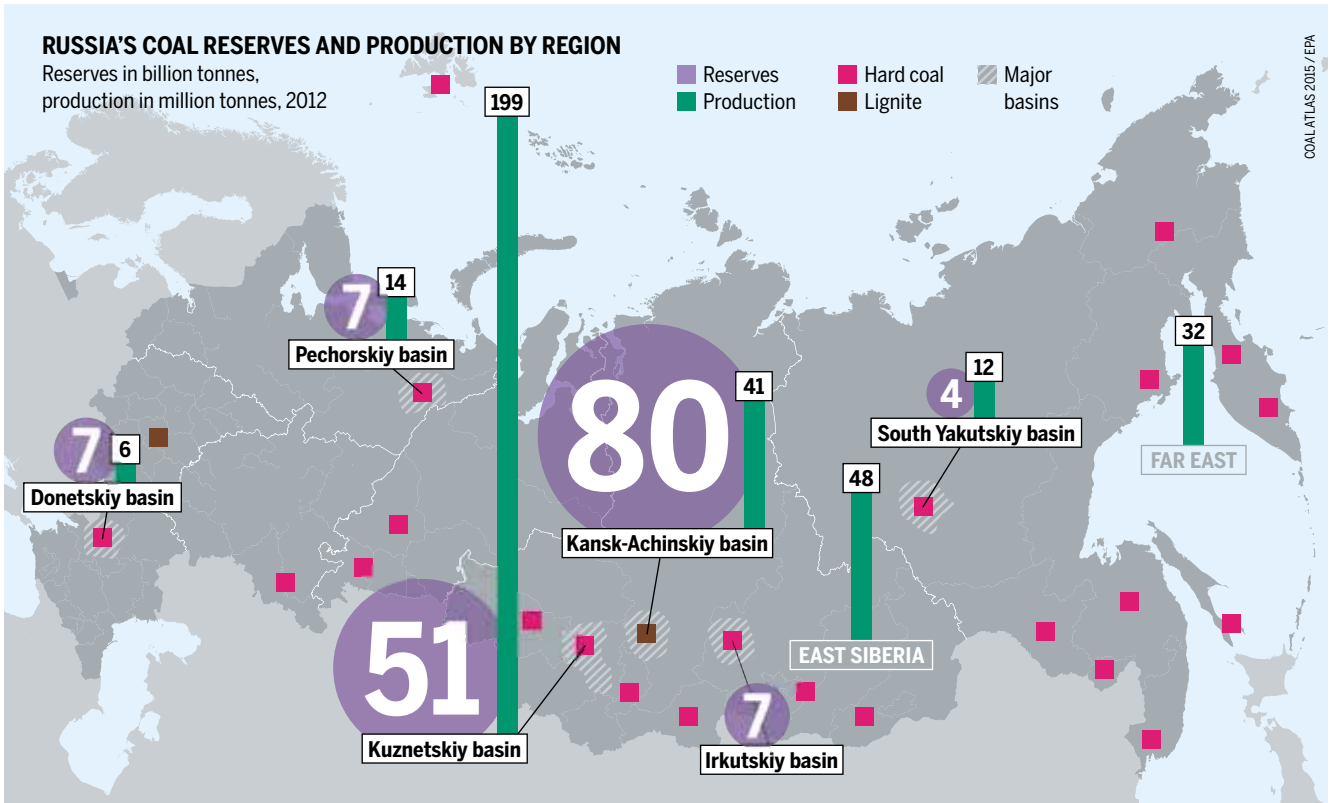
The Russian government support for the coal industry includes around \$7 billion in subsidies supplied by the state budget until 2030. The government plans to use local coal reserves to generate more power in Siberia and the Far East. These include the Yelginskoye field in South Yakutia, Syrdasaiskoye in the Krasnoyarsk Region, and Udokanskoye in the Chita Region. That would mean a series of power plants with a combined capacity of over 10 gigawatts is due to go online between 2020 and 2022. It also paves the way for major investments that envision exporting over 50 billion kilowatt-hours to China.

Each year, 360 million cubic metres of air are blown into Russian underground mines, and over 200 million tonnes of water are pumped out. At open-cast mines, between 300 million and 350 million tonnes of rock are shifted into waste dumps.

Drilling and blasting operations, exhaust from vehicles used to excavate the coal, emissions from power plants, and fires caused by the spontaneous ignition of coal during mining and processing are all sources of air pollution. With open-cast mining, solid particles – inorganic dust containing silicon dioxide, coal ash and black carbon (soot) – are

On a national scale, coal is less important in Russia than natural gas. But export revenues have been growing over the last decade





the main pollutants. In the Kemerovo Region alone every year, over 1.5 million tonnes of pollutants are emitted into the atmosphere, and over half a million cubic metres of polluted wastewater are discharged. A 2011 report on the state of the environment in the region estimates that the average concentrations of harmful air pollutants were two or three times higher than the allowable maximum in Russia. On a number of occasions, they exceeded these limits by as much as 18 times.

Coal mining affects not just the area immediately around the mines, but neighbouring areas as well. Cities in mining areas, such as the Kuzbass and Vorkuta regions, typically suffer from high concentrations of suspended particles in the air. Raised levels of lead, cadmium, mercury and arsenic are found in locally grown food.

The grime shows its effects in disease patterns. In the Kemerovo Region, where coal is the biggest polluter, respiratory ailments were the most common type of ailment, affecting 23.5 percent of patients seeking medical assistance. The health risks are highest for pregnant women and children. In the past decade, disease rates among pregnant women in the region have risen almost fivefold. Maternal mortality rates are double the Russian average.

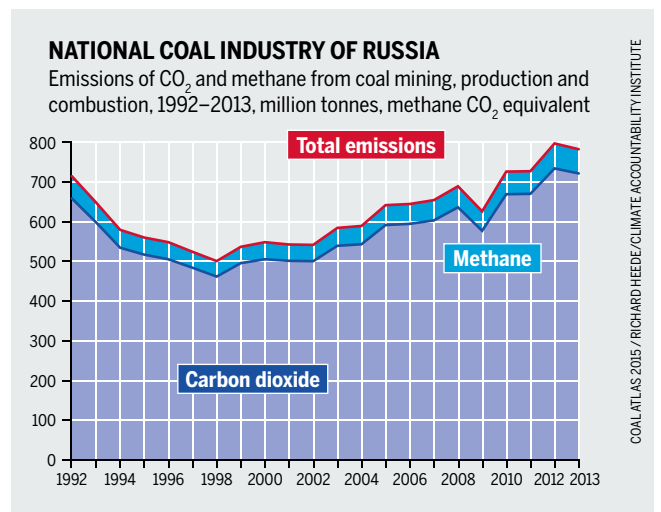
Russia's energy mix currently consists of gas (54 percent of primary energy consumption), oil (21.7 percent), coal (12.5 percent) and nuclear (5 percent). Almost all the rest comes from large hydropower plants. Renewables are next to invisible; they are regarded as suitable only for places not connected to the grid. The Ministry of Energy says that there

Obsolete technologies and negligence: due to lack of money and the will to reduce emissions

Vast distances and high transport costs are the norm in Russia. Digging up coal is profitable only because it is so cheap

will be no federal funding for regional energy-efficiency programmes in 2015 due to the economic crisis.

There is no political debate on the future of the coal industry in Russia. The government sees the sector as an important exporter of fossil fuels and as a big employer. Historically, civil society has never been very active on coal-related issues. Moreover, the environmental movement is under heavy pressure as the government shuts down critical voices. Civil society is showing signs of interest in examining the environmental damage caused by coal, but it is hard to predict whether this will grow into a strong movement in Russia's politically hostile conditions. ●



GERMANY

A TURNAROUND YET TO TURN

Germany is phasing out nuclear power and has come to rely more on coal for its electricity. Despite a steep rise in renewable energy, the use of coal is endangering Germany’s ambitious target to reduce its greenhouse gas emissions.

Germany has declared an “energy turnaround”, but is still heavily dependent on coal. Lignite is the only significant fossil fuel that the country has and does not have to import. The reserves are estimated at 40 billion tonnes, and are split among three major regions: the Rhineland, Lusatia and central Germany. In 2014, more than one-quarter of the electricity produced came from lignite, and its output of 178 million tonnes a year makes Germany the world’s biggest producer. The industry has benefited from 95 billion euros in subsidies (in real terms) since 1970, and open-cast mines have gobbled up 176,000 hectares of land. Current mines cover 60,000 hectares.

The mine sites are rehabilitated and brought back into cultivation after mining ends, but the original ecosystem never fully recovers. In many cases, the pits are flooded to form lakes. In the Rhineland that means diverting river water into the pits for decades on end. The negative environmental impacts of mining include damaged ecosystems, degraded soil, acidified water, water contaminated with sulphates and sludge containing iron, as well as disturbed groundwater regimes. In Lusatia, sulphate from nearby open-cast pits threatens the water quality in the River Spree and, therefore, Berlin’s drinking water supplies.

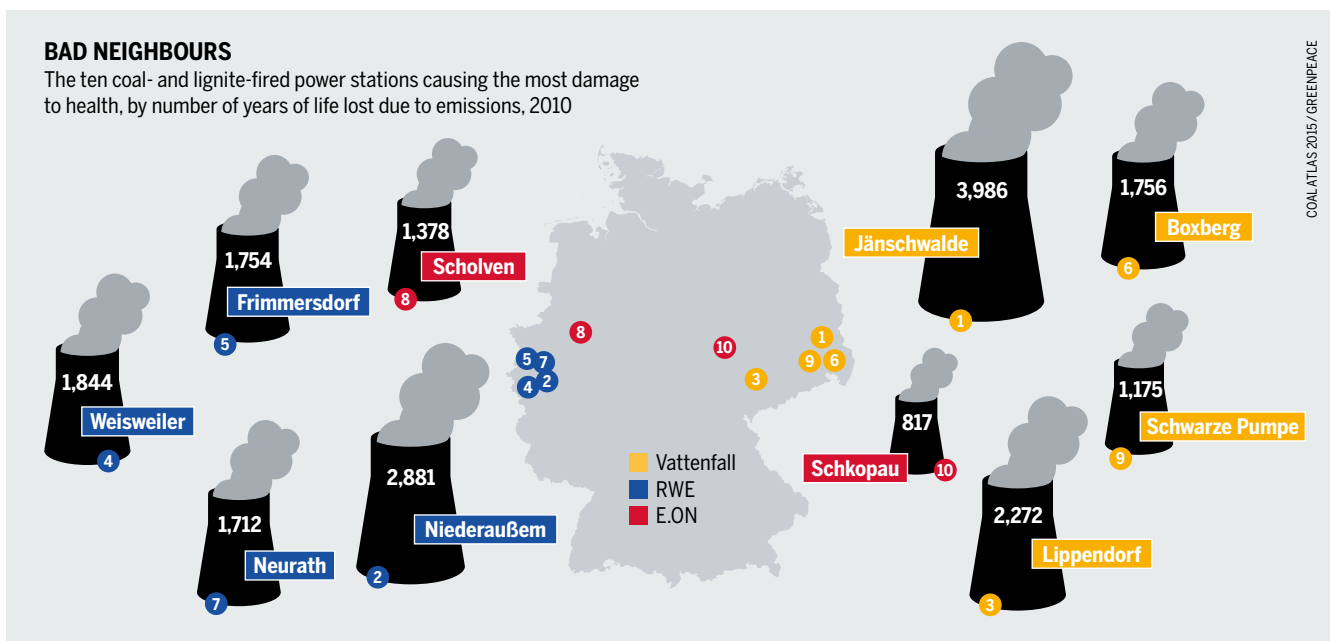
The federal states that host lignite reserves plan to continue mining well into the 2040s. Vattenfall, the state-owned

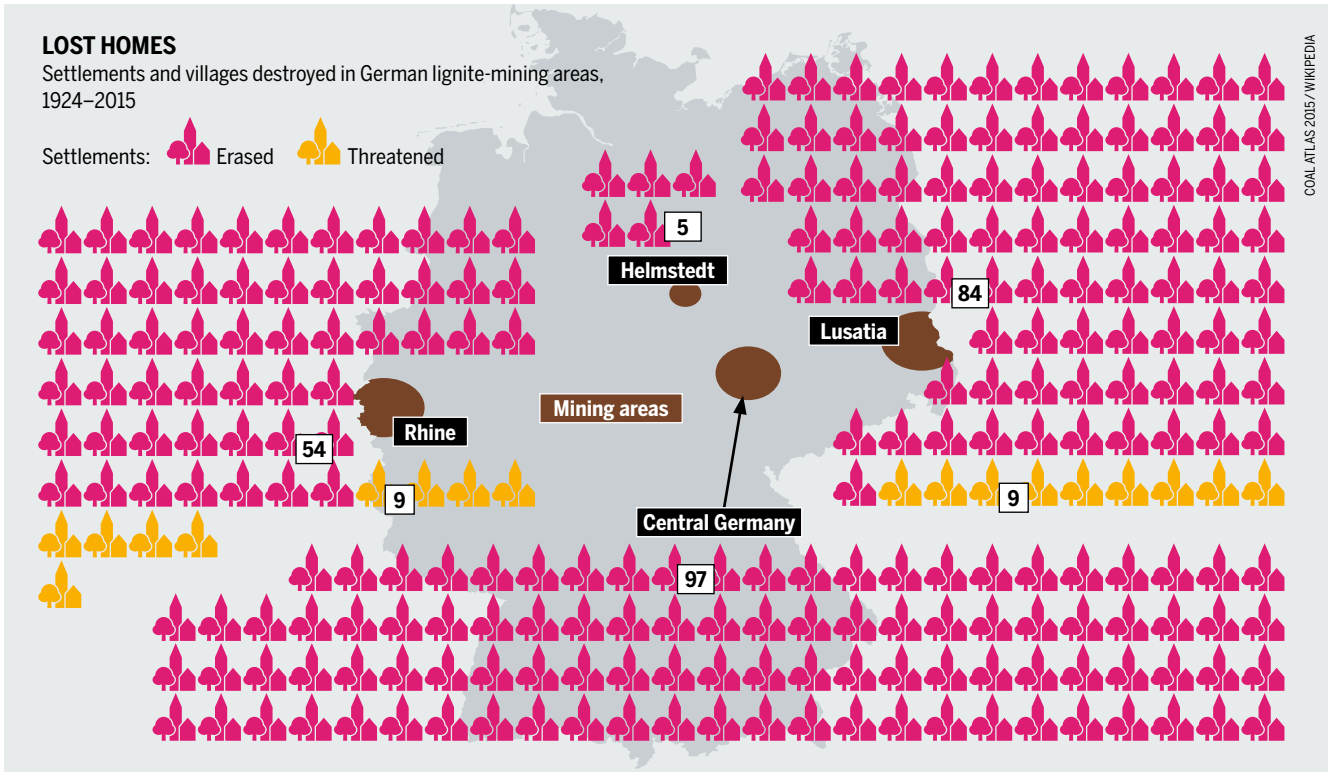
Swedish power generator, plans to develop five mines in Lusatia in eastern Germany. Two of these were recently approved. The excavators will demolish ancient Sorbian villages, even though this minority group is protected by the constitutions of both the federal states of Brandenburg and Saxony. In North Rhine-Westphalia, in western Germany, the state government decided to reduce the size of Garzweiler II, an extension of an existing pit.

If Germany intends to stick to its target of cutting its greenhouse gas emissions by 80 to 95 percent by 2050, two-thirds of the lignite reserves already approved for mining will have to stay in the ground. In contrast, Germany’s extraction of hard coal will end in 2018. The three pits still in operation produced 7.6 million tonnes of coal in 2014. Germany still gets about 18 percent of its power from hard coal. Despite repeated public criticism regarding the human rights situation and environmental effects of coal mining in many coal-exporting countries, Germany imported more than 56 million tonnes in 2014, of which 42 million tonnes were destined for power stations. Most of this coal comes from Russia, followed by the United States, Colombia and Australia.

Germany’s remaining hard-coal mines are closing down because government subsidies are due to end in 2018. Without these government funds, the mines would have been unprofitable since the middle of the 20th century. Since 1970, the mining companies have benefited from subsidies to the tune of €327 billion in real terms. One of the so-called “inher-

It is possible to calculate the number of years of life lost as a result of emissions from individual power stations





ited liabilities” of hard-coal mining is the need to pump out mine water to protect groundwater. From 2019 onwards, dealing with this and other liabilities will cost at least €220 million a year, indefinitely. The money is supposed to come from an endowment fund set up by the industry, but this will probably not be sufficient to cover the costs.

Unlike hard coal, the inherited liabilities of lignite are not recognized politically, and the perpetrators have not had to make adequate financial arrangements. Furthermore, the public cannot access the financial presumptions and models that the mining companies use to make plans for reserves to cover damage caused by mining.

Renewables account for around 26 percent of Germany’s energy mix. That is slightly more than lignite, but lignite and hard coal together make up 44 percent. Fixed feed-in tariffs (long-term contracts for energy producers) have spurred the expansion of renewable power and made compensation for the loss of generating capacity possible after Germany decided to turn off its nuclear power plants.

Germany is likely to miss its climate goal of 2020 (a 40 percent reduction in greenhouse gas emissions compared to 1990), mainly because of the increase in burning coal. In addition to those measures that have already been decided, supplementary measures are needed to achieve further necessary reductions in the power sector.

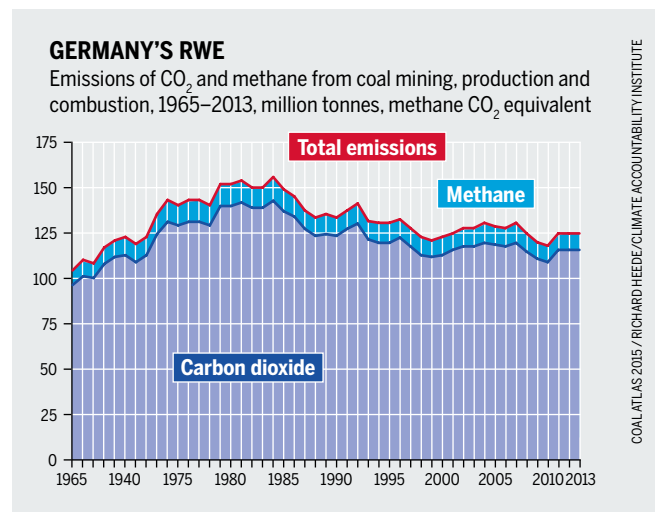
In early 2015, the government proposed to limit emissions from coal-fired power plants with a so-called “climate levy” on old, emissions-intensive power plants. This plan was supported by environmentalists. The public debate over these proposals has been very lively, and there has

From a peak in the 1980s, RWE’s greenhouse-gas emissions have declined only slightly. RWE is Germany’s second-biggest electricity generator

Over the last 90 years, more than 250 settlements and 110,000 people have had to give way to lignite mines in Germany

been strong and effective resistance from coal companies, trade unions and the governments in the three affected states.

The failure of the climate levy and its replacement by a capacity reserve for old coal plants demonstrates the strength of the coal lobby. Unfortunately, the replacement will not be enough to attain the climate goals. Many local governments own shares in the energy group RWE, and they fear a loss of income, which is a major obstacle to the switch away from coal. Nevertheless, the general public’s opinion has turned against coal, and opposition is rising. In fact, accelerating a coal phase-out is the top priority for German activists. ●



LOBBYING

PAID TO PREVENT PROGRESS

Wherever climate and energy negotiations take place, the coal industry wants to have their say. They often succeed.

Ever since climate change and the role of fossil fuels in it became a hot topic, the coal industry has intervened in the debate and used its political and economic weight to tip the scales. In the 1990s, global industry came together to combat research on climate change. The biggest private coal firms, collectively known as Big Coal, have been hindering efforts to prevent climate change for decades. The fact that many of the biggest coal companies are state-owned – for example in Poland, the Czech Republic, India and China – has helped brake the progress of reform.

The coal sector often has a seat at the table when political decisions are made. In 2007, when Chancellor Angela Merkel took over the EU presidency and hosted a G8 summit on the Baltic coast, the German government had previously appointed the Swede Lars Göran Josefsson as one of two climate-protection advisors. At the time, Mr Josefsson was the boss of Vattenfall, the largest energy company in the European Union and the owner of lignite power plants in Lusatia, in eastern Germany. He later became an advisor to the UN Secretary-General Ban Ki-moon.

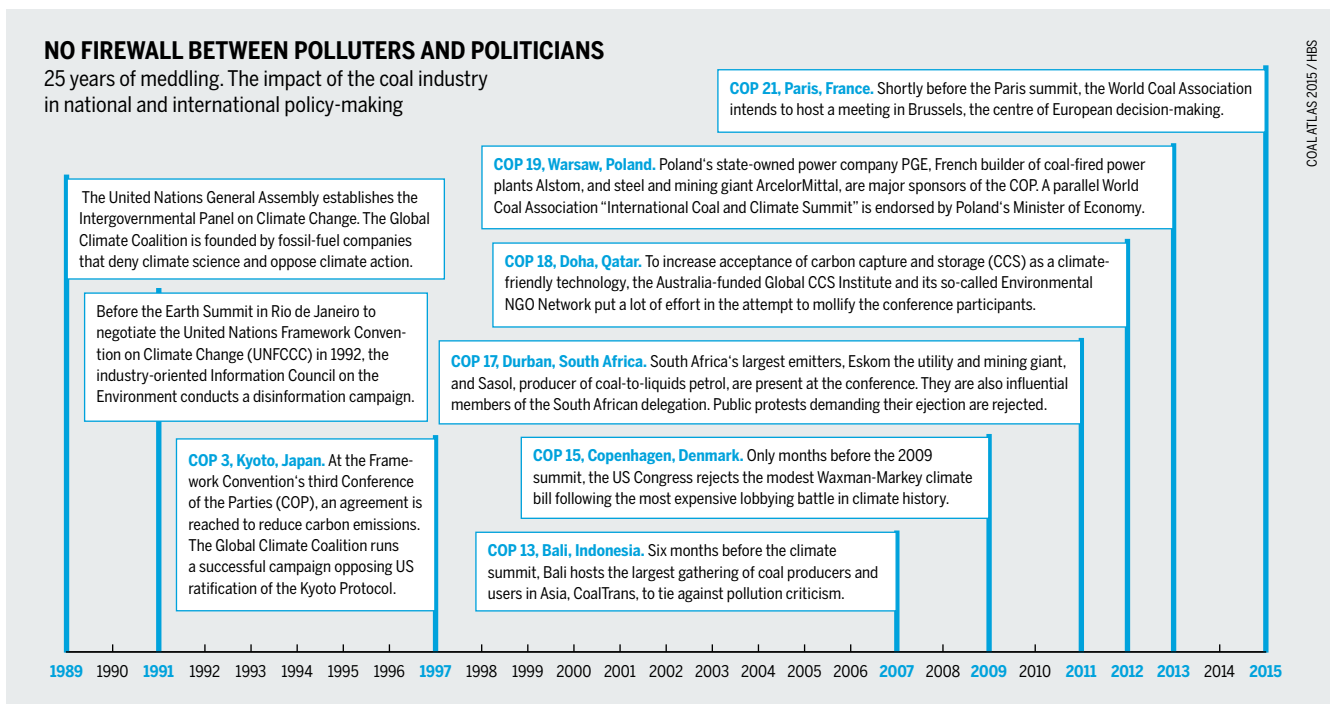
At a climate summit in Durban, South Africa, in 2011, two of the host government's delegates were representatives of local companies. One came from Eskom, Africa's largest power producer, and one of the biggest CO₂ emitters in the world. The other was from Sasol, the world's biggest producer of synthetic petrol, a fuel produced by liquefying coal.

Over the years, critical voices such as the Corporate Europe Observatory have watched as companies try to influence international climate negotiations. The energy companies' tactics range from sponsoring conferences to the formulation of draft agreements. The oil and gas majors are more active than the coal industry in international climate discussions. The coal industry prefers to shape national discourse and legislation because its activities are more strongly affected by policies at this level.

In the EU, the coal lobby has mainly targeted renewable energy. It argues that it is not necessary to fix what proportion renewables must have in the overall energy mix; emissions trading will be enough to determine this. One of the loudest voices in this debate has been Euracoal, the European Association for Coal and Lignite. Lo and behold, the EU's climate targets for 2030 no longer include binding national targets for the expansion of renewable power or for improving energy efficiency.

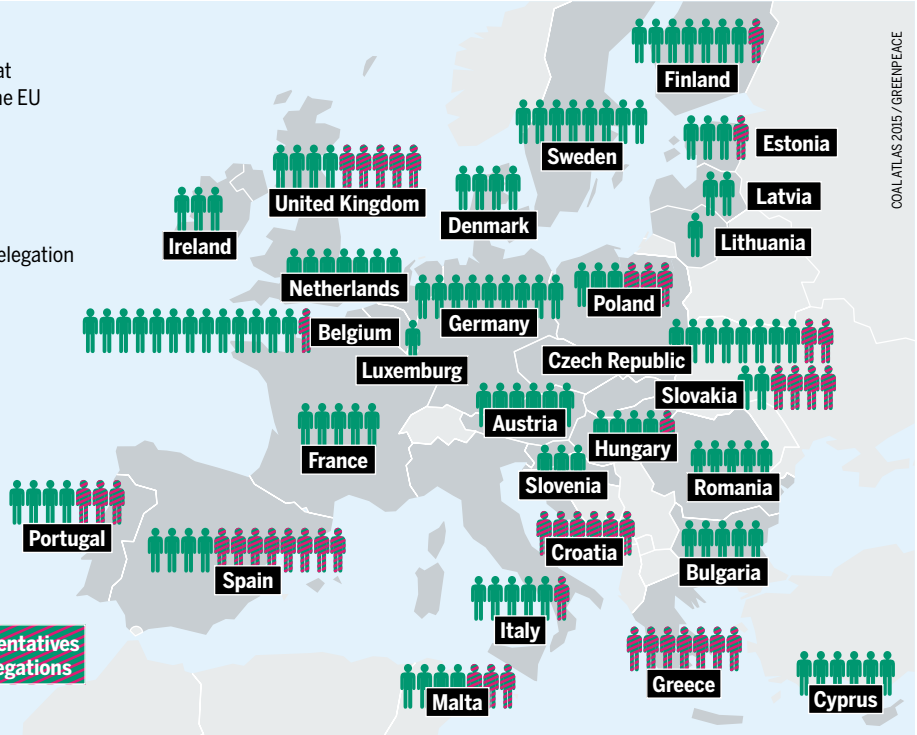
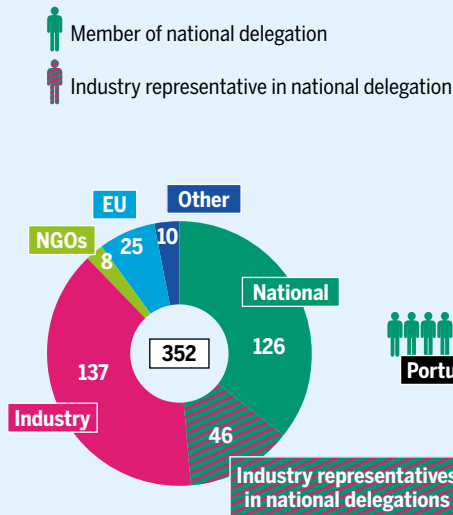
Europe's planned limits for air pollution have also been subject to influence from the coal lobby. The methods are simple: some of the specialists named by member states to the crucial technical working groups are direct representatives of the industry's interests. The makeup of the Greek delegation was particularly biased. All the delegates worked either for the Public Power Corporation, whose power plants are among the dirtiest in Europe, or for Hellenic Petroleum.

The coal industry enjoys close contacts with governments around the world and tries to influence the direction of international negotiations



FOXES GUARDING THE HENHOUSE

Composition of technical working groups that develop requirements for power plants for the EU Industrial Emissions Directive, 2015



COAL ATLAS 2015 / GREENPEACE

The United States traditionally has a powerful coal lobby. A core element of all its campaigns has been to discredit scientific studies. Since the 1990s, coal companies and industry associations have financed scientists who dispute the findings on global warming - and with success. In 2014, only eight Republicans in the US Congress recognized global warming as scientifically proven; 278 denied it. This reflects the spending patterns of the coal industry which donated \$57.5 million to American politicians, 84 percent of them Republicans, between 1990 and 2014.

The American Coalition for Clean Coal Electricity is one of the more important associations of coal lobbyists in the USA. It campaigns against regulations in the coal sector and climate protection. The conservative American Legislative Exchange Council is composed of state legislators and financed partly by money from the energy sector, including Big Coal. In 2013/14, it was active in at least 16 states working against renewable energy.

The lobbyists have everything covered: from the drafting of regulations against the supply of privately generated solar power into the grid, to combating the Environmental Protection Agency and President Obama's climate policies. Even schools are included. The Kentucky Coal and Energy Education Project distribute educational materials that are one-sided in their portrayal of the coal industry.

Big Coal is fighting renewable energy in Australia, too. The Conservative government, in power since 2013, has reversed comprehensive laws to protect the climate. In 2014, it turned its attention to the requirement obliging Australian power generators to obtain 20 percent of their electricity from renewable power by 2020. Then Prime Minister Tony

A booming business: the climate debate is generating lots of business for coal-industry representatives in Washington

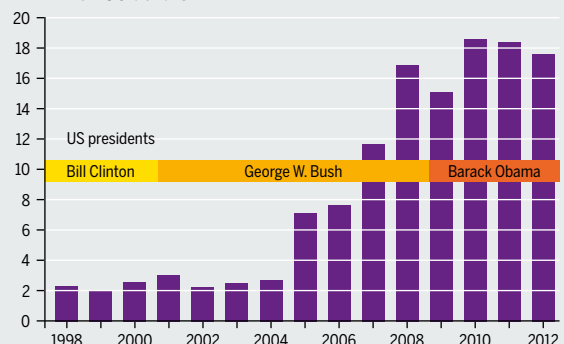
Limits for power plants? No problem. The industry constitutes the majority on the relevant committees

Abbott called on Dick Warburton, a noted climate-change sceptic, to review the target. The industry ran big advertising campaigns that were supported by media owned by Rupert Murdoch, whose reports repeatedly question the efficiency of renewable energy and the findings of climate science. Sowing the doubts has borne fruit; the 2020 target for expanding renewable energy was reduced from 41,000 to 33,000 gigawatt-hours.

In 2014, Australia invested less money in generating clean electricity than Honduras or Myanmar. A new government directive is even expected to halt Australia's "green bank", the Clean Energy Finance Corporation, from investing in wind and rooftop solar power because the federal government does not regard them to be emerging technologies. ●

MONEY FOR SPECIAL INTERESTS

Annual lobbying expenditure by the coal industry in Washington, D.C., according to mandatory reports, in million US dollars



COAL ATLAS 2015 / B. CHAMERIDES

EMISSIONS TRADING

STRONG PLAYERS, FEEBLE INSTRUMENTS

Trading in pollution permits has blossomed into a big business. The system has produced little benefit for the climate. Even so, the alternatives are barely discussed.

To limit the amount of greenhouse gas they churn out, the European Union and various other countries have set up emission-trading schemes. Based on national plans these schemes set the total amount of emissions permitted for the affected industries. The operators of these industries can trade permits among themselves. If an operator emits less of the offending gas than allowed, it can sell the permits that it does not need. An operator that emits more gas has to buy additional permits. This system is supposed to provide a financial incentive for reducing emissions. A company that discharges too much gas has to pay more, while one that cuts its emissions can sell permits to pay for the investments needed.

Seventeen such schemes have been set up around the world, and several more are planned. The biggest is the European Emission Trading Scheme. National schemes exist in Switzerland, New Zealand and South Korea; California, the Canadian province of Quebec, Tokyo and several provinces in China have regional schemes. By 2016, some 6.8 billion tonnes of CO₂ equivalent will be covered by such measures.

Emissions trading is based on two premises. First, that it limits the emissions of climate-killing CO₂. Second, the scheme aims to stimulate investments in protecting the climate. Sadly, it does neither, as can be seen from how the European scheme has performed.

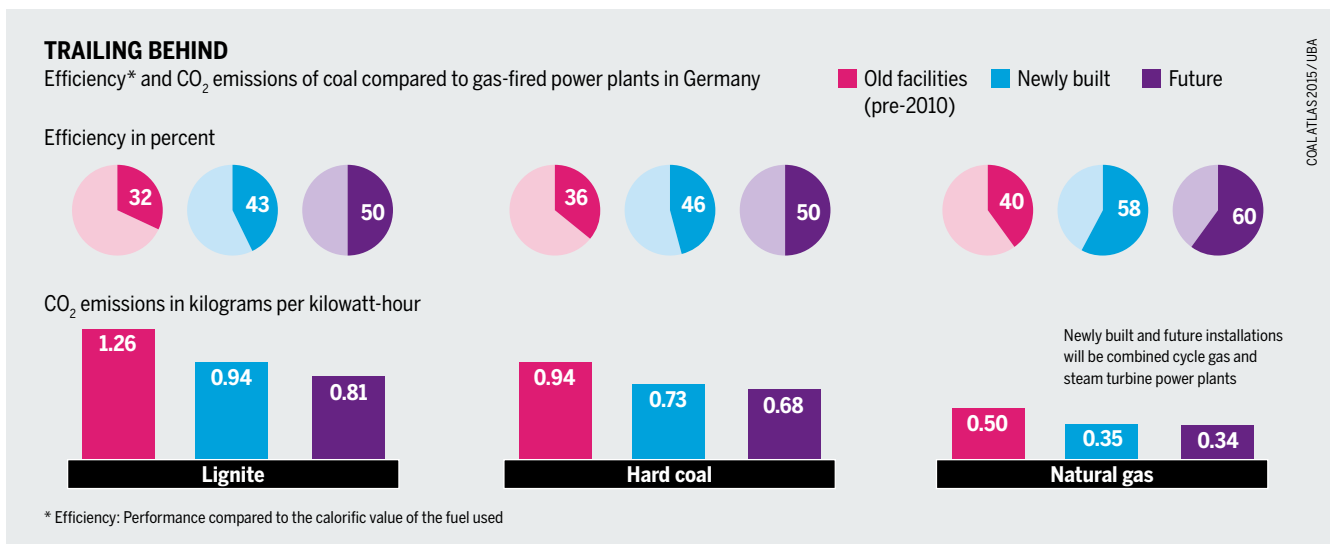
Under heavy lobbying pressure, the EU set the permitted limits for emissions far too generously, and subsequently cut

them back too slowly. From the start, the number of permits has been too high, so the prices they have attracted have been too low to stimulate investment in climate protection. In addition, governments have given away permits for free to the most climate-damaging firms, handing them a big financial windfall.

The recipients, including large power generators, took advantage of the situation and sold their excess certificates. Between 2008 and 2012, the ten major beneficiaries profited by 3.2 billion euros. The energy companies must now bid for the permits they want, but lavish exemptions mean that nearly all polluters in the industry still get them for free. Plus, all companies continue to benefit from the transfer of their surplus permits from earlier trading periods. The steel firm ArcelorMittal, for example, will not have to buy any extra permits before 2024.

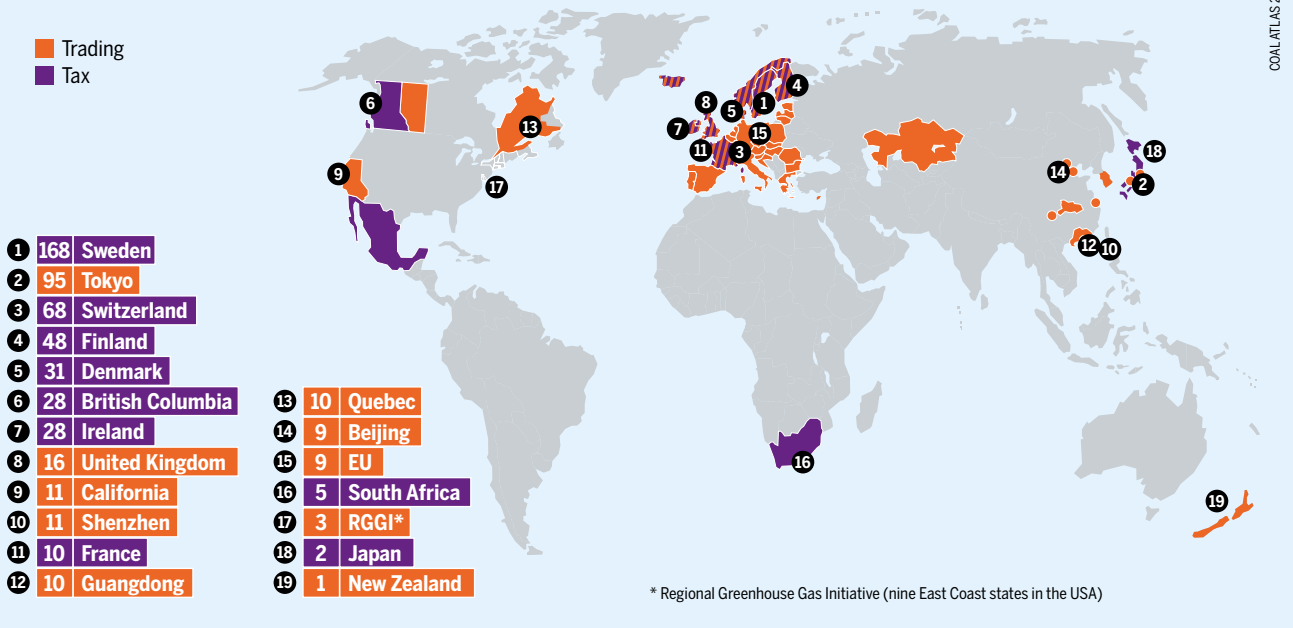
In theory, emissions trading is capable of reducing CO₂ emissions while still allowing entrepreneurial freedom. In practice, however, the trading scheme has not made a significant contribution to climate protection. This is because of the so-called offset credits that companies have been able to buy in large numbers outside the emissions trading scheme. The reasoning goes like this: it does not matter where in the world the CO₂ emissions are cut, so rather than investing lots of money in reducing their own emissions, European companies may as well contribute to initiatives that save emissions elsewhere. But how would the initiatives have performed without this financial support? Between

The latest technology doesn't help: even the most modern coal-fired power plants still lag behind on the most important criteria



SOME ARE SERIOUS

Regulation of CO₂ emissions through market mechanisms (trading) or state regulations (tax) by countries, regions and cities; prices for CO₂ emissions in US dollars per tonne of CO₂, 2013/2014, selected



one-third and one half of such projects result in no additional benefit because the investments would have been made anyway. Further, these offsets reduce the pressure in Europe to switch to products that produce fewer emissions.

Emissions trading has long become a business opportunity for the financial industry. Simple, direct transactions between buyers and sellers of pollution permits have become rare. For institutional investors, carbon dioxide is now something akin to a raw material, and is traded in the form of various financial products. But because of the oversupply of permits, trade is virtually at a standstill. Scandals involving tax fraud, including those involving the Deutsche Bank, have revealed the susceptibility and vulnerability of the system. HM Revenue & Customs, the British tax authority, believes that a large share of emissions trading is laced with fraud.

Through offsets, oversupply, the economic crisis of 2008/9 and the associated erroneous forecasts, the number of excess permits in Europe has risen to over two billion. As a result, the price of CO₂ is far too low. Combined with low prices for coal and high prices for natural gas, coal has boomed. Between 2010 and 2013, emissions from this sector rose by six percent. The CO₂ surcharge was not high enough to make power generated from less-harmful natural gas competitive with the more-harmful coal. To achieve the desired effect, the trading scheme needs stricter limits on emissions.

An alternative approach, used by several states in the United States, as well as by Canada and Britain, is to impose CO₂ standards on power plants that use fossil fuel. Since 2013, the British government has set a minimum price for CO₂ and annual emission budgets for new power plants,

Most trading systems do not cover the majority of CO₂ emissions; those that are covered are still too high

To encourage investment by pushing up the price of CO₂ emissions, taxes are more effective than most trading schemes

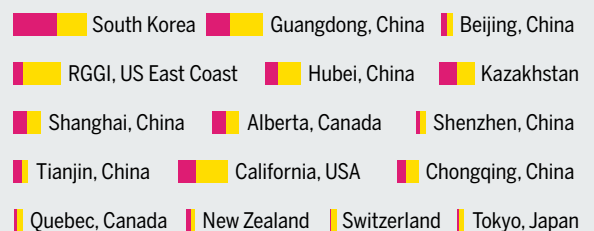
equivalent to the emissions from a modern gas-fired plant. Since 2014, France has charged a tax – albeit a small one – on fuels. The rate will quadruple until 2020. It is also possible to force old power plants offline by applying a technical criterion to their efficiency. The Netherlands will bring in a minimum requirement that will ensure that four older plants will shut down by 2017.

Explicit criticism of emissions trading as the “wrong solution” came recently from an unexpected quarter. Pope Francis wrote in his encyclical “Laudato si” that emissions trading gives rise to a new type of speculation, but does not serve the cause of cutting greenhouse gases. ●

OUTSIDE THE SYSTEM

CO₂ emissions in various trading schemes, in million tonnes of CO₂ equivalent

Emissions ■ Included ■ Not included in trading schemes



0 500 1,000 1,500 2,000 2,500 3,000 3,500 4,000 4,500 5,000

CARBON CAPTURE AND STORAGE

PROBLEMS AT DEPTH

With the promise of “clean coal”, the industry intends to store carbon dioxide underground. However, this method of dealing with the climate crisis fails for both technical and economic reasons.

In recent years, political and economic circles have discussed a particular way of making coal-fired power stations more climate friendly. This method is known as “carbon capture and storage”. The technique involves capturing the carbon-dioxide emissions from power plants and factories, and storing them in geological formations deep underground. Some scientists and environmentalists hope that this will decelerate the rise of carbon dioxide in the atmosphere, or perhaps even reduce it. Many of the scenarios prepared by the Intergovernmental Panel on Climate Change assume that if carbon capture and storage is used the probable warming level will stay below 2°C. But such assumptions carry a critical flaw. It is already evident that the technologies currently under development cannot achieve what they promise.

It is now possible to capture only 85 to 90 percent of the CO₂ from power stations. Doing so takes energy, which has to come from the power plant itself. The plant, therefore, works 11 to 15 percent less efficiently, cutting its operating efficiency from 35 to 30 percent – back to levels common in the 1980s. The plant would have to burn up as much as one-third more coal to produce the same amount of energy. The commercial use of carbon capture and storage would re-

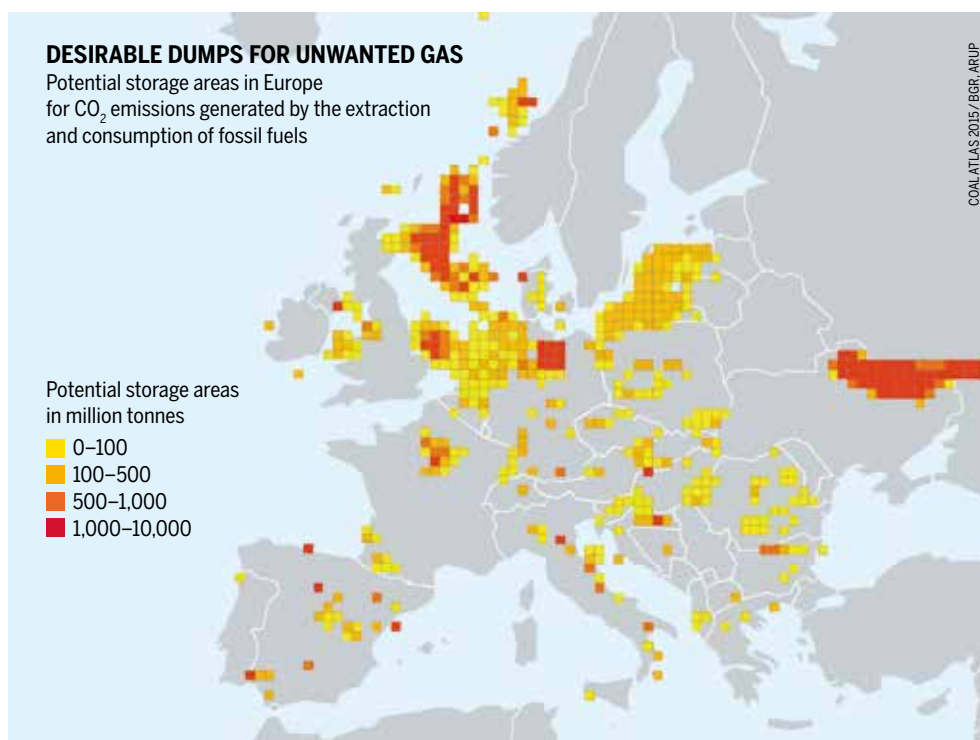
quire digging up yet more coal – with all the accompanying negative environmental consequences.

Where could the captured CO₂ be stored? One possibility is in depleted oil and gas fields. In the United States and Norway injecting CO₂ into oilfields is a common procedure to boost the yield of oil. A much bigger but more controversial potential store is in saline aquifers: porous rock formations filled with saline water that are capped by impermeable layers of rock.

The Norwegian energy firm Statoil launched one such storage-and-capture project in 1996 at the Sleipner gas field under the North Sea. Because the natural gas extracted from this field contains too much CO₂, Statoil separates almost a million tonnes of the gas each year, and injects it into rock formations above the gas field to reduce its carbon tax bill.

But it is uncertain whether the storage locations will stay sealed over the long term, whether gas can leak out, or whether the seals on the boreholes will corrode. A sudden release of a lot of CO₂ would endanger humans and other living creatures. The saline water displaced by the CO₂ might be forced up into shallower rock layers and contaminate groundwater with salt and toxic substances. The risks are just as high if the CO₂ is injected into rock formations below the seabed, as planned in countries including Australia and Britain. This type of offshore storage can severely damage the marine environment through leaks of CO₂ and contaminated saline water.

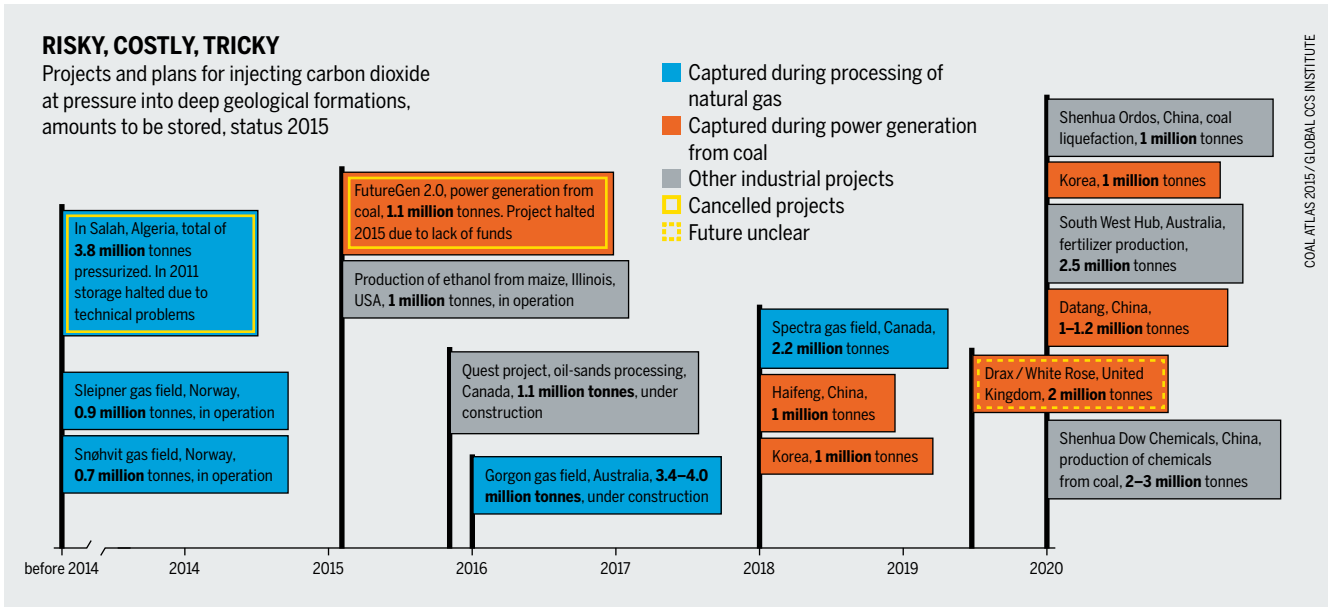
No technique yet exists to monitor CO₂ storage sites, systematically identify leaks or plug them when they are found. A flagship project at In Salah in Algeria was shut



Europe's carbon storage potential is constantly being revised downwards. Current estimates are 5 to 8 billion tonnes a year

RISKY, COSTLY, TRICKY

Projects and plans for injecting carbon dioxide at pressure into deep geological formations, amounts to be stored, status 2015



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down in 2011 because of concerns about storage safety. At present, as a result of technical difficulties and the high cost, which would amount to several billion euros for a big power plant, no plant anywhere in the world separates significant amounts of CO₂ for storage. A small power station in Canada is the only project that gets support from the public purse to boost production from an oilfield. A major project in the United States to demonstrate carbon capture and storage, called FutureGen, would have cost over \$1.6 billion. It was suspended in 2015.

Technically, there are several ways of capturing carbon. One is to use chemicals to “wash” CO₂ out of the stream of exhaust gases after combustion. A second approach relies on the principle of coal gasification; it extracts the CO₂ before combustion takes place. A third method involves burning coal using pure oxygen, making it easier to extract the CO₂ from the exhaust. From a technical point of view, carbon capture is better suited to the steel and cement industries because they are less able to avoid producing CO₂.

Despite all the failures, the promise of “clean coal” is still used as a justification for building new coal-fired power plants and thus extending the life of the fossil-fuel business model and decelerating the transition to renewable energy. Carbon-capture plants are less flexible than traditional coal-fired plants in responding to fluctuations in demand for power.

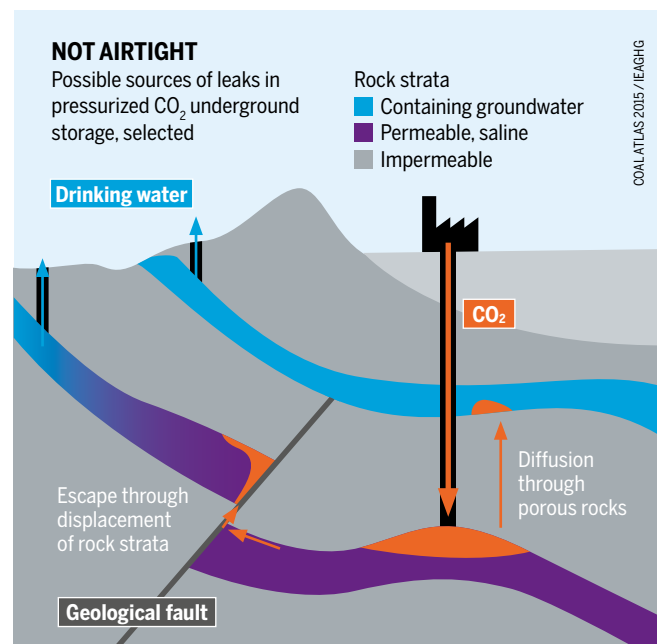
Some coal-fired plants, such as the Drax station in Britain, are able to burn wood as well as coal. In theory, such power stations are supposed to achieve negative carbon emissions by combining carbon capture and storage with the use of bioenergy. Trees absorb CO₂ as they grow. When they are burned, the resulting CO₂ can be pulled out of the cycle if it is captured and stored. A nice idea – but experts say the sums do not add up. Monoculture plantations of fast-growing trees merely displace intact forests, and store a lot less CO₂.

Out of sight, out of mind? We do not know how carbon dioxide might move through geological formations

The coal industry emits billions of tonnes of CO₂ a year. Carbon capture and storage projects may reduce that by a few tenths of one percent

In addition, it is questionable whether the trees absorb as much CO₂ as is released by fertilizer applications, wood processing, transport and the destruction of intact soils. Using bioenergy would further raise the pressure on arable land as investors acquire large areas to plant biomass. Critics call attention to the connection between this “land grabbing” and the violation of traditional land-use rights of local people who lose their means of subsistence.

At Drax, however, an ambitious carbon-capture project hit an obstacle when the plant owner halted its investment. A cut in subsidies for renewable energy caused a sharp decline in the company’s share price. The other partners in the consortium say the project will continue; a feasibility study will be completed in 2016. ●



THE ENERGY TRANSITION

TURNING FROM BURNING – POWERING UP RENEWABLES

The share of renewable energy in the global power mix is growing fast. Nations and corporations are switching over. However, a complete shift away from fossil energy is still not in sight.

The structure of energy supplies is changing rapidly, but in different ways in different places. On the one hand, the share of renewable energy in power generation is climbing constantly. On the other hand, new coal-fired power plants are still being built. European power generators face a tricky period. Many countries have excess capacity in conventional forms of power; these have to compete with renewables.

In 2014, Denmark and Germany consumed the same amount of energy as in the 1970s. They have managed to decouple their energy use from economic growth. Investments in ageing power plants and stricter standards for air pollution are pushing the generators' costs upwards.

Even new plants like the coal-fired power station in Hamburg-Moorburg, which was put online by its operator Vattenfall in 2015, are scarcely economic today. The expansion of renewables in Germany has significantly exceeded most predictions. Many scenarios drawn up in the early 2000s predicted a share for 2020 that was attained by 2010. Renewables are emerging from their niche. Wind and solar power account for 79 percent of all new generation capacity. In Germany, more and more communities are deciding

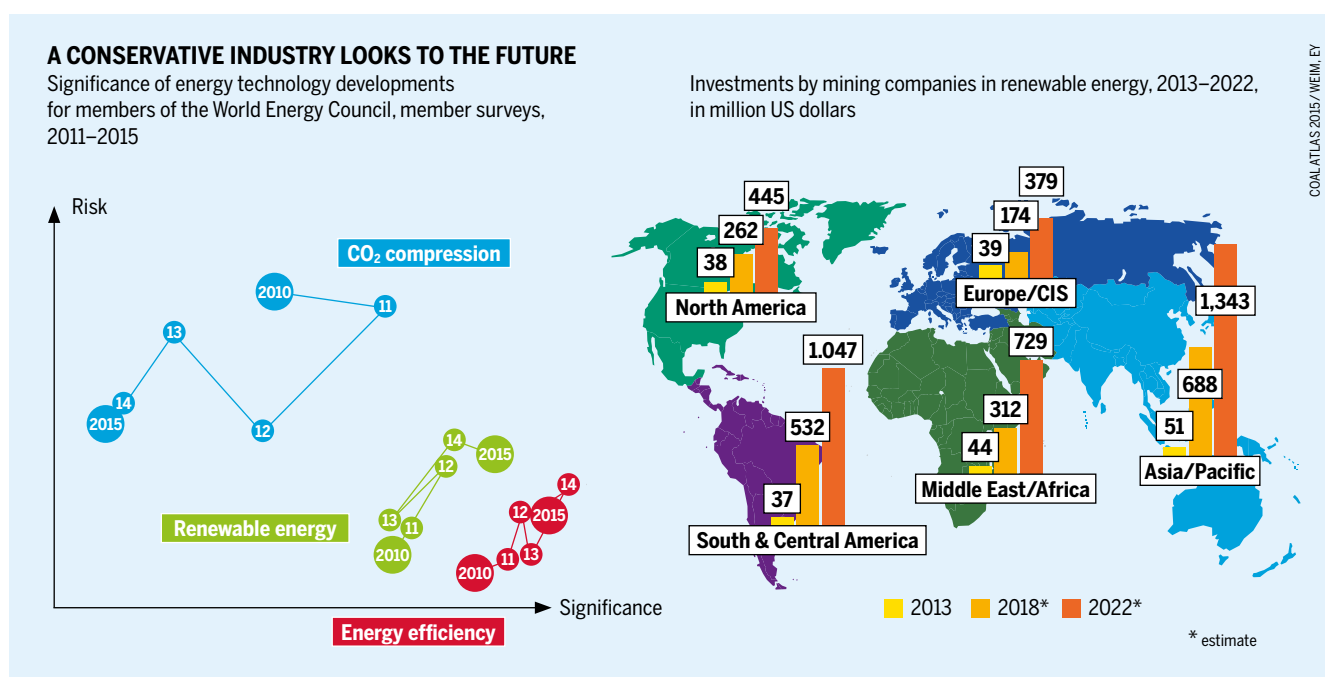
to go fully renewable; around 20 million people now live in so-called 100-percent regions. Power cooperatives in which citizens own shares are leading the shift to decentralized and eco-friendly energy. This grassroots energy transition has attracted interest from abroad. In Germany, the focus is now on maintaining an energy market that does not restrict citizen's initiatives and is legally aligned to and supports renewable power sources.

Renewables already produce 25.8 percent of the electricity generated in Germany. Together, solar, wind, biomass and co. have displaced lignite from the top of the pecking order of energy sources. On sunny and windy days, renewables can supply up to 80 percent of the German demand – unimaginable only a few years ago. But around noon on 11 May 2014, this was achieved for the first time.

This new reality necessitates a redesign of electricity grids, because the locations where the power is now being generated have moved. To cater for variations in wind and solar power, more flexibility is needed from conventional power plants and from consumers, as well as more storage capacity.

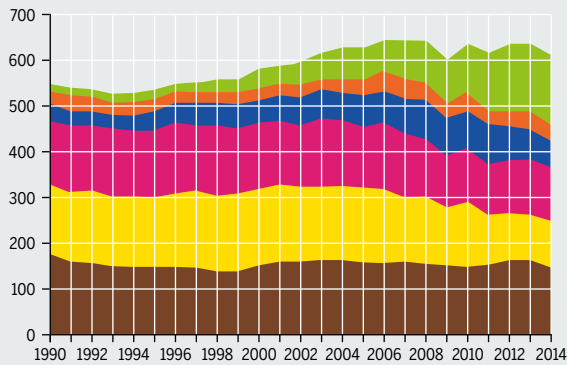
But Germany is just one example; renewables are advancing throughout the world. Half comes from "old" renewables such as hydropower or wood burning. But the "new"

Mining companies are on the lookout for new types of activities. Meanwhile, they carry on with the old

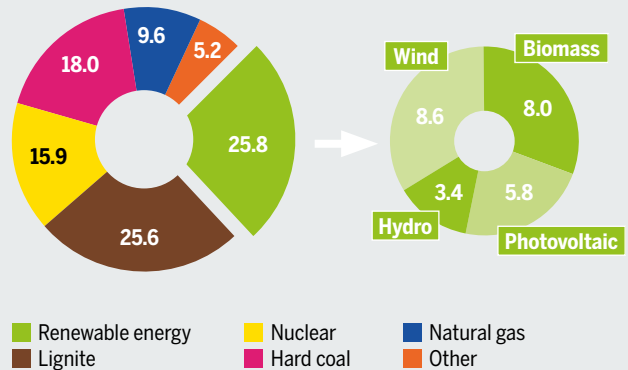


OLD POWER AGAINST NEW ENERGY

Change in electricity generation in Germany, in billions of kilowatt-hours



Electricity mix in Germany, 2014, in percent



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renewables such as photovoltaic, wind, geothermal, wave and biogas are gathering steam. In global rankings, large countries such as Germany, China and the United States are normally at the forefront. But relative to their economic capacity, Uruguay, Mauritius and Costa Rica are investing significantly more in renewables than their larger counterparts. The fact that energy guzzlers in the information technology sector like Facebook and Google are switching to renewables should be a signal to other sectors too. Greenpeace praises Apple because it already gets all the energy it needs from renewables. Data centres worldwide consume more than 30 gigawatts of power – the amount generated by 30 large nuclear plants.

Developments in wind and solar energy are promising. Mass production, technical advances and bigger markets mean that the costs of facilities are falling fast, in some cases by half in just four years. More and more projects are funded without government support because they are cheaper than fossil-energy sources. For wind power, 2014 was a record year. Globally, new turbines with a total capacity of 51 gigawatts were installed, 44 percent more than in the previous year. China is out in the lead; the 23 gigawatts that joined its grid accounted for almost half of the new global capacity. In Europe wind energy also increased sharply, by 12 gigawatts, led by Germany and Britain. After a weak performance the previous year, the United States also grew by 4.8 gigawatts.

In addition, the market for photovoltaics expanded strongly. In 2014, more than 40 gigawatts of capacity were added. China accounts for about one-quarter of the total market. The United States added 6 gigawatts; solar power there produces enough energy to supply four million homes. Upward trends can also be found in Japan (+9 gigawatts), Europe (+7), Latin America and South Africa.

In many developed countries, it is now cheaper for most homeowners to produce their own energy from solar cells on their roof than to buy it from the grid. Solar power is crit-

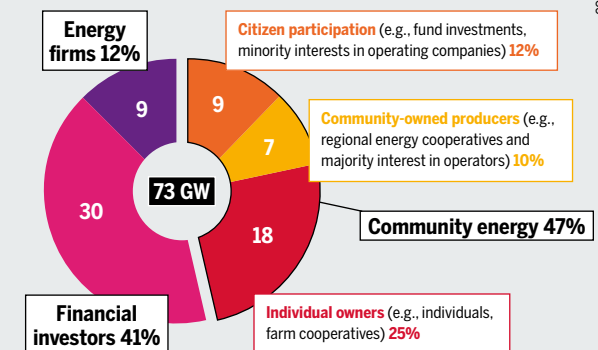
Renewables generated more power than lignite for the first time in 2014

ically important in developing countries, in particular in rural areas that are not yet connected to the grid. For the first time, solar power can supply electricity to residents of these areas and thus improve their lives. This development would have taken years if the rural areas had to wait for power to be supplied by big centralized plants.

Renewables can also present ecological and social problems. Large hydropower dams, mega windparks and big plantations to produce biofuels can lead to human-rights abuses and often to evictions. Widespread planting of monocropped biofuels harms the environment, and the use of agrochemicals is bad for the climate balance. Therefore, the global energy transition is not just about moving away from fossil fuels toward renewable sources. It is also about producing energy in a decentralized, ecological and democratic way. ●

NEW BUSINESS MODELS

Installed renewable energy capacity by type of owner, 2012, in gigawatts and percent



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

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Not just renewable: the energy production of the future should also be decentralized, ecological and democratic

ON TRACK, BUT AIMING TOO LOW

The European Union’s climate policy aims for lower emissions, lower consumption and an increase in renewable energy. The targets are achievable – but they ought to be more ambitious.

The EU wants to contribute to limiting climate change by cutting its CO₂ emissions by the middle of this century. In 2007 it set itself three targets for 2020:

- to reduce emissions of climate-damaging greenhouse gases by 20 percent compared to 1990,
- to increase renewable energy to cover 20 percent of total consumption, and
- to consume at least 20 percent less energy than predicted in 2005.

At half time, the verdict is mixed. The emissions target was unambitious, and it has almost been reached. In 2013, 19 percent less greenhouse gas was emitted than in 1990. This is mainly due to the abrupt adjustments made in the former Soviet-bloc countries that are now EU members as well as the 2008 economic crisis, which led to lower consumption.

The EU is on track in terms of energy efficiency and it is making good progress in developing renewable energy. With a 15 percent share of renewable energy consumption by end users in 2013, the EU has nearly reached its 20 percent target. But the European Environment Agency is handing out very different marks to individual countries. Only nine of 28 member states are on course for all three targets.

One reason why the report card is not better is because new coal-fired power stations have come on stream. That particular trend has now been stopped, but coal remains an important fuel for Europe. In 2014, one in four kilowatt-hours in the EU came from coal; 68 percent of the lignite and 79 percent of the hard coal came from Germany, Poland or the Czech Republic. These three countries gener-

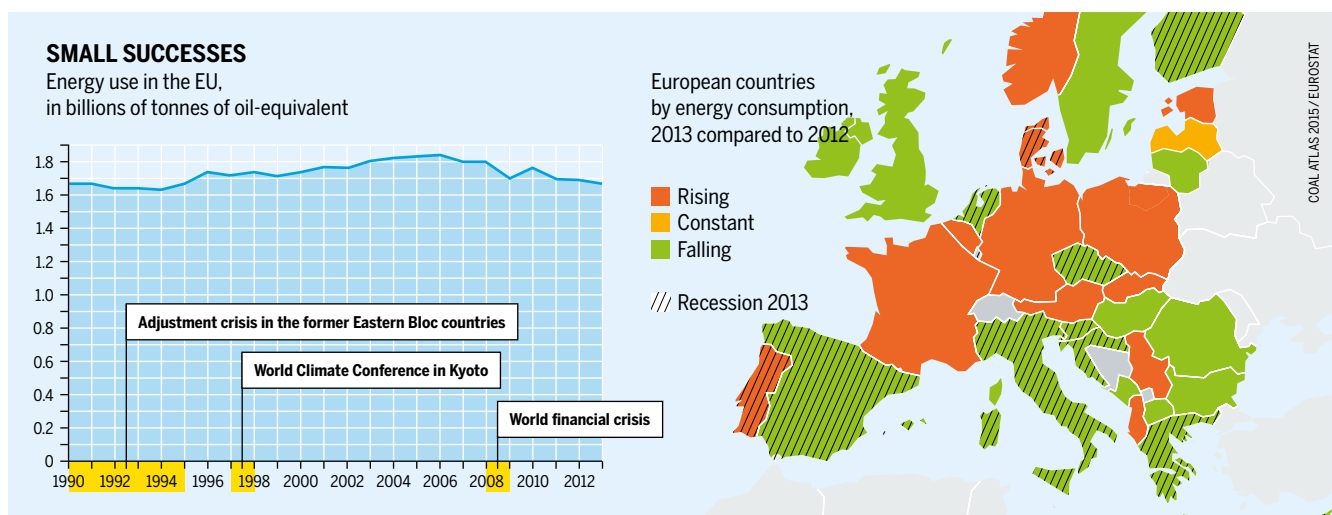
ate more than half of the EU’s coal power, even though they have only one-quarter of its population.

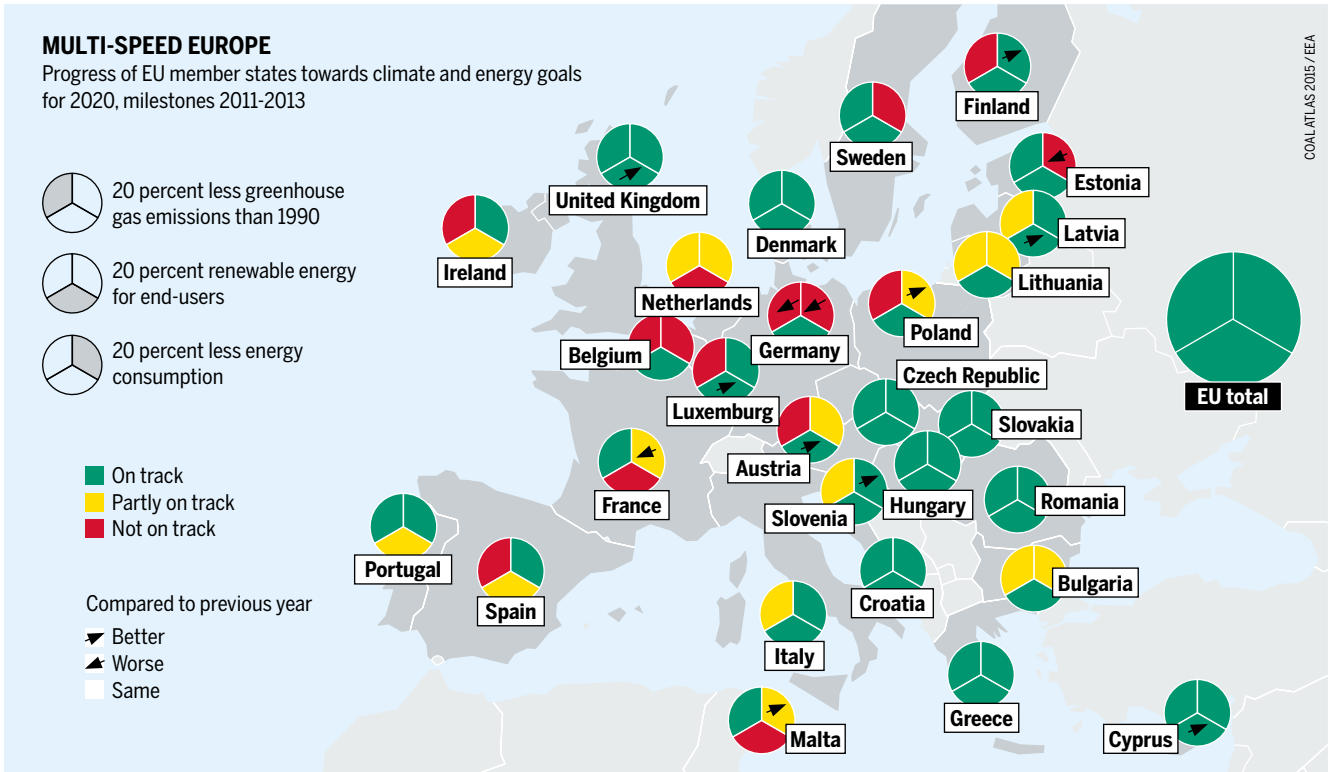
The European Commission wants all member states to join forces in a European energy union. This stems from a proposal by former Polish Prime Minister, Donald Tusk, who, in the face of hostilities between the Ukraine and Russia, welcomes energy security, derived from an increase in nuclear power and coal, for the EU. Additionally, an energy union could jointly negotiate better terms for gas imports. The energy union idea has since been developed further. Germany, Austria and Denmark want to use it to make power supplies more climate and environmentally friendly.

The energy union encompasses five closely related and mutually supporting ideas. The first is the creation of a completely integrated internal market for power, making it easier to trade gas and electricity among member states. Second is the improvement of energy efficiency by cutting consumption of electricity, heat and fuel to save 200 billion euros a year by 2020. The third aspect is climate protection which includes the reformation of the emissions trading scheme, an increase in energy from renewable sources, and the electrification of the transport system. Some experts counter that these proposals are not really new. Research and innovation for low-carbon technologies are the fourth dimension of the energy union. The long-term vision and the union’s fifth pillar is labelled “decarbonisation of the EU economy”. By 2050, the EU has undertaken to reduce its emissions of greenhouse gases by 80 to 95 percent compared to 1990. It hopes to decouple economic growth from energy-related emissions, with positive effects on employment.

How binding are these climate and energy targets? That is subject to debate. A group of countries, led by the UK,

The euro crisis is one, but not the only, cause of declining energy consumption. The picture is uneven





wants less oversight from the EU. Germany and Denmark stress the savings that can be achieved with an integrated power grid to even out the volatile inputs from solar and wind, and to store surplus power in facilities in Norway and the Alps. Poland, the Czech Republic and Slovakia are pushing for more energy from nuclear, coal and shale-gas – a stance that is incompatible with climate goals. The EU wants to cut its emissions further, by at least 40 percent by 2030 compared to 1990.

By then, renewables are expected to contribute at least 27 percent of the total – counting both electricity and heat used for heating and in industry. Reducing consumption is the cheapest way of protecting the climate; the current goal is to improve energy efficiency by 27 percent. It may sound good, but remember that the initial target was 35 percent, and the current target is not binding.

Surprisingly, energy consumption decreased in 2014, thanks to a warm winter. Wind power has been expanding quickly in several member states. But it is possible to see the figures in another light; the EU's targets for 2020 were just too low. The bar for 2030 should be set higher. From a climate-science perspective, a reduction of at least 55 percent would be advisable. Calculations by Greenpeace show what is possible: by 2030, the EU could generate 70 percent of its power from cheap, renewable sources, with more wind turbines on- and offshore, solar cells, biogas plants, and flexible power stations fuelled by natural gas.

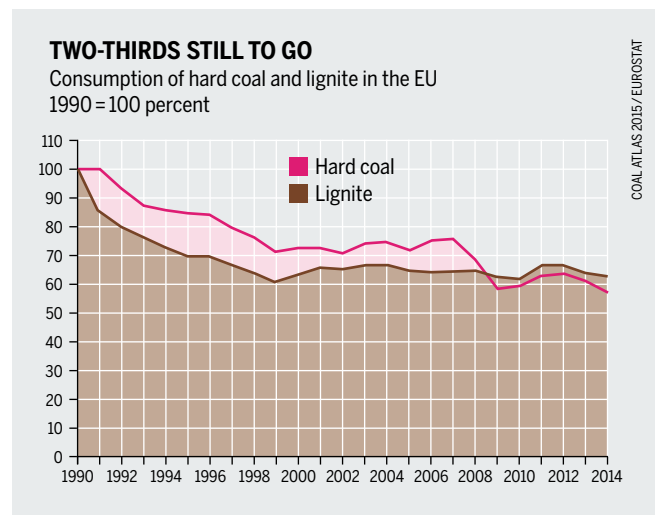
Older coal and nuclear power stations would have to be shut down soon because they cannot offset the volatile supplies of energy coming from renewable sources. The longer

Despite significant progress in the development of renewable energy, Germany risks missing its goals for 2020

the coal and nuclear plants are kept running, the more expensive the whole system will be. Cheap renewables would have to be throttled back in order to accommodate the constant output of the older plants, which can only be operated continuously and at full blast.

Europe's energy supplies used to rely on big, centralized power plants run by a few major operators. In the future, it will be necessary to switch to smaller, intelligently connected suppliers of heat and power, and to reward savings. By putting together many small pieces on a large scale, the EU would send a powerful message to the rest of the world: climate-friendly energy offers big economic opportunities in a more equitable society. ●

For years, the EU's coal consumption has stayed stubbornly at around 60 percent of its 1990 level



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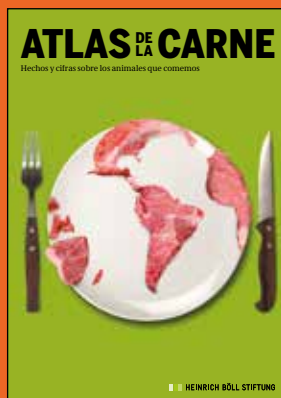
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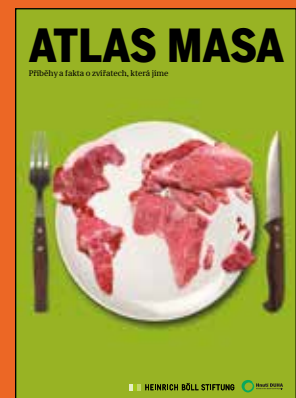
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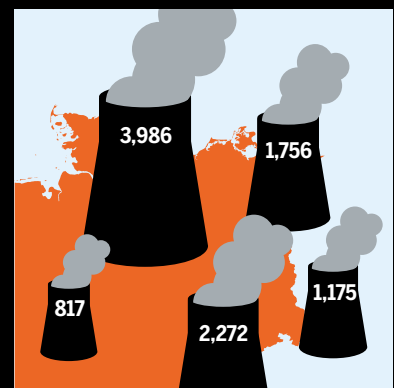
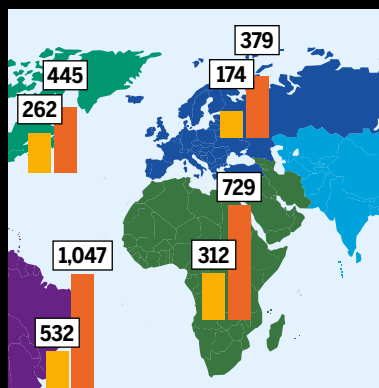
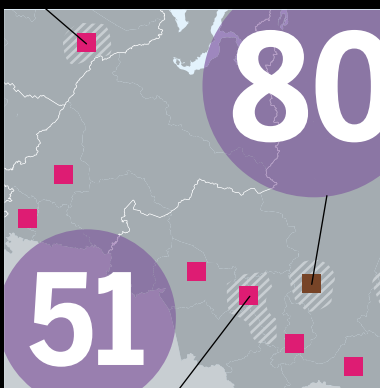
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Generating electricity from coal damages the climate most. Gas-powered plants emit only half as much CO₂.

from **SPOILING THE CLIMATE**, page 14

The apparent cheapness of coal is also a result of subsidies from the taxpayer, both current and in the past.

from **HIDDEN PAYMENTS, UNPAID BILLS**, page 27

No technique yet exists to monitor CO₂ storage sites, systematically identify leaks or plug them when they are found.

from **PROBLEMS AT DEPTH**, page 46

Divesting from coal now is necessary to prevent disastrous climate change and a global financial crisis.

from **DEFLATING THE CARBON BUBBLE**, page 30