European Association for Coal and Lignite AISBL

EURACOAL

A STRATEGY FOR CLEAN COAL

EURACOAL — European Association for Coal and Lignite AISBL
Avenue de Tervueren 168 Bte 11 — B-1150 Bruxelles
Phone: +32 2 775 31 70
E-Mail: euracoal@euracoal.org — www.euracoal.org

CONTENTS

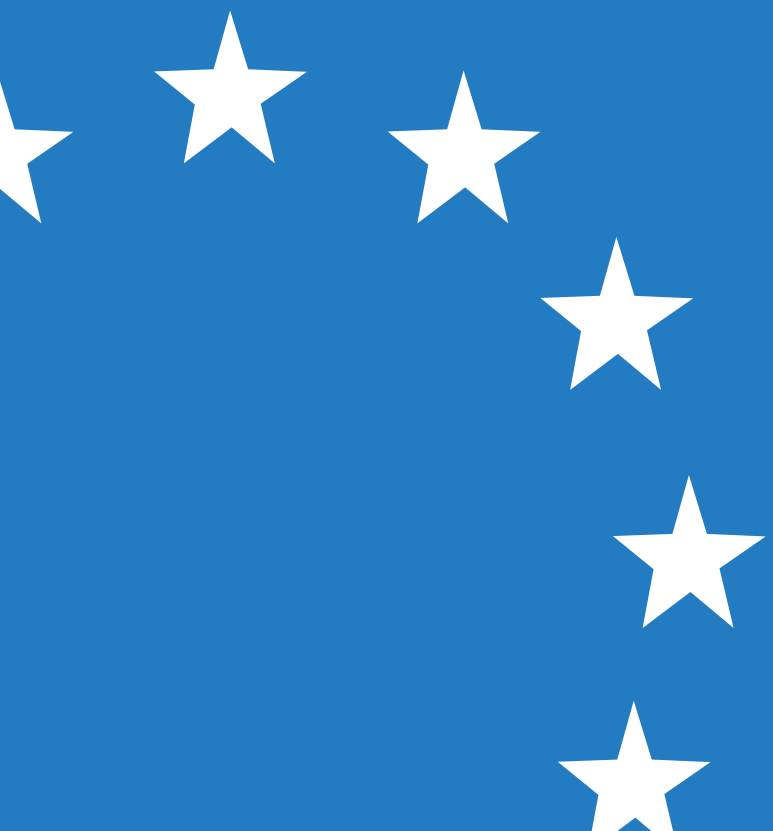
Front cover: Jänschwalde power plant, Germany

1. SUMMARY

EURACOAL presents here a pragmatic three-step strategy for a cleaner, securer and more prosperous future. Today, the replacement and modernisation of old coal-fired power stations should be welcomed by policy makers as a way to improve energy efficiency and to reduce emissions. In planning for tomorrow's world, we should invest in R&D for the next generation of highly efficient coal-fired power stations that can complement renewable generation with their flexibility. The final step is the demonstration and deployment of carbon dioxide capture and storage, a suite of technologies that will see coal become one of the most competitive low-carbon sources of electricity generation. To achieve this will require a new public infrastructure: trunk pipelines to transport CO_2 from industrial regions to suitable storage sites. By following these three steps, the EU can show global leadership in a world where coal accounts for the largest share of electricity generation by a wide margin. In the EU, the strategy would allow electricity users to benefit from all the advantages of coal: supply security, competitive prices and abundant resources.

2. INTRODUCTION

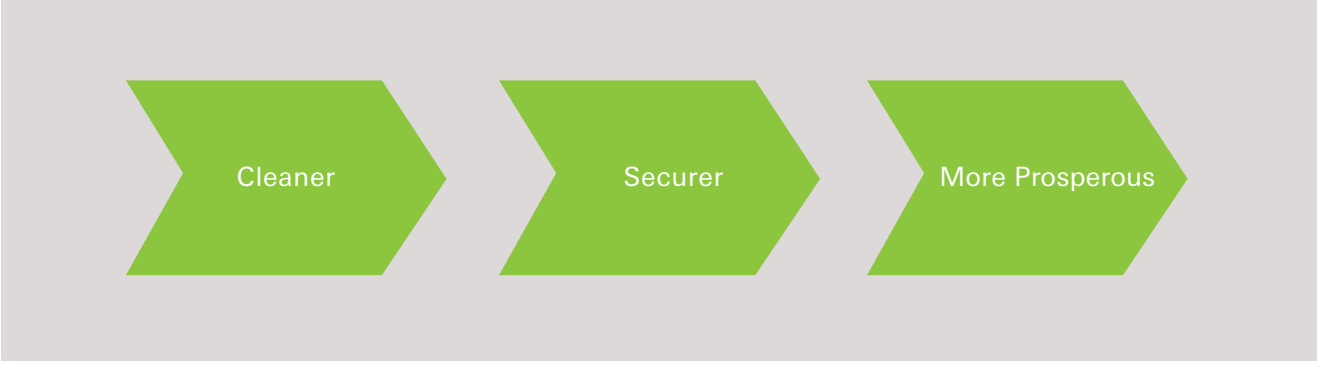
→ EURACOAL's aim is to stimulate a pragmatic discussion on coal.



2. INTRODUCTION

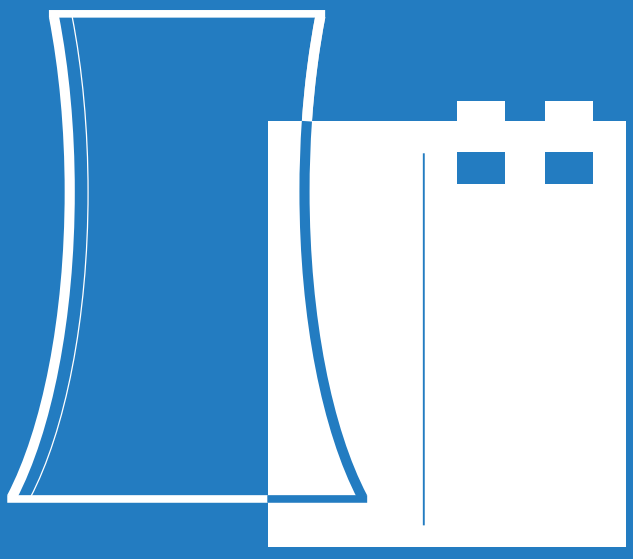
In this short pamphlet, the European Association for Coal and Lignite (EURACOAL) lays out its strategy for a clean and prosperous future with coal. This strategy is as relevant to the developing world – where coal consumption is rising fast – as it is to the European Union where coal continues to underpin the competitive electricity supplies enjoyed by industry and households alike. EURACOAL's aim is to stimulate a pragmatic discussion on coal at a time when the growing use of this "forgotten fuel" reflects its abundance, competitiveness and security.

1 — A Clean Coal Strategy



3. A CLEAN COAL STRATEGY – THREE STEPS TO A SUSTAINABLE FUTURE

→ EURACOAL supports the leadership approach with the progressive introduction of new technologies to reduce emissions.



3. A CLEAN COAL STRATEGY – THREE STEPS TO A SUSTAINABLE FUTURE

The EU has a choice: it can ignore rising coal use in the rest of the world, or it can bring its expertise to bear and lead the world in how to use coal cleanly and efficiently. EURACOAL supports the leadership approach with the progressive introduction of new technologies to reduce emissions. R&D that is taking place now in the EU aims to improve the efficiency of coal-fired power generation to 50% or more. This reduces emissions – by 40% when replacing older power stations – and is good news for resource efficiency because more electricity is produced from the same amount of coal.

No one expects the EU to end its reliance on coal, especially for electricity generation. All scenarios point to a role for coal to 2050 and beyond. So policy makers need to make sure that coal is used in modern, efficient and clean power plants. Unfortunately, the current policy framework and investment climate do not favour coal or any other energy source except heavily subsidised renewables.

2 — **Lignite-fired power plant Schwarze Pumpe in East Germany**

A three-step approach to sustainable coal utilisation:

1. Introduce state-of-the-art technology across the EU coal-fired generation sector to boost efficiency and reduce emissions.

2. Develop the next generation of high-efficiency flexible technologies for coal-fired electricity generation.

3. Demonstrate and deploy CO_2 capture and storage at coal-fired power stations around the world.

4. EFFICIENCY - MORE ELECTRICITY FROM LESS COAL

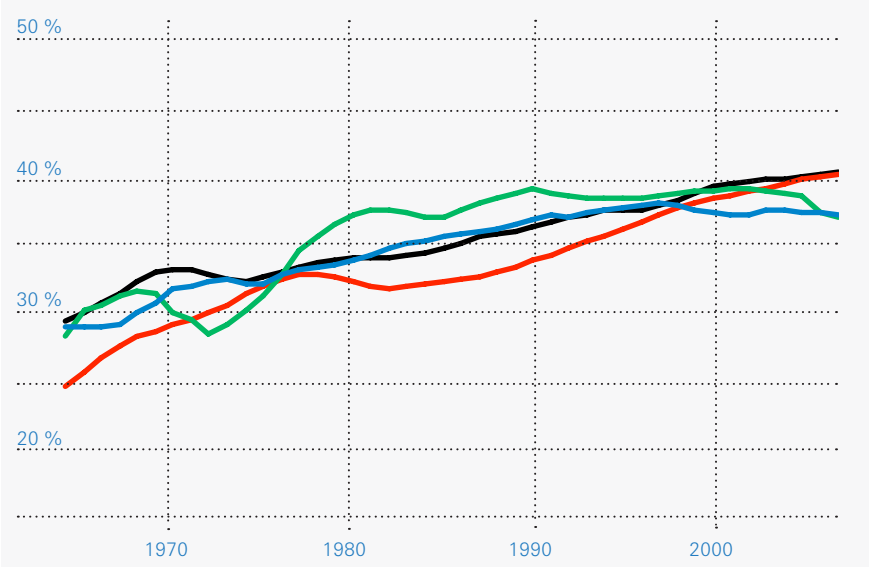
→ Replacing an old power station with a new state-of-the-art plant reduces emissions.

4. EFFICIENCY – MORE ELECTRICITY FROM LESS COAL

The core of any clean coal strategy is to increase the efficiency of power generation from coal at existing and new power stations. Over the last 30 years, efficiency of generation has improved across Europe. Modern installations now regularly achieve efficiencies of 40% to 45% and they emit less CO_2. A one percentage point improvement means >2% less CO_2 is emitted: replacing an old power station with a new state-of-the-art one with around 47% efficiency reduces emissions (e.g. CO_2 by up to 40%, but also SO_2 and NOx), and less coal is needed to produce each unit of electricity.

Looking to the future, new materials will allow higher efficiencies. Components that operate at steam temperatures of 700°C have already been tested at power stations in Europe and promise efficiencies of 50% or more. In the longer term, new technologies will see this improvement trend continue. For example, coal gasification with fuel cells is under development in Japan.

3 — **Efficiency of electricity generation from coal in selected EU Member States**
Data presented as five-year moving averages - Source: IEA CIAB, 2010
Germany Italy Poland United Kingdom



Improved power plant efficiency means:

- CO_2 emissions are lowered by up to 40%.
- Less coal is needed to produce each unit of electricity.
- A single power station can meet the needs of more people.
- Coal reserves will last longer.

5. FLEXIBLE CLEAN COAL - COMPLEMENTING RENEWABLES

→ A partner of renewables.

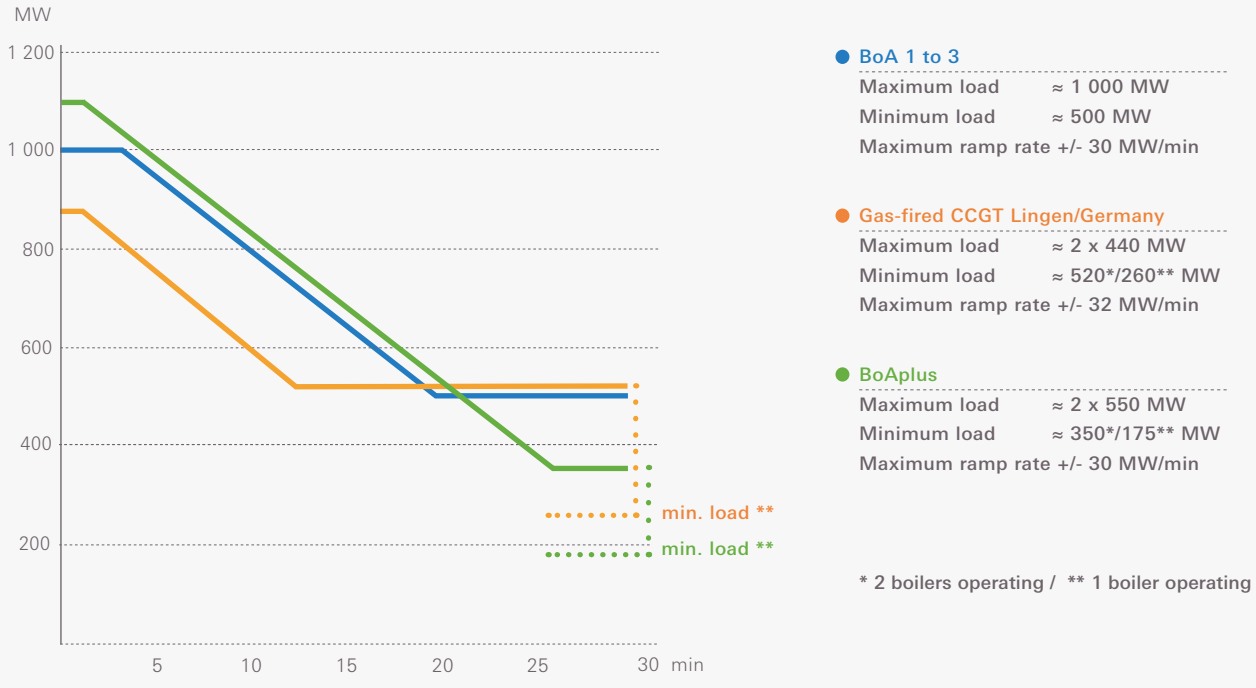
5. FLEXIBLE CLEAN COAL – COMPLEMENTING RENEWABLES

Coal-fired power plants will not only become more efficient, they will also become more flexible, providing essential grid services and backup capacities for renewables. Thus, "clean coal" must also be "smart coal".

Already today, the growth in intermittent wind and solar power challenges the design of both electricity markets and system operations. Increasingly, fossil-fuelled power plants are losing their traditional base-load operating hours and moving into a new role of "auxiliary" power provider, with renewables having priority dispatch. This new régime demands that coal-fired power plants operate with unprecedented flexibility. In fact, modern coal plants are much more flexible than old gas-fired CCGT plants (10 MW/min) and almost match new gas-fired plants (32 MW/min).

Flexibility is often assumed to come from natural gas-fired power stations. However, it would be a fatal mistake to underestimate both coal's present-day contribution to grid stability and its potential to provide very high flexibility and backup capacity in the future. Even today, coal plants run at partial load, providing reserve capacity and a number of system services, competing with gas plants. Modern coal plants can change from full load capacity to 50% in less than a quarter of an hour and, unlike gas-fired plants, with little efficiency penalty. Thus, a 1 000 MW plant can provide a 30 - 40 MW load change each minute, and the flexibility of coal plants continues to be improved.

4 — **The flexibility of modern gas-fired and coal-fired power plants is comparable**
Source: RWE



6. CO_2 CAPTURE AND STORAGE – TOMORROW'S TECHNOLOGY PROVEN TODAY

→ A CO_2 transport and storage infrastructure is needed.

→ When the wind doesn't blow or the sun doesn't shine, flexible coal-fired power stations are there to meet demand.

6. CO_2 CAPTURE AND STORAGE – TOMORROW'S TECHNOLOGY PROVEN TODAY

To meet politically agreed targets on CO_2 emission reductions will ultimately require the roll out of technologies to capture and store the CO_2 emitted from fossil fuel use. Large-scale projects are operational today in the oil and gas industry. The technologies to capture CO_2 at power stations are proven – great progress has been made over the last few years. The costs of capturing CO_2 will fall in the future – just as the costs of capturing sulphur dioxide (SO_2) have fallen. Many projects have made progress across Europe, but no large-scale demonstration projects are yet in operation, despite good support from the European Commission and the commitment of the coal industry. Commentators present the delays in different ways. EURACOAL believes that the large integrated projects are simply too complex to succeed in isolation. A CO_2 transport and storage infrastructure is needed to attract many CO_2 capture projects, large and small. This "chicken-and-egg" problem can be solved once governments see that a national infrastructure comprises roads and railways, water supply and sewerage, energy transmission and distribution, and CO_2 transport and storage. The latter requires new infrastructure, new business models, new laws and a new realisation that climate protection is as important to society as our other wants and needs.

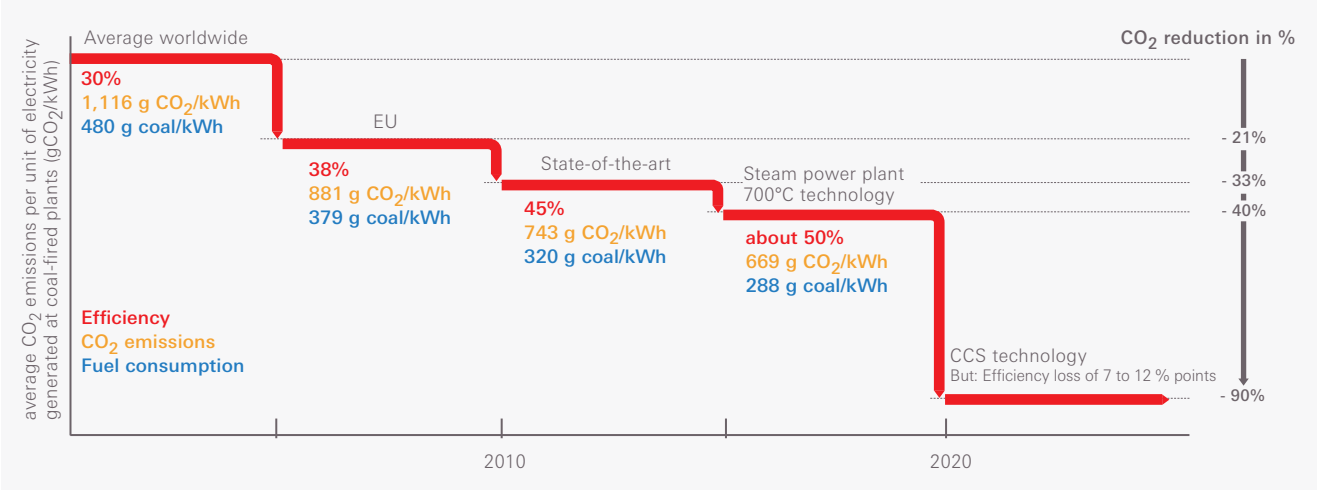
In 2005, EURACOAL said that the most promising CO_2 capture technologies would be identified "by the beginning of the next decade". They have been. We also said that demonstration plants would be built during the 2010s and that the "first industrial installation, along with a reliable storage concept, could be in operation by 2020". We are still on track to achieve this, despite some recent setbacks. Governments and industry must work together to overcome the financing and public acceptance hurdles that persist, because without CCS the cost of climate change mitigation will be significantly higher and make it more difficult to concurrently eradicate fuel poverty.

As our energy system evolves, with intermittent renewables and more distant gas suppliers, flexible coal-fired power stations have a vital role to play. When the wind doesn't blow or the sun doesn't shine, flexible coal-fired power stations are there to meet demand. We have taken that role for granted in the past. Coal is set to play an important long-term role in providing Europe with a cost-effective, environmentally friendly and reliable energy supply for decades to come. EURACOAL is convinced that in a competitive EU market for energy, as envisaged by the European Commission, coal will continue to enjoy a strong position – one that reflects the undeniable importance of coal in the modern world and its economic value to the EU.

CO_2 capture and storage:

- The technologies to capture and store CO_2 are proven at large scale.
- Demonstration at coal- and gas-fired power plants is the next step.
- CCS will cap carbon prices at affordable levels.
- CCS is a "must have" if the rise of global CO_2 emissions is to be stopped.

5 — **Reducing CO_2 emissions through improved efficiency and CO_2 capture at coal-fired power plants**
Average data for hard coal-fired power plants - Source: VGB, 2012

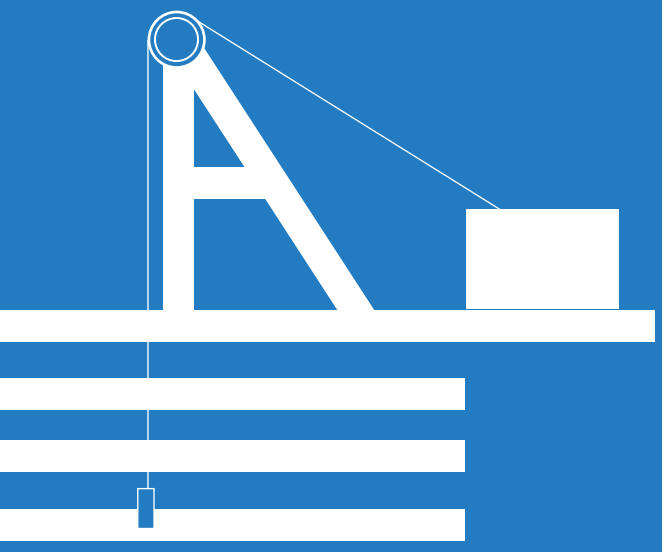


7. PROGRESS REVIEW – IS THE CLEAN COAL STRATEGY ON TRACK?

→ Include the efficient and clean use of coal in the next R&D framework programme Horizon 2020.

→ A balanced energy mix brings security.

→ A stockpile of coal at a coal-fired power station is the cheapest virtual storage of electricity.



7. PROGRESS REVIEW – IS THE CLEAN COAL STRATEGY ON TRACK?

Much of the above analysis and commentary was presented by EURACOAL in early 2005, so it is timely to reflect on how much progress has been made in Europe with a clean coal strategy fit for the 21st century.

Europe has taken a leading role in the development of clean coal technologies: many of the world's leading technology suppliers are European. They build very efficient and very flexible modern coal-fired power plants in the EU and compete around the world with the other major suppliers from the USA, Japan and South Korea. To maintain this leading position, EURACOAL calls on the European Commission to include the efficient and clean use of coal in the next R&D framework programme Horizon 2020.

The average life of a coal-fired power station (30 to 40 years) means that between 2% and 3% of installed capacity must be replaced each year. Unfortunately, in some countries, this renewal rate is not being achieved because energy policy has either linked the future of coal too tightly to the immediate deployment of CCS or focus has shifted away from coal to populist "green" measures or "big-hitter" nuclear projects. A result, in some countries and regions, is that natural gas has often been the default fuel choice for new power generation projects. This has serious consequences: it compromises energy security; it compromises Europe's industrial competiveness with high electricity prices; it compromises climate objectives by locking-in gas plants without CCS; it compromises prosperity by shifting upstream energy-sector jobs outside the EU; and it means upstream emissions of greenhouse gases should be closely scrutinised using life-cycle analysis.

Market forces and entrepreneurship, not political rhetoric and restrictive legislation, create the best balance between the different energy sources. A balanced energy mix brings security. We know that there needs to be greater oil and gas supply security – cold winters are not the time to discover any vulnerability. Thankfully, coal is available from diverse sources and is easily and cheaply stocked, so countries that include coal in their energy mixes can enjoy greater energy security. A stockpile of coal at a coal-fired power station is the cheapest virtual storage of electricity.

6 — **Post-combustion carbon capture installation at German power plant Staudinger**

Next steps for policy makers:

- have belief in markets, not dirigiste central planning;
- encourage what is possible today – power plant modernisation and renewal;
- prepare for what will be possible tomorrow – R&D;
- plan for the day after tomorrow – the deployment of CO_2 capture and storage;
- set clear long-term targets and refrain from making short-term interventions; and
- invest in CO_2 transport infrastructure so that CCS can deliver its potential.

8. POLLUTION CONTROL – AN EU SUCESS STORY

→ Emissions of sulphur dioxide from the EU have been slashed by more than 80% since 1990.

8. POLLUTION CONTROL – AN EU SUCESS STORY

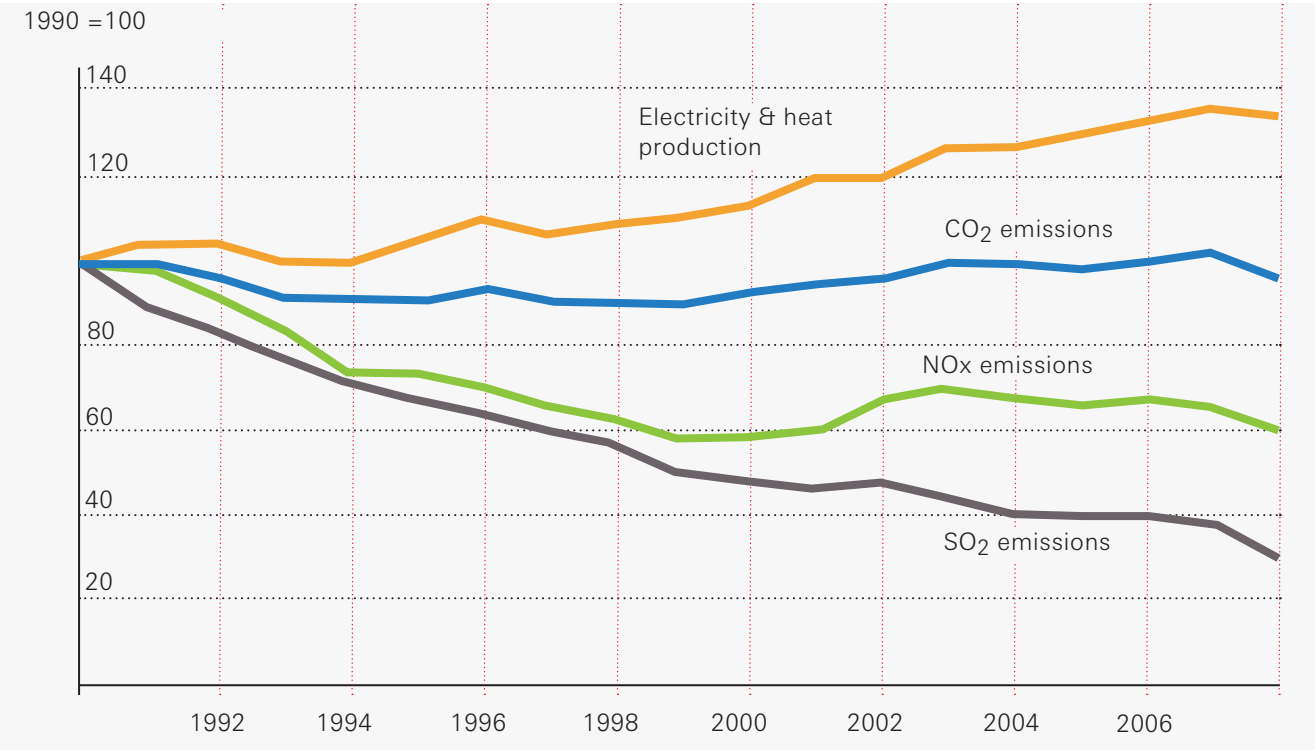
In the EU:

- State-of-the-art pollution control has reduced pollution substantially.
- Strict environmental legislation ensures that power plants, old and new, are run cleanly.
- New Member States have invested heavily to improve the emissions performance of their power stations.

In practice, the 3-step clean coal strategy described above is a continuation of the progress already made by the coal industry over recent decades. Clean coal means less dust, less sulphur dioxide and less oxides of nitrogen are released into the atmosphere. The first European emission regulation for power stations dates from 1988 and has been successively revised and extended.

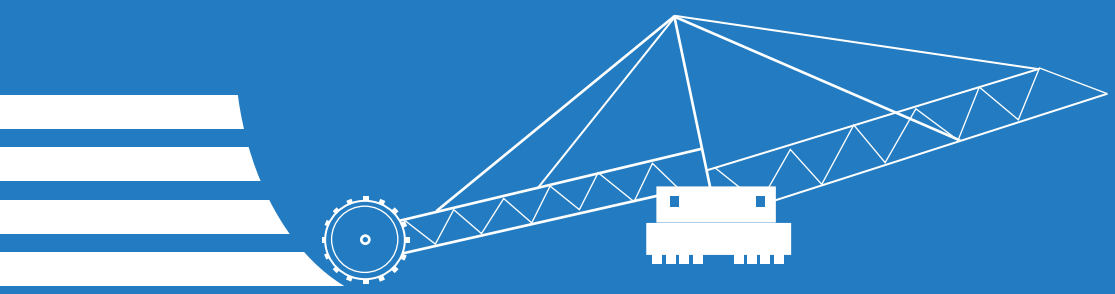
More than 90% of SO_2 is removed from flue gases at coal-fired power plants with flue gas desulphurisation. The by-product of this process is gypsum which is used in the making of plasterboard. Emissions of NOx from power generation have been reduced so much that it is now the emission from cars and lorries that pose a challenge in terms of meeting air quality objectives. Emissions of sulphur dioxide from the EU have been slashed by more than 80% since 1990.

7 — **Emissions from electricity and heat production across Europe (EEA-32) 1990 - 2008** - EEA-32 are the members of the European Environment Agency: EU-27 + EFTA-4 (Iceland, Liechtenstein, Norway and Switzerland) and Turkey - Source: EEA, 2011



9. COAL ACROSS THE EUROPEAN UNION

→ The EU sits on coal and lignite reserves sufficient to last 130 years and resources to last a thousand years.



9. COAL ACROSS THE EUROPEAN UNION

Coal in the EU:

No. 1: most of our electricity comes from coal and nuclear.

Flexible: whatever the weather, coal-fired power is there to keep the lights on 24/7.

Diverse: locally mined coal and lignite, plus imported coal from many countries.

Wealth: provides 220 000 jobs and supplies fuel worth € 27 billion.

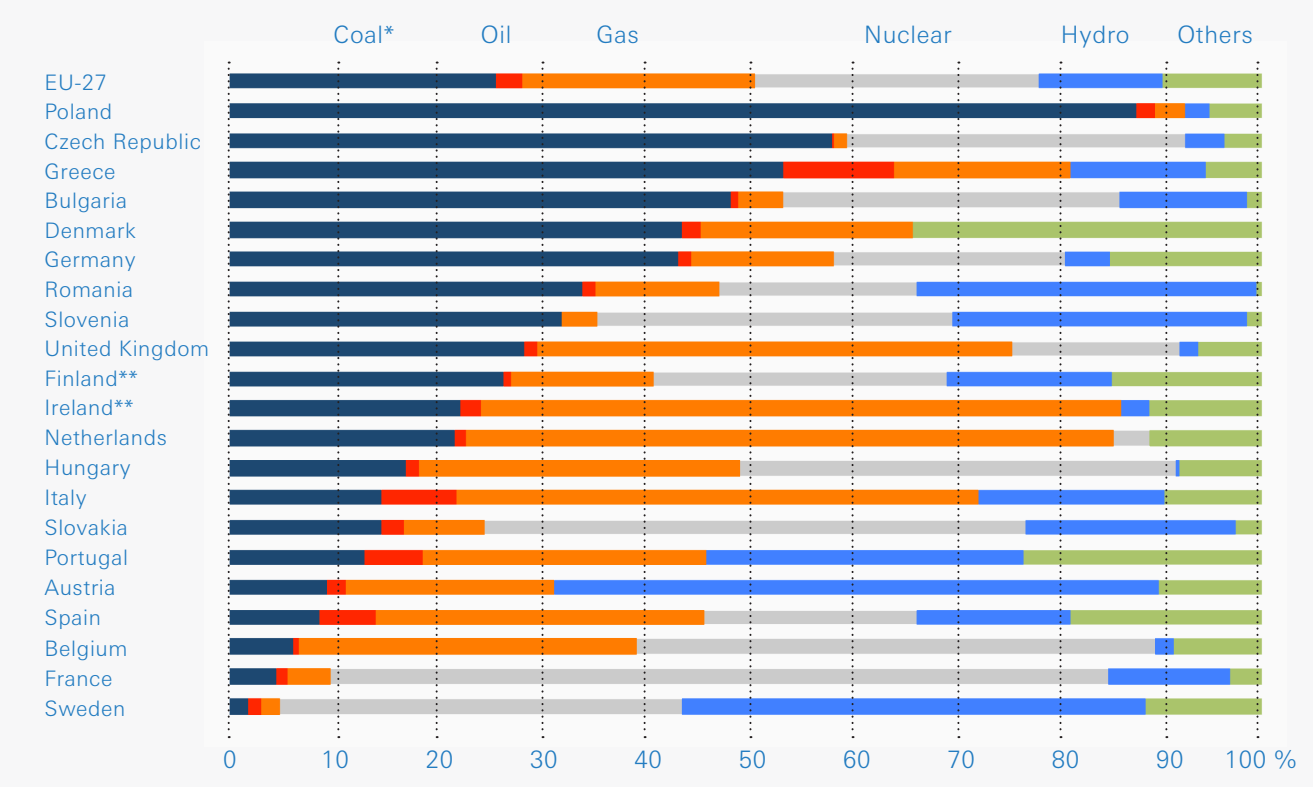
Secure: coal and lignite mined in the EU reduce import dependence and supply risks.

In the EU, coal is a central pillar of a balanced energy mix. The Lisbon Treaty gives Member States the right to exploit their indigenous energy resources and to determine their own energy mixes. Given our limited oil and gas reserves, it is comforting to know that the EU sits on coal and lignite reserves sufficient to last 130 years and resources to last a thousand years. Users of indigenous coal and lignite face lower price risks than users of imported energy: prices are more certain and subject to less volatility. Add imported coal, from a competitive international market that is free from cartels or threats to supply security, and it becomes clear why many Member States rely on coal.

It is a fundamental social and political requirement that each country should be able to fulfil its energy needs at an affordable cost. This means using all available resources as effectively as possible, including coal.

8 — **Energy mixes for power generation across the EU, 2010**

*coal includes coal products, **coal figures include peat - Source: EUROSTAT database nrg_105a, updated 24 May 2012



10. COAL AROUND THE WORLD

→ In the EU, more than 80% of fossil energy reserves are in the form of coal and lignite.

→ 41% of global electricity is generated at coal-fired power stations.

10. COAL AROUND THE WORLD

Coal:

- The world's most abundant fossil fuel.
- The world's No. 1 fuel for electricity generation.
- The world's fastest growing fuel.
- The world's largest coal user: China.

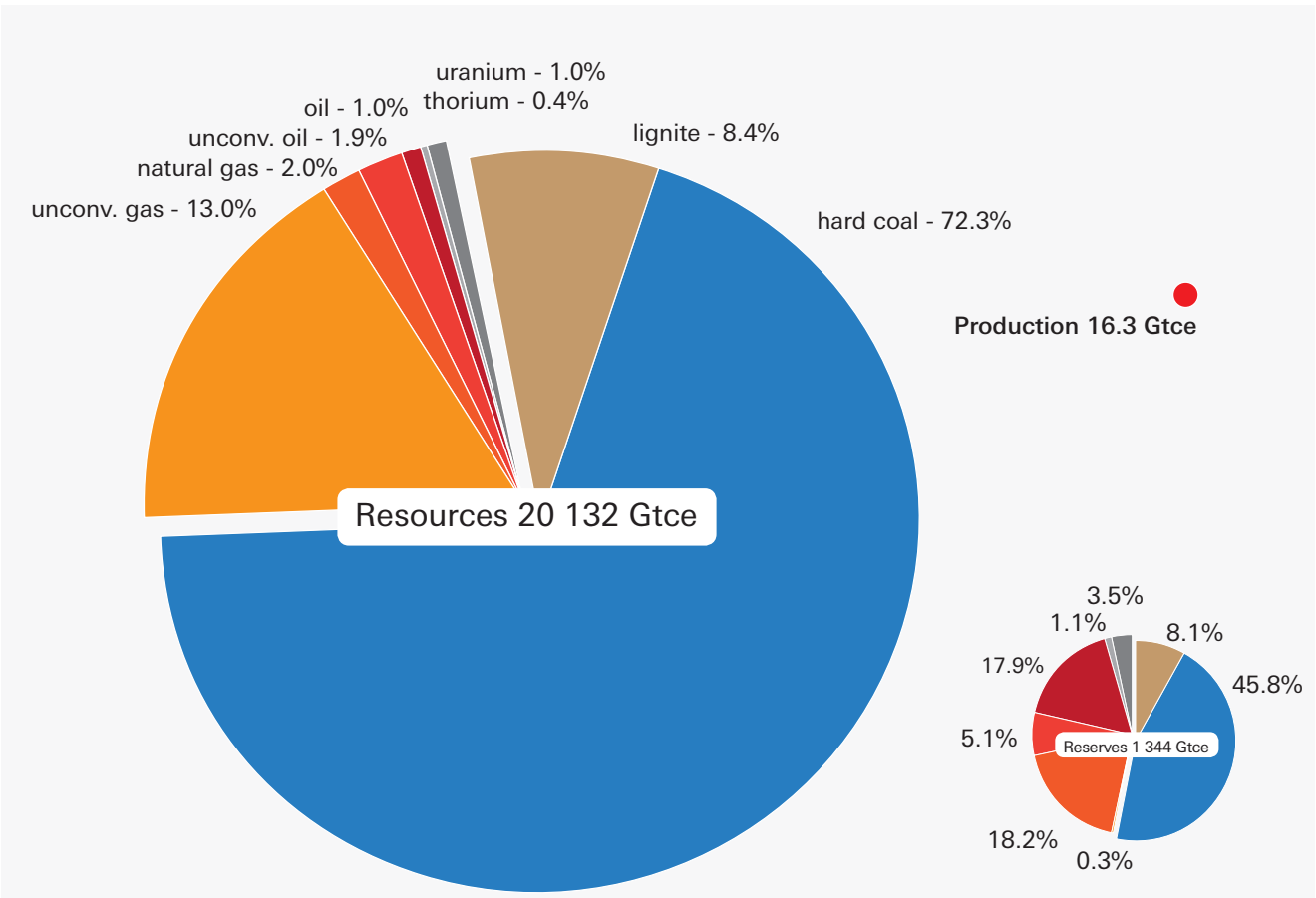
Global energy resources are vast: the equivalent of around 20 000 billion tonnes of coal. Taken together, our proven energy reserves of 1 300 billion tonnes will last over 80 years: we are not about to run out of energy.

Hard coal and lignite (brown coal) account for more than three quarters of the world's energy resources and more than half of the world's energy reserves. In the EU, more than 80% of fossil energy reserves are in the form of coal and lignite.

1.3 billion people live without electricity. Over the coming years, electricity from coal will help move these people out of poverty. More generally, electricity demand is rising as more people become more prosperous and enjoy Western life styles. This is why coal is becoming more important: it is the cheapest fuel source for electricity generation, it is secure and it is abundant.

China's economic boom has been fuelled by coal; between 1990 and 2010, China's annual coal consumption trebled to over three billion tonnes. In second place, the USA uses around one billion tonnes of coal each year. Like many other countries, China and the USA depend on coal for electricity generation. 41% of global electricity is generated at coal-fired power stations.

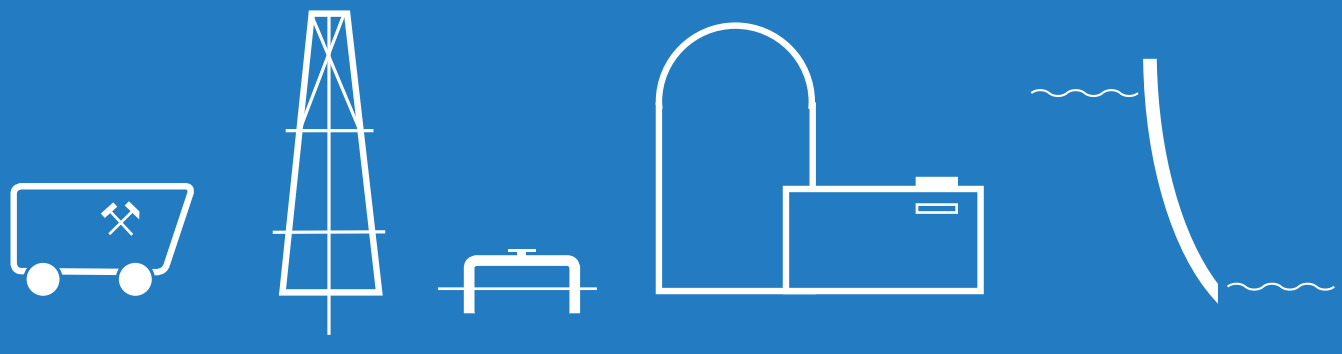
9 — **World energy reserves and resources**: resources: 20 132 Gtce; reserves: 1 344 Gtce; production 16.3 Gtce - R/P= 82 years - Source: Federal Institute for Geoscience and Natural Resources (BGR), 2012



10. COAL AROUND THE WORLD

→ Growth in coal use since 2000 almost equalled the growth in all other energy sources combined.

→ EU's carbon footprint grew by 47% between 1990 and 2010.



10. COAL AROUND THE WORLD

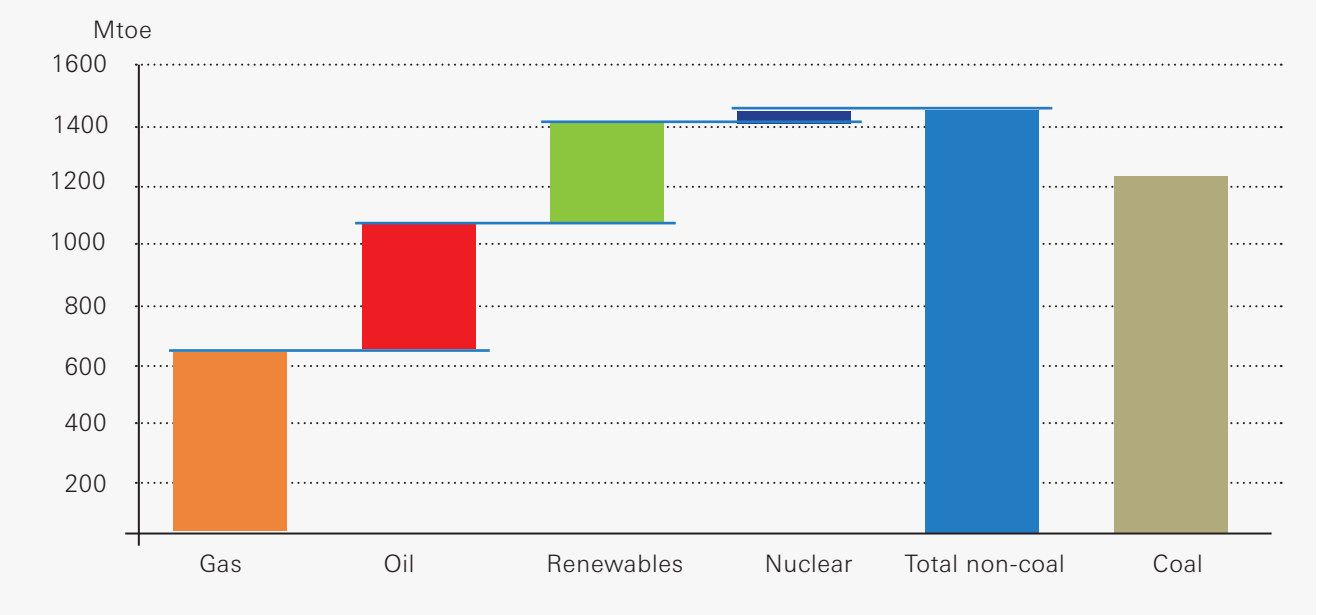
Over the last decade, coal use has been growing far faster in absolute terms than any other source of energy. New renewables, such as wind, solar and geothermal, also grew strongly over the decade. However, in absolute terms, their contribution remains rather limited, amounting to just 1.3% of worldwide primary energy consumption in 2010. Growth in coal use since 2000 almost equalled the growth in all other energy sources combined.

Since 1990, global emissions of the greenhouse gas (GHG) carbon dioxide (CO_2) have risen by almost 50%. The 5% reduction, agreed by many of the world's developed countries under the Kyoto Protocol, is simply irrelevant to the challenge we now face. Even in the EU, where emissions of GHGs are set to fall by 20% by 2020, the true picture is one of rising emissions. If emissions are calculated on a consumption basis, rather than a production basis, then the EU's carbon footprint grew by 47% between 1990 and 2010 (Brinkley and Less, 2010).

Steelworks and other heavy industries have closed in Europe, not because of any lack of demand, but because it is cheaper to import many of the products and materials we use in our everyday lives. This "carbon leakage" cannot be ignored: a sound climate policy must tackle rising emissions in a holistic way and not claim success by simply pushing emissions beyond EU borders.

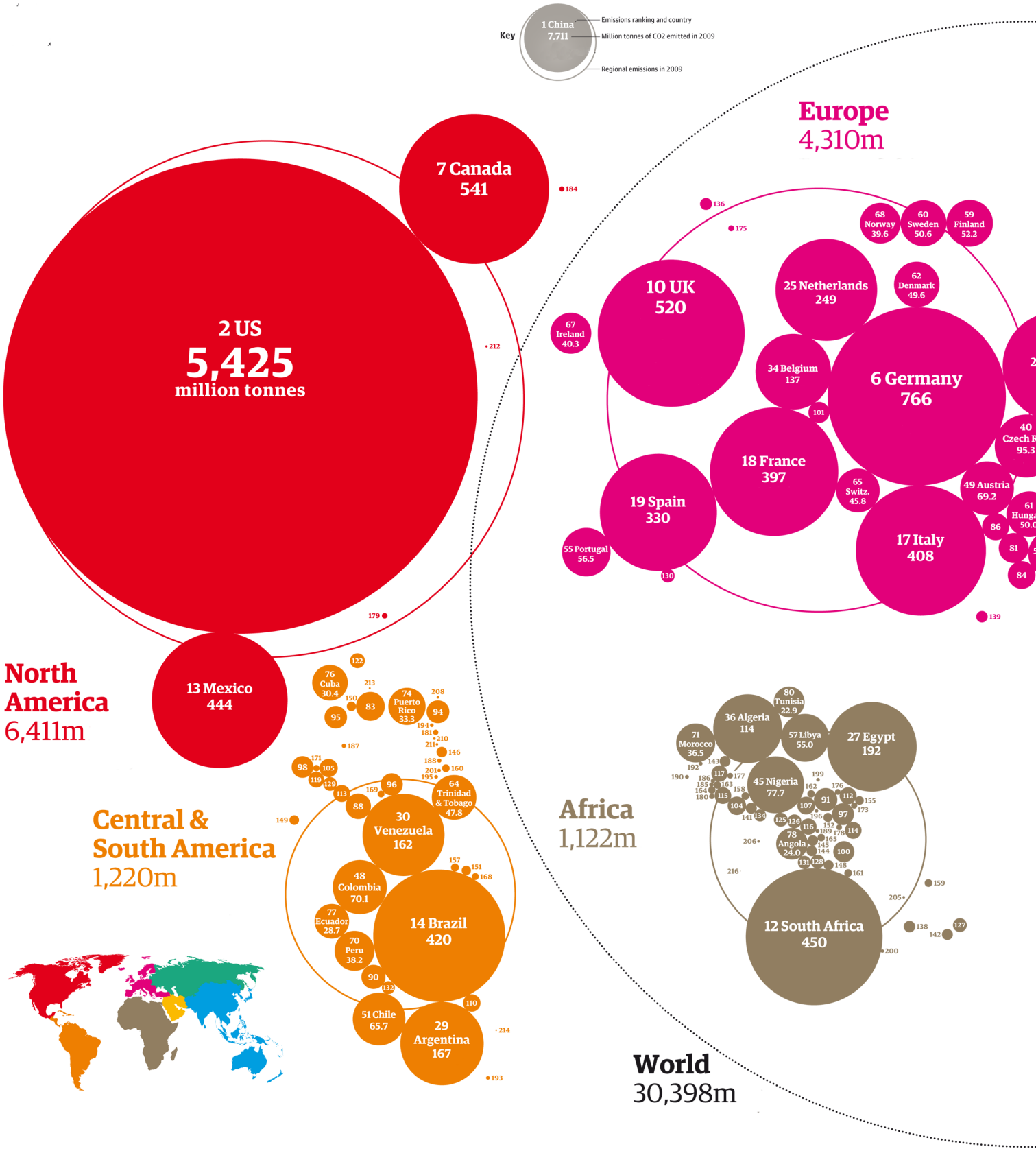
Growing coal use around the world means that a "clean coal strategy" is not just of interest to the coal industry, it is an imperative for the sustainable future of mankind. The International Energy Agency (IEA) expects world energy consumption to grow 40% by 2035 to 26 billion tonnes of coal equivalent, with coal use growing by 65% under a business-as-usual reference scenario. Whilst the IEA presents alternative scenarios which show less growth, it should be noted that actual coal use has always exceeded IEA forecasts, mainly because China's voracious appetite for commodities has exceeded all estimates.

10 — **Growth in global primary energy demand by fuel, 2000 - 2010**
Source: IEA, 2011



10. COAL AROUND THE WORLD

11 — **Global CO_2 emissions, 2009**
Source: Guardian, 2011, using data from US Energy Information Administration (reproduced with permission)



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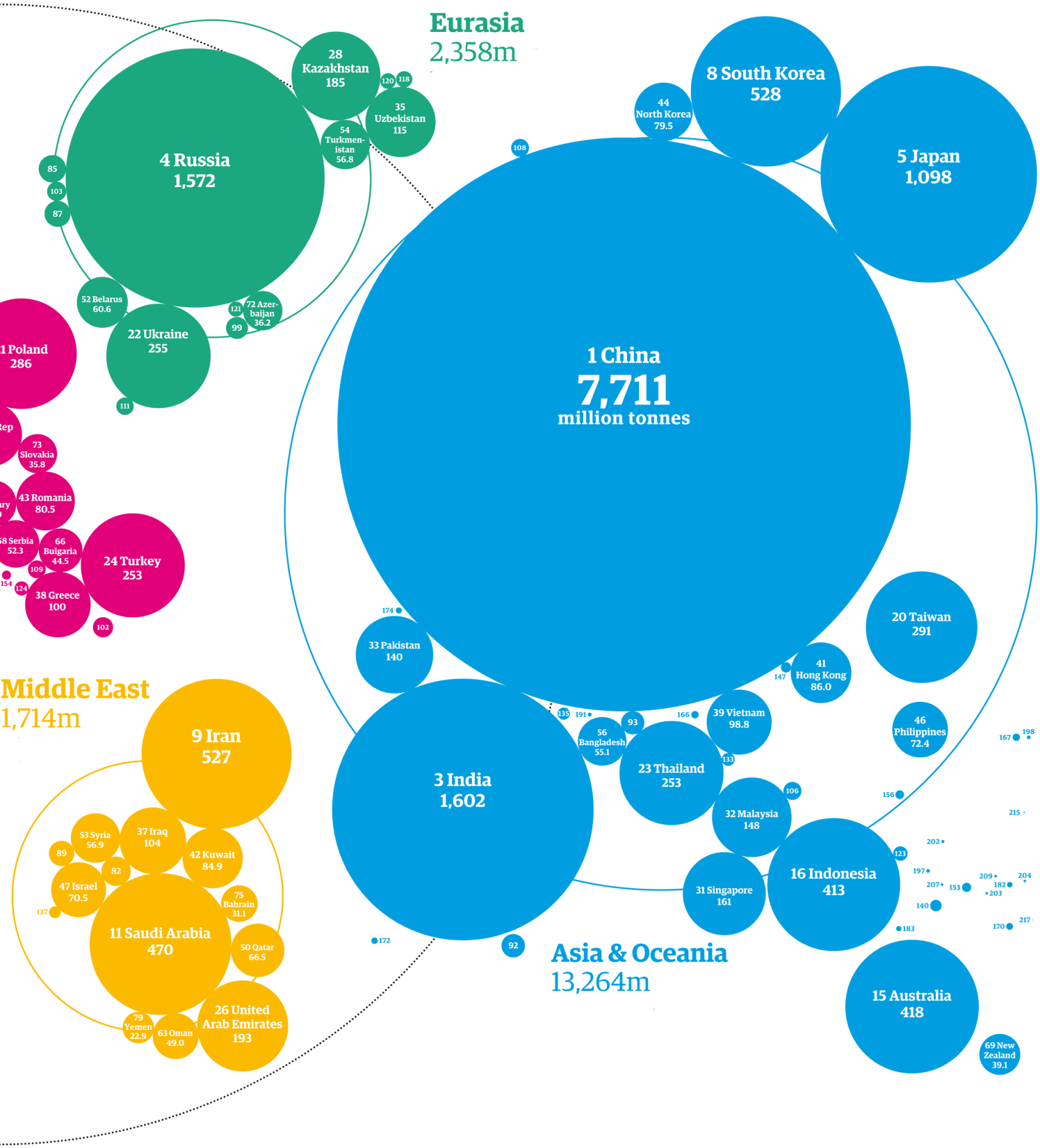

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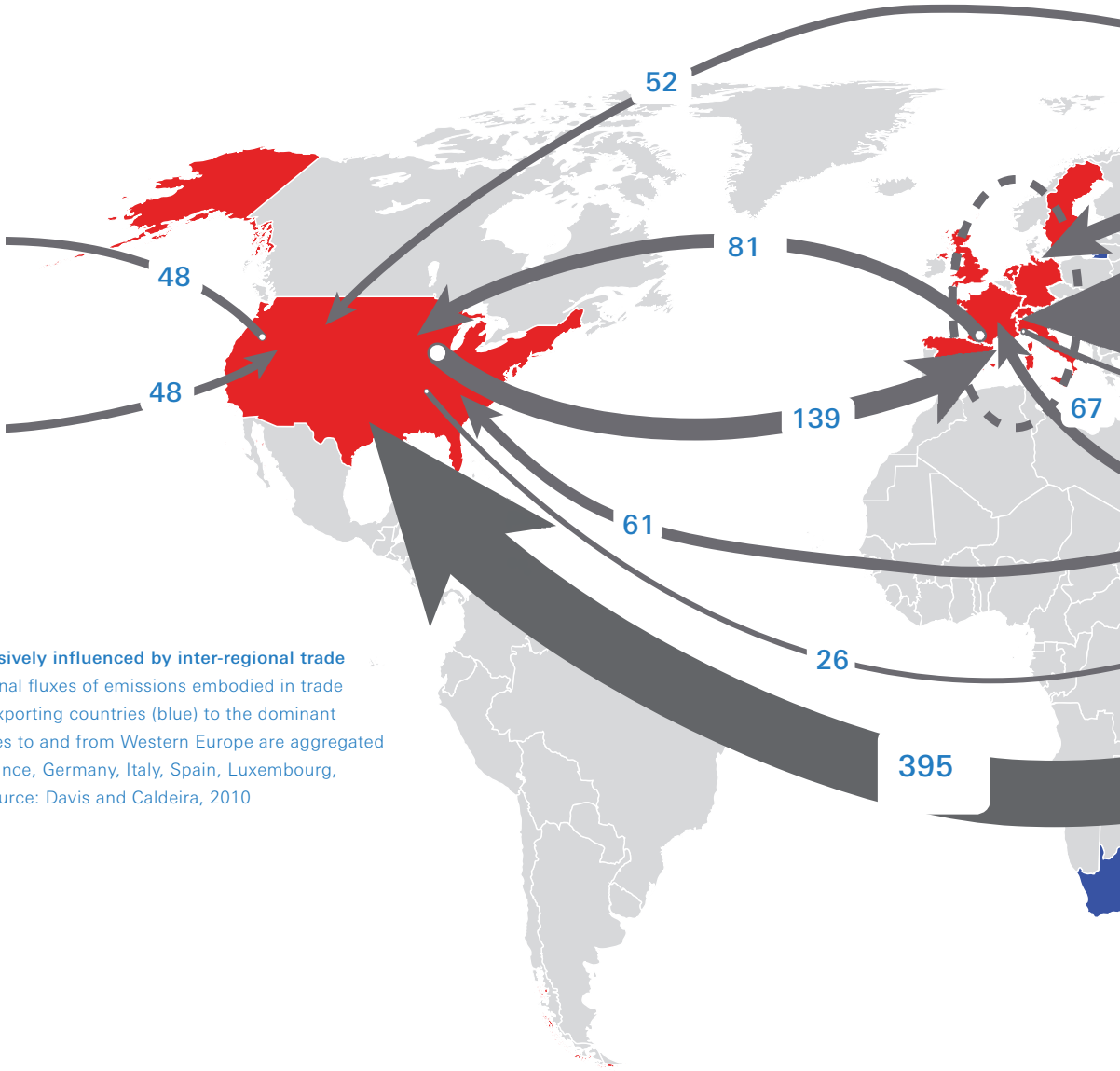
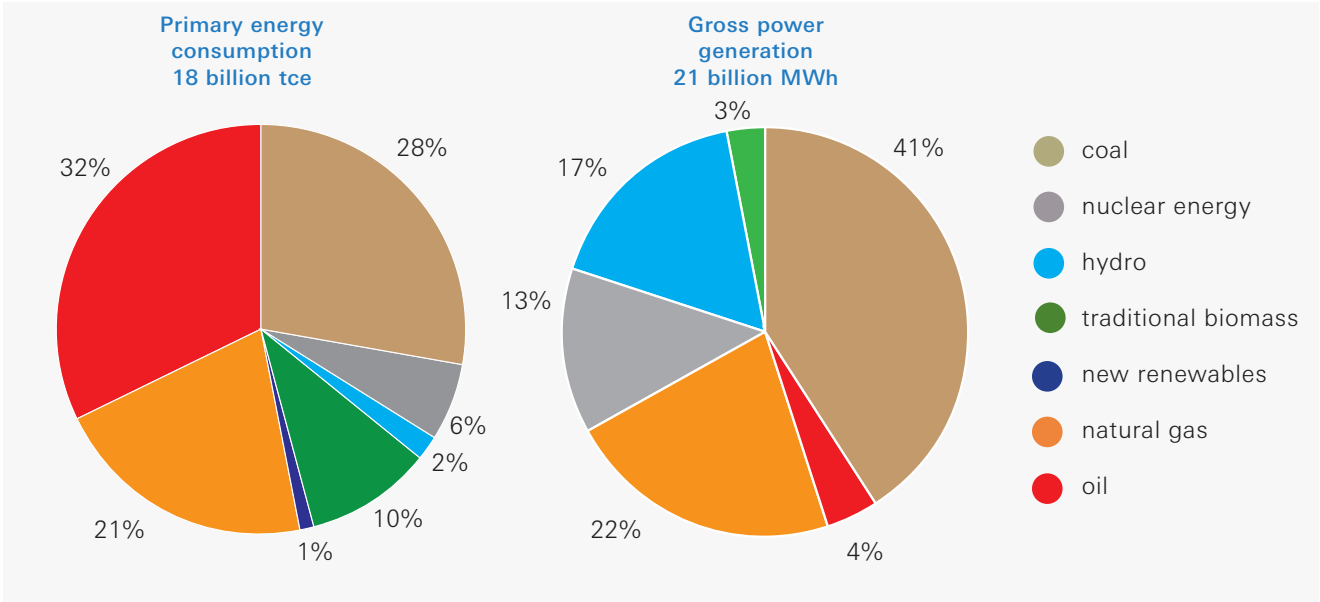


12 — **EU carbon footprint is massively influenced by inter-regional trade**
Chart shows the largest inter-regional fluxes of emissions embodied in trade ($MtCO_2$/year) from dominant net exporting countries (blue) to the dominant net importing countries (red). Fluxes to and from Western Europe are aggregated to include the United Kingdom, France, Germany, Italy, Spain, Luxembourg, The Netherlands and Sweden. - Source: Davis and Caldeira, 2010

13 — **Coal's share in global primary consumption and electricity generation, 2010**
Source: IEA and own calculations



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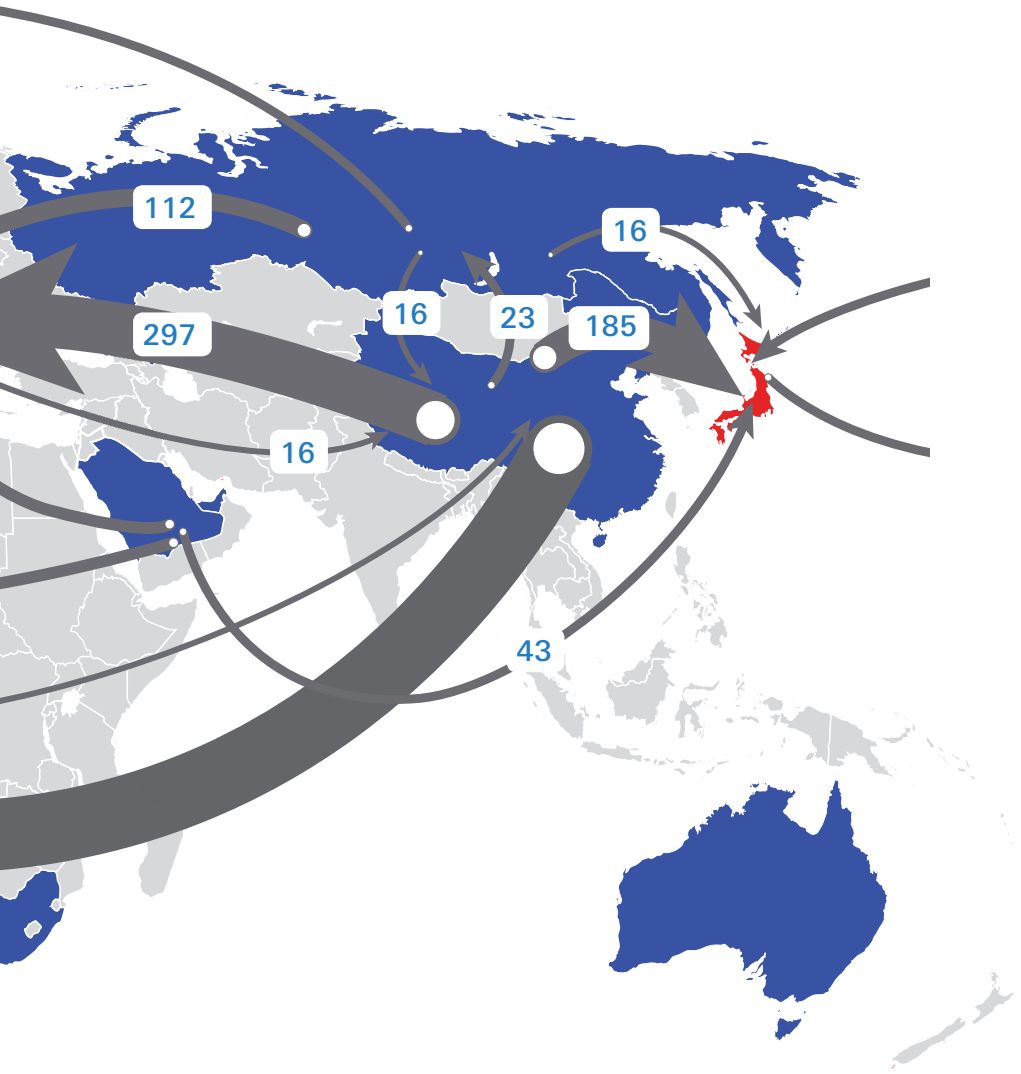


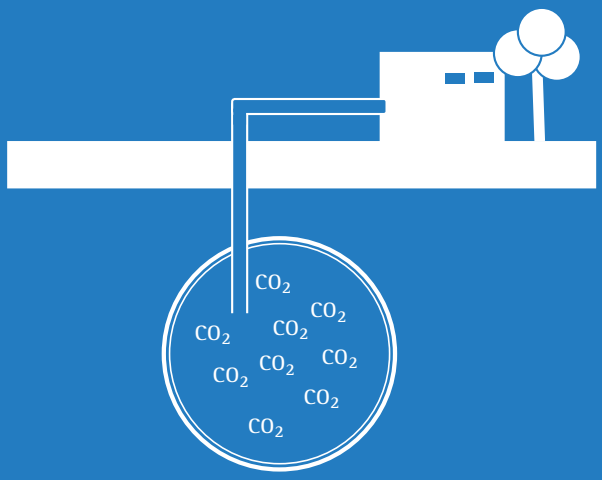
14 — **Coal's share in electricity generation for selected countries, 2010**

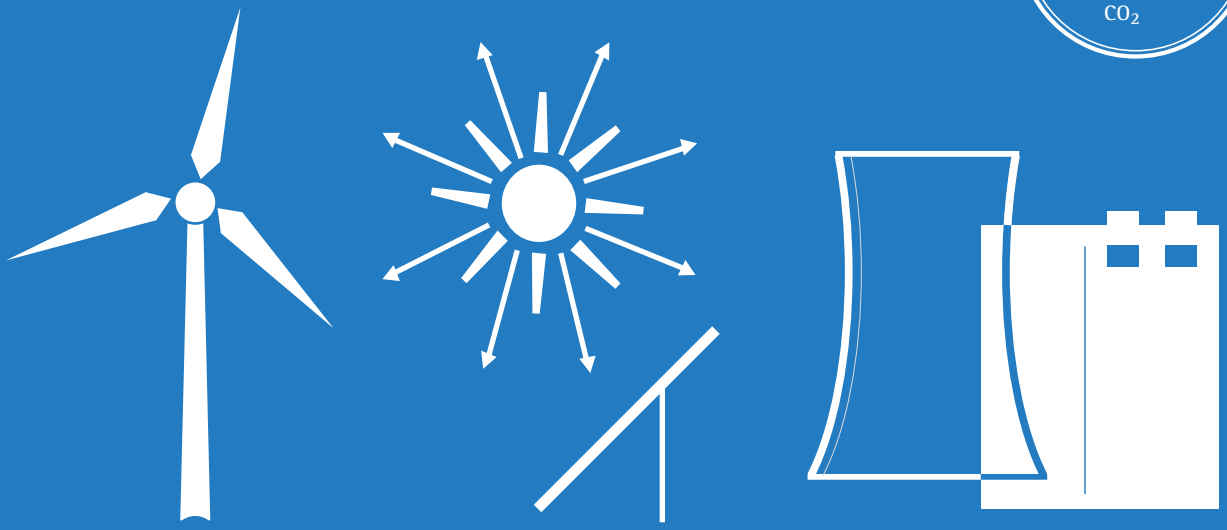
* 2009 data for non-OECD countries - Source: IEA and own calculations

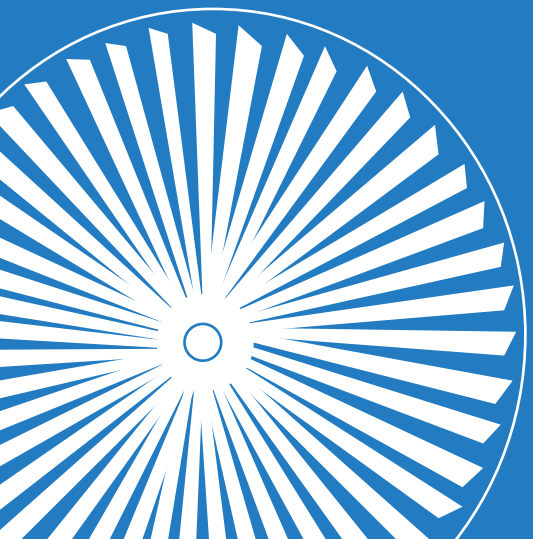
	Hard coal	Lignite	
South Africa*			94%
Poland	57%	31%	88%
China*			79%
Australia	53%	23%	76%
Kazakhstan*			75%
Serbia*			72%
India*	67%	2%	69%
Czech Republic	7%	52%	59%
Israel			58%
Taiwan*	50%	5%	55%
Bulgaria*	14%	36%	50%
USA	44%	2%	46%
Greece			45%
Germany	20%	24%	44%
World	37%	4%	**41%**

11. NEXT STEPS

→ EURACOAL's aim is to stimulate a pragmatic discussion on coal.







11. NEXT STEPS

EURACOAL calls for a pragmatic approach to the climate change challenge: take the steps that we know are possible NOW to renew and replace old power plants, develop options for the future, and prepare for that future by planning a new infrastructure to carry CO_2 away from large industrial sites and to safely store it underground. Unless the EU can show that wealth creation, climate protection and energy security can co-exist, then the rest of the world will remain sceptical about the EU's progressive climate and energy policies. EURACOAL's three-step strategy allows the EU to show leadership based on a pragmatic response to the challenges we face.

12. REFERENCES

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For more information about coal and this clean coal strategy, please contact:

EURACOAL — European Association for Coal and Lignite AISBL
Avenue de Tervueren 168 Bte 11 — B-1150 Bruxelles

Phone: +32 2 775 31 70
E-Mail: euracoal@euracoal.org
www.euracoal.org

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A STRATEGY FOR CLEAN COAL

Coal – the world's most abundant fossil fuel – is secure and competitively priced. It offers price stability, especially for power generation. Today, the use of coal is growing faster than any other energy source, nowhere more so than in developing countries. In the EU, most of our electricity comes from coal: locally mined coal and lignite, plus imported coal from many countries. Coal mining in the EU cushions our growing dependence on imported fuels, provides 220 000 jobs and generates much-needed wealth by supplying fuel worth € 27 billion annually. Looking to the future, coal will remain indispensable as global energy demand rises. In response, the EU must show leadership in the sustainable use of coal and EURACOAL proposes here a three-step strategy.

A CLEAN COAL STRATEGY – THREE STEPS TO A SUSTAINABLE FUTURE:

1. Introduce state-of-the-art technology across the EU coal-fired generation sector to boost efficiency and reduce emissions.
2. Develop the next generation of high-efficiency flexible technologies for coal-fired electricity generation.
3. Demonstrate and deploy CO_2 capture and storage at coal-fired power stations around the world.

EFFICIENT CLEAN COAL – MORE ELECTRICITY FROM LESS COAL:

- CO_2 emissions are lowered by up to 40%.
- Less coal is needed to produce each unit of electricity.
- A single power station can meet the needs of more people.
- Coal reserves will last longer.

FLEXIBLE CLEAN COAL – COMPLEMENTING RENEWABLES:

- Whatever the weather, coal-fired power is there to keep the lights on 24/7.
- Flexible coal-fired power plants provide essential grid services and backup capacities for renewables: "clean coal" is also "smart coal".

CO_2 CAPTURE AND STORAGE – TOMORROW'S TECHNOLOGY PROVEN TODAY:

- The technologies to capture and store CO_2 are proven at large scale.
- Demonstration at coal- and gas-fired power plants is the next step.
- CCS will cap carbon prices at affordable levels.
- CCS is a "must have" if the rise of global CO_2 emissions is to be stopped.

NEXT STEPS FOR POLICY MAKERS:

- have belief in markets, not dirigiste central planning;
- encourage what is possible today – power plant modernisation and renewal;
- prepare for what will be possible tomorrow – R&D;
- plan for the day after tomorrow – the deployment of CO_2 capture and storage;
- set clear long-term targets and refrain from making short-term interventions; and
- invest in CO_2 transport infrastructure so that CCS can deliver its potential.

A PRAGMATIC 3-STEP STRATEGY FOR A CLEANER MORE PROSPEROUS FUTURE

SECURE
COMPETITIVE
ABUNDANT
FLEXIBLE

DAY AFTER TOMORROW

CO_2 capture & storage demonstration
Public CO_2 infrastructure

TOMORROW

R&D for high efficiency & flexibility

TODAY

Replace old power plants
with new plants