# Other EU Member States and Energy Community stakeholders

#### Figure 1

EU-28 Member States and Energy Community stakeholders



#### Source: Energy Community

\*\* the 16 EU member states shown in bold on the map hold participant status

Earlier chapters have reported on the key coal-producing countries of the EU and its neighbours. This chapter examines the other EU member states that all use coal to a greater or lesser extent. Also included, because of their alignment towards EU energy policy, are the contracting parties and observers to the Energy Community.

The 2005 treaty establishing the Energy Community requires contracting parties to implement important parts of the EU *acquis* on energy markets and the environment. It provides for the creation of a single energy market and a mechanism for the operation of networks in the South

### Austria

Austria has limited primary energy resources and is dependent on energy imports for over two thirds of its primary energy East European region which disintegrated following the conflicts of the 1990s. In 2011, the contracting parties agreed to implement the EU's third internal energy package by January 2015, although parties are not obliged to join the EU emissions trading scheme.

The Energy Community offers opportunities to owners of coal-fired power plants in South East Europe who will gain access to what should soon become the world's largest electricity market. At the same time, plant owners will be required to make very substantial investments in pollution control equipment to meet stringent EU emissions legislation.

supply. Although no longer exploited, lignite resources total 333 million tonnes, lying mainly in western Styria near Graz.

During the Monarchy, Austrian energy demand was largely met by coal from Moravia and Silesia, although coal mining in Austria began during the second half of the 18th century. After each World War, hard coal and lignite mining in Austria was expanded to replace production lost elsewhere; lignite output peaked at over 6 million tonnes in 1963 when hard coal output was 100 thousand tonnes. However, with the re-opening of borders and resumption of trade, as well as the general trend towards greater oil and natural gas use and the development of hydro power, Austria's underground hard coal mines became less competitive and were closed during the 1960s. By 1991, lignite production had fallen to 2 million tonnes, this being a rather small component of energy supply. After more than two centuries of mining activity, Austrian coal production definitively ended in 2006 with the recultivation of Oberdorf lignite mine.

Today, the steel industry and the power industry each consume around 2 million tonnes per year of mainly Czech, Polish, US and Russian coal. The integrated steel works operated by VOESTALPINE AG at Linz has an annual crude steel production capacity of 6 million tonnes. At the 757 MW Dürnrohr power plant in Lower Austria, one unit is owned by VERBUND and the other by EVN. Small quantities of hard coal are consumed by the cement and paper industries.

In 2011, EVN and AE&E installed a  $CO_2$  capture pilot plant at Dürnrohr. The clean  $CO_2$  is sold to the industrial gas industry and is also used in innovative  $CO_2$  conversion processes that are at the experimental stage.

### Baltic States

The neighbouring states of Estonia, Latvia and Lithuania lie between the Baltic Sea and Russia. In 2004, these former Soviet states joined the EU and, in 2011, Estonia joined the euro area. To their south, the Russian enclave of Kaliningrad Oblast borders Lithuania and Poland.

Whilst no coal is produced in the Baltic States, all three countries consume modest volumes of imported coal, mainly from Russia. More significantly, Estonia, Latvia and Lithuania offer alternative transit routes for Russian coal exporters, since ice can hinder exports from Russia's Baltic ports at Vyborg, St. Petersburg and Ust-Luga.

Some Russian coal is shipped through Tallinn port in Estonia. Latvia's major ports – Riga, Ventspils and Liepāja – are likely to grow in importance with a planned high-speed upgrade to the 922-km rail link between Moscow and Riga. Lithuanian ports, notably Klaipėda, can also ship Russian coal, although none was handled in 2012. However, Klaipėda State Seaport is strategically important, because it is the northernmost ice-free port on the eastern coast of the Baltic Sea and has good infrastructure links to Russia.

The Kaliningrad enclave is dependent on imported fuel and power from Russia, although power is also locally produced from hydro, gas and wind. In February 2012, construction work began at a new 2 400 MW nuclear power plant (NPP), but was stopped in June 2013 because of financing, offtake and political problems. When operational, the Baltic NPP would be able to export electricity to the EU. However, the intention is to desynchronise the Baltic States from the Russian IPS/UPS network, leaving Kaliningrad isolated unless DC links are built or the enclave joins the ENTSO system. The closure of Ignalina NPP in Lithuania at the end of 2009 left a power vacuum in the Baltic region. This could have been filled by the proposed Visaginas NPP, but a consultative referendum in October 2012 saw Lithuanians vote against this project. Meanwhile, the first unit at the 2 400 MW Astravyets NPP is also under construction in Belarus. If all NPP projects move to completion, the region will become a significant exporter of electricity.

For its energy supply, Estonia is uniquely dependent on indigenous oil shale. Large quantities are used to generate competitively priced electricity at thermal power plants where it is used in much the same way as coal – either as a pulverised fuel in older boilers or in new circulating fluidised beds (CFBs).

Oil shale is a sedimentary rock containing up to 50% organic matter – Estonian oil shale extracted from the Baltic kukersite basin has a heating value of 8-11 MJ/kg and 1.5-1.8% sulphur content. Once extracted from the ground, the rock can be either used directly as a fuel in power plants or processed into petroleum products. EESTI ENERGIA and privately owned VKG and KIVIÕLI KEEMIATÖÖSTUS process oil shale into mainly heavy fractions such as bunker fuel. EESTI ENERGIA's new Enerfit280 plant produced its first oil in December 2012 and the private companies also have new projects; when fully operational, these will increase Estonia's oil production capacity from the current 20 000 bbl/day. Looking ahead, Estonia is exploring whether to build a refinery to produce lighter transport fuels from shale oil.

Although oil shale deposits are found in fourteen EU member states, only Estonia has any exploitation experience. Its oil shale industry is the most developed in the world, and accounts for 4% of Estonian GDP and about 1% of national employment (over 7 700 people). In 2012, 18.8 million tonnes of oil shale were mined from reserves that total 1-2 billion tonnes. The VKG Ojamaa oil shale mine was opened in February 2013, the first new mine in 40 years, whilst EESTI ENERGIA plans to open a new underground mine at Uus-Kiviõli, having closed the exhausted Viru mine in June 2013, and is developing large integrated projects in Jordan and Utah, USA.

In 2012, Estonia generated 85% of its electricity supply from oil shale, a share that is expected to decrease in the future in line with government policy. Almost 80% of oil shale production is used for electricity generation, notably at the EESTI ENERGIA Narva energy complex, comprising the 1 615 MW Eesti power plant and the 765 MW Balti power plant which also supplies heat to the town of Narva. In January 2011, a contract to add two 300 MW units was signed with ALSTOM; completion of the first unit of the

#### Figure 2

"Room and pillar" oil shale mine in north-east Estonia



EESTI ENERGIA operates one underground and one opencast mine as well as a rail transport division

Port (north to south)	million tonnes
Vyborg (Vysotsk), Russia	3.30
St. Petersburg, Russia	0.00
Ust-Luga, Russia	15.72
Tallinn (Muuga), Estonia	0.04
Riga, Latvia	14.90
Ventspils, Latvia	7.87
Liepāja, Latvia	0.28
Klaipėda, Lithuania	0.00
Kaliningrad, Russia	0.14

#### Russian seaborne Baltic coal trade (including coke), 2012

Source: Klaipėda State Seaport Authority

Auvere power plant is scheduled for 2015. State-owned EESTI ENERGIA has enough generation capacity to cover all of Estonia's electricity needs, helping to ensure the country's energy security.

The Estonian electricity market became fully liberalised in January 2013. Electricity is traded with other Baltic States and with the Nordic power market via the 350 MW HVDC Estlink 1 undersea cable to Finland. The 650 MW Estlink 2 is being laid and will open in 2014. By 2016, the NordBalt project linking Lithuania and Sweden will further strengthen the Baltic Ring that connects the electricity grids and markets of the Baltic and Nordic States, bringing greater competition and opportunities for the most efficient power producers.

The environmental issues associated with oil shale exploitation are complex. With 45% incombustibles, ash can occupy 25% more volume than the original shale which does not collapse when burnt. Under the accession treaty agreed when Estonia joined the EU in 2004, oil shale has certain temporary derogations. To meet EU directives on emissions to air, all old pulverised-fuel boilers must be closed or upgraded by the end of 2015. Balti 11 and Eesti 8 have already been repowered with CFB boilers and a further four units have been fitted with ALSTOM's novel integrated desulphurisation, supplemented with lime injection.

# Belgium

In the 19th century, the Walloon coal mines of southern Belgium made a major contribution to the industrial expansion of the country. Coal mining started in the north-east of the country in 1917, around Limburg where the geological conditions were favourable. Between 1952 and 1953, national coal production peaked at 30 million tonnes and was maintained at this level until the late 1950s, after which output gradually declined as the Walloon mines closed. Closure of the Limburg mines followed twenty years later, with Belgium's last colliery at Heusden-Zolder ceasing production in 1992. Although not currently economic to exploit, remaining hard coal resources are estimated to be 4 100 million tonnes.

Imported coal remains an important energy source for the steel industry and for power generation. Consumption of imported coal in 2012 totalled 3.5 million tonnes, coming mainly from the USA, Australia and Russia (more coal is imported into Antwerp for onward delivery to customers in other EU countries). Coal provides 5% of Belgium's primary energy supply.

Power generation in 2012 totalled 77.3 TWh: 52% from nuclear power stations, 27% from gas-fired power plants and 7.1% from coal-fired plants E.ON Langerlo (556 MW) and ELECTRABEL Ruien (290 MW) which finally closed at the end of August 2013. Other coal-fired plants consumed biomass. Renewables grew to 12%. Belgium's largest power utility, ELECTRABEL – a subsidiary of GDF SUEZ, has further investments in coal-fired power plants in the Netherlands.

Coal imports are expected to decline with the closure of DUFERCO's Carsid blast furnace in 2013 – ARCELORMITTAL announced the permanent closure of its last blast furnaces at Liège back in 2011. Whilst the Belgian steel industry will continue to consume smaller volumes of coal, a highly political situation developed in 2013 with the fall in global steel demand and competition from Chinese steel exports leading to the potential for further job losses at ARCELORMITTAL.

#### Cyprus

Cyprus imported 13 thousand tonnes of hard coal in 2012 for use mainly in the cement industry. With the memorandum of understanding signed by Cyprus,

# Denmark

With the rise in oil and gas production from the North Sea, Denmark became energy self-sufficient in 1999 and is today the only EU member state producing more energy than it consumes. The country is the third largest oil producer in Western Europe, after Norway and the UK. However, oil and gas production are in decline. Gas production in 2012 was 5.6 billion cubic metres – less than half of its 2005 peak – placing Denmark in fourth place behind the largest North Sea producers: Norway (115 bcm), the Netherlands (64 bcm) and the UK (41 bcm).

Danish energy production has changed significantly as a result of political efforts to promote the use of renewable energy, combined heat and power (CHP) and energy efficiency. The Energy Strategy 2050, published in 2011, aims at 100% renewable sources in the energy and transport sectors by 2050. It was given a boost in March 2012 when broad political support was reached on a new Energy Agreement which outlines how renewables will be subsidised to 2020. In 2012, renewable energy (excluding renewable electricity imports) accounted for 27% of total energy consumption, mainly from biofuels and waste, but also from a steadily growing wind capacity which provided 34% of electricity generation.

The relatively high use of wind for electricity generation enhances supply security, but also poses balancing challenges. As a part of the integrated Nordic electricity market, Denmark's coal-fired generation plays an important role in balancing not only wind power, but also hydro power from Norway and Sweden which depends on annual Greece and Israel in August 2013 and its new offshore gas exploration, Cyprus is set to become a link between Europe and Asia for electricity transmission and gas supply.

precipitation. High reservoir levels at the beginning of 2012 were the result of record inflows in 2011 and Denmark electricity imports soared such that its domestic electricity generation fell by 23% between 2010 and 2012.

In 2012, 35% of Danish electricity generation came from coal-fired power plants at Amager (319 MW), Asnæs (1 057 MW), Avedøre (810 MW), Ensted (626 MW), Esbjerg (378 MW), Fyn (409 MW), Nordjylland (660 MW), Randers (52 MW), Stigsnæs (409 MW) and Studstrup (700 MW), having a total capacity of 5.4 GW. With the exception of Randers, the plants are owned by DONG ENERGY and VATTENFALL, both majority state-owned. Some co-fire coal with biomass and many are CHP plants with connections to district heating systems, including Nordjyllandsværket 3 which is one of the world's most efficient coal-fired power plants. Its "supercritical" boilers and steam turbines result in a very high electrical generation efficiency of 47% and, with the supply of heat, the overall efficiency can exceed 95%. Under the Energy Agreement, some of the larger coal-fired CHP plants will be converted to fire 100% biomass, mainly wood pellets.

Denmark has no indigenous coal resources. In 2012, the country imported 3.9 million tonnes of coal, mainly from Colombia, Russia and South Africa. Over 95% of this coal is used for electricity and heat generation, including district heating. Having peaked in 1984 at 96%, the share of electricity produced from coal has fallen and the Danish government expects this decrease to continue: to 27% in 2020 and 15% in 2030.

## Finland

Finland is very dependent on foreign energy supplies, as the country lacks its own oil, natural gas or coal reserves. Around half of the energy consumed in Finland is imported. This fact has dictated and will continue to dictate Finland's energy policy: the energy mix must be as diversified as possible. One third of electricity production is from nuclear plants and Finland's fifth nuclear reactor, a 1 600 MW EPR, is under construction at Olkiluoto, with more reactors planned. Around 4 million tonnes of locally produced peat are consumed each year for its energy value. Peat is used at dedicated district heating plants and at combined heat and power (CHP) plants, the latter accounting for 6% of total electricity supply in 2012.

Finland is one of the world's leaders in renewable energy, especially bio-energy. Renewable energy meets over one quarter of Finland's total energy consumption and accounted for 40% of its power generation in 2012. Nevertheless, coal and natural gas are the main fuels for CHP plants in Finland. For conventional thermal power generation, coal is the leading source of energy. In 2012, the share of coal in electricity production was 11% (70 TWh total) and 25% in district heating (58 TWh total). The efficiency of heat and power production in Finland is very high compared with most other countries. Approximately one third of electricity is produced at CHP plants which operate with overall efficiencies of 80% to 90%. These plants are used widely by industry and for district heating and cooling.

Annual coal consumption in Finland is fairly stable at about 6 million tonnes: 5 million tonnes of steam coal for energy production and 1 million tonnes of coking coal for the steel industry. Smaller quantities of coal are used by the cement industry. All coal is imported, steam coal mainly from Russia and coking coal from North America and Australia.

The EU's role in domestic energy policy has increased in recent years. The core framework for Finnish energy policy comes from the Union's energy and climate policy, notably the 20-20-20 targets. Finland must implement integrated energy and climate policy measures, in particular energy efficiency and energy savings measures, and increase the share of renewable energy to 38% by 2020, which is fairly challenging.

In the future, energy sources for electricity production should continue to be diversified and versatile, thanks to the flexibility and variety of CHP plants. As well as the increased share of renewable energy, the objectives of the national energy and climate strategy are to maintain the position of peat as an indigenous energy resource, but to diminish the share of fossil fuels, in particular coal. Therefore, the construction of new coal-fired capacity is very unlikely, except where coal is co-fired with biomass or used in multi-fuel boilers.

### France

Hard coal mining in France ended in April 2004 with the closure of the last operational mine, La Houve in the Lorraine region. The state-owned coal company Charbonnages de France ceased its activities at the end of 2007. Today, all coal is imported, with the exception of small quantities recovered from spoil tips in Northern France and slurry ponds in Lorraine – an estimated 100 thousand tonnes in 2012.

Coal resources in France are estimated by the French geological survey (BRGM) to be 425 million tonnes of hard coal plus an additional 300 million tonnes of lignite. Despite various proposals, there has been, to date, no successful project to revive coal mining in France.

In 2012, coal imports amounted to 17.0 million tonnes, including one million tonnes of coking coal. The main coal suppliers were the USA (24%), Australia (20%), Colombia (19%), Russia (15%) and South Africa (11%). Coal is delivered through the ports of Dunkerque, Le Havre, Rouen, Montoir and Fos-sur-Mer, as well as via the ARA ports.

The Service de l'observation et des statistiques reports that gross power generation in France was 561 TWh in 2012, with 75.8% of this total generated at nuclear power plants. Thermal electricity production contributed 9.6%, hydro 11.2%, wind 2.7% and solar PV 0.7%. Coal-fired generation accounted for 3.3% of the total, while the share of renewables reached 14.6%.

Coal consumption amounted to 15.9 million tonnes in 2012 of which 7.1 million tonnes was consumed at power plants. The largest plants are located at Le Havre (1 450 MW) and Cordemais (1 200 MW), both owned by EDF adjacent to ports, and Emile-Huchet (1 045 MW) owned by E.ON in Lorraine. In compliance with the Large Combustion Plants Directive (LCPD), two of Le Havre's three units will close by 2014. The remaining unit 4 is expected to operate until 2035 and, with a view to the future, EDF commissioned a pilot-scale  $CO_2$  capture plant at Le Havre in 2012. The company owns four smaller coal-fired plants: Blénod (500 MW), Bouchain (250 MW) and La Maxe (500 MW)

which it plans to close by 2015. Similarly, E.ON plans to close the four oldest units at its French coal-fired power plants (235 MW Hornaing 3, 245 MW Lucy 3 and Emile Huchet 4 and 5) between 2013 and 2015, as required by the LCPD, while the 230 MW Provence 4 will be converted to biomass, leaving the 595 MW unit 5 on coal.

The French steel industry consumes important but declining volumes of coal – 5.6 million tonnes of

coking and steam coal in 2012. ARCELORMITTAL plants at Dunkerque, Florange and Fos-sur-Mer are the biggest coal consumers in this sector. However, the company created a political controversy in 2013 when it announced the closure of Florange because of sluggish demand in the major steel consuming sectors (construction and automotive).

#### Georgia

Lying in the Caucasus region between Europe and Asia, Georgia has proven hard coal reserves of 201 million tonnes plus resources of 700 million tonnes in the Tkibuli-Shaori and Tkvarcheli deposits. The Akhaltsikhe lignite deposit near Vale has reserves of 76 million tonnes. These deposits supported a major coal industry during the 1950s to 1970s supplying power stations at Rustavi, Kutaisi, Tkvarcheli and Gardabani, the metallurgical industry (Rustavi iron and steel works and Zestafoni ferroalloys works) and residential customers. Production peaked at 3 million tonnes in 1958. By 2000, coal production had collapsed to almost zero. Today, following the "Rose Revolution" of 2003 and conflict with Russia in 2008, the coal industry is being revitalised.

In 2011, 77% of Georgia's electricity production of 10.2 TWh came from hydro plants. The balance was produced at gas-fired plants, using imported gas from Russia. Greater political stability has seen new investment in hydro plants and electricity transmission, including the commissioning of a 700 MW DC link with Turkey in 2013 – part of the bigger "power bridge" project with Azerbaijan which will facilitate electricity exports to the EU.

Today, the Dzidziguri and Mindeli underground coal mines (up to 1 200 m deep) are operated by SAQNAKHSHIRI (GIG Group) LLC in the Tkibuli-Shaori coalfield, supplying cement works at Kaspi and Rustavi and the ferroalloy industry. The company produced 258 thousand tonnes of coal in 2012 and employed 1 600 workers. In the breakaway republic of Abkhazia, TAMSASH produces coking coal from an opencast mine in the Tkvarcheli coalfield. Although no coal is used for electricity production, there is some political support for a new 300 MW coal-fired power plant at Tkibuli and a 160 MW lignite-fired plant at Gardabani, both promoted by GEORGIAN INTERNATIONAL ENERGY CORP.

#### Ireland

The Republic of Ireland has no indigenous coal production, although 1.5 million tonnes of peat were extracted in 2012 for energy use. Coal imports totalled 2.2 million tonnes in 2012, mainly from Colombia, but with small volumes from Poland and the USA. Coal and peat have taken a declining share of the Irish industrial and residential markets, but together still accounted for 20% of primary energy supply in 2012 – used mainly for power generation.

BORD NA MÓNA is the leading peat producer and distributes solid fuel products within the residential heating market in Ireland. The company's peat briquettes are popular due to their low sulphur emissions and competitive price.

Since 2001, peat-fired electricity plants have been supported by a public service obligation as they contribute

to security of supply through the use of indigenous fuels. However, this support will expire over the coming years: 2015 in the case of Edenderry power plant and 2019 in the case of West Offaly and Lough Ree. In addition, the government has set biomass dilution targets for peat used as a fuel. Taken together, these developments will further reduce the demand for peat. In 2012, 10% of Irish electricity was generated at peat-fired power plants.

The main user of coal is the 915 MW coal-fired power plant at Moneypoint. Commissioned in 1987, it is owned and operated by the ELECTRICITY SUPPLY BOARD (ESB) which recently invested €368 million in pollution control equipment to meet EU regulations on NO<sub>x</sub> and SO<sub>x</sub>. In 2012, the plant met 20% of the country's electricity demand and consumed an estimated 1.9 million tonnes of coal.

In 2012, Ireland imported 92% of its natural gas needs. Given that 50% of the country's electricity generation is gas-fired, this points to a high security of supply risk since all imports must flow through a single transit point at Moffat in Scotland. According to a government White Paper

#### Italy .

The only coal reserves and resources in Italy are located in the Sulcis Iglesiente basin, in south-west Sardinia, estimated to be 610 million tonnes. Mining activities were stopped there in 1972, but restarted in 1997 with many environmental improvements. Currently, CARBOSULCIS, owned by the Autonomous Government of Sardinia, is struggling to survive and production fell in 2012 to an estimated 80 thousand tonnes.

Imported coal plays a small but growing role in the Italian energy sector. In 2012, 9.8% of Italy's primary energy supply was provided by coal, 90% of which was consumed for power generation. It is expected that the share of coal in electricity production will continue to grow from the 16% share in 2012. Following a heavily subsidised investment boom in wind and solar PV, new renewables accounted for a 16% share in 2012. Hydro produced 14%.

With a share of 46%, Italy is one of the most dependant countries in the EU on natural gas for electricity production. Moreover, it has an overall energy import dependence of over 80% - far exceeding the EU average of 54%. This situation, which makes Italy heavily dependent on Algerian and Russian gas imports, will continue in the years to come and will have a significant impact on Italy's security of energy supply and electricity costs. It is therefore perhaps not surprising that in 2012 Italy's energy bill hit a new record of €65 billion or 4.2% of GDP, compared to an average figure of 1.5% during the 1990s. High electricity costs are having a negative impact on industrial competitiveness: in 2012, Italian industry paid 23.29 €c/kWh compared with an EU average of 14.66 €c/kWh. Only Denmark with its expensive wind energy and Cyprus with its dependence on fuel oil for power generation have higher electricity rates than Italy.

In a decisive June 2011 referendum, Italian voters rejected government proposals to restart a nuclear programme that was abandoned following an earlier referendum held after the 1986 Chernobyl disaster. The government responded with the National Energy Strategy. Approved in March 2013, the strategy places great emphasis on renewable energy sources and the greater use of natural gas for power generation – both of which would further increase the cost of electricity in Italy. "Delivering a Sustainable Energy Future for Ireland" which outlines an energy policy framework for 2007-2020, the increased market penetration of renewable energy sources in the electricity, heat and transport sectors will displace fossil fuels and improve energy security.

In 2012, Italy imported 19.8 million tonnes of steam coal and 4.6 million tonnes of coking coal. Since the year 2000, steam coal imports have grown by over 4% per annum. The main supply countries are the USA, Indonesia, South Africa, Colombia and Australia. ENEL has a 10% shareholding in PT BAYAN RESOURCES of Indonesia which produced 16.3 million tonnes of coal in 2012. Italy has thirteen coal-fired power plants with a total capacity of 11.2 GW. Of these, nine are built with the very latest technologies, reaching an average 39% efficiency – 46% in the case of ENEL's Torrevaldaliga Nord which went into full operation in 2011 following its conversion from oil-firing. With more conversions planned, steam coal imports should reach 25-26 million tonnes over the coming years.

A key new project is ENEL's 1 980 MW oil-to-coal conversion at the Porto Tolle power plant on the Adriatic coast. It will have an efficiency of 45% - halving CO<sub>2</sub> emissions - and use new clean coal technologies to reduce sulphur dioxide,  $NO_x$  and dust emissions by 70% to 80%. The company has well-developed plans to capture and store the CO<sub>2</sub> from one of the plant's three units in an offshore saline aquifer. Porto Tolle's authorisation has suffered legal delays, but the conversion can go ahead as soon as permission is granted. In addition, TIRRENO POWER has been granted authorisation to build a new 460 MW coal-fired unit at the Vado Ligure power plant in the province of Savona. This unit will also have a very high efficiency of 47%. Other coal-fired projects that have been submitted for permitting include Saline Joniche, a 1 320 MW coal/biomass-fired plant proposed by SEI in the province of Calabria.

Recent years have seen significant developments in CCS technologies in Italy at various scales, from pilot to demonstration. At the 2 640 MW Federico II power plant near Brindisi, a 50 MW pilot plant was inaugurated in March 2011 and other R&D projects, such as an oxy-combustion experimental plant at Gioia del Colle, are adding to the knowledge base. Separately, coal gasification at the proposed Sulcis power plant could offer another route for  $CO_2$  capture.

#### Luxembourg

In 1952, when its prosperity was based on steelmaking, the Grand Duchy of Luxembourg was chosen as the site of the European Coal and Steel Community (ECSC), marking the start of the institutional development that led to the European Union.

Luxembourg is almost entirely dependent on imports for its energy needs. At 97%, it has an energy import dependence second only to Malta among the EU member states. Hence, the government aims to develop the national potential for energy production and conversion. For example, the gas-fired Twinerg CCGT power plant at Esch-sur-Alzette has

#### Malta

Malta has no indigenous energy production and reports no coal consumption. Until 1995, coal was imported for power generation. Today, the Delimara and Marsa power stations, with a combined capacity of 571 MW, burn imported fuel oil in steam boilers/turbines and diesel engines, as well as distillate fuel in gas turbines. In 2013, the utility company ENEMALTA announced a competitive bidding process to build a LNG terminal to import fuel for a new 200 MW gas-fired CCGT, as well as refuelling some existing plants.

increased the country's electricity production since it opened in 2002, but at the expense of a sharp rise in  $CO_2$  emissions. The country has the highest  $CO_2$  emissions per capita of all the OECD countries (20 tCO<sub>2</sub>/capita).

The steel industry's conversion to electric-arc furnaces (ARCELORMITTAL steel works at Belval, Differdange and Schifflange) has practically eliminated Luxembourg's coal use. Coal is used today mainly for the production of cement at the CIMALUX Rumelange plant. All coal is imported – 82 thousand tonnes in 2012 – and makes only a small contribution to the country's primary energy supply.

An alternative proposal for Delimara comes from SARGAS AS: a new 360 MW power plant with a fluidised-bed boiler burning bio-paste (coal and biomass). Around 95% of the plant's  $CO_2$  emissions – 0.7 million tonnes per annum – would be captured using a post-combustion process.  $CO_2$  could be transported by ship for enhanced oil recovery or urea production.

### Moldova

The Republic of Moldova does not produce coal or lignite. It imports small quantities of hard coal for use by industry and in heating plants – 155 thousand tonnes was consumed in 2012. The 2 520 MW Kuchurgan power station, in the breakaway region of Transnistria on the Ukrainian border, can be fuelled by coal (8 units) and natural gas or fuel oil (2 units). In 1990, over 4 million tonnes of coal were consumed there, but since the late 1990s the station has used virtually no coal. Although the Moldovan electricity grid is synchronised with Russia's (IPS/UPS), some units at Kuchurgan could be synchronised with Continental Europe to allow exports of electricity via Romania. Owned by CJSC MOLDAVSKAYA GRES, a subsidiary of INTER RAO UES, the plant is in need of refurbishment.

# The Netherlands

Hard coal mining dominated the South Limburg area of the Netherlands from the early 1900s to the mid-1970s. The coalfield, located in the south of the country close to the German and Belgian borders, was mainly exploited from underground mines.

Since around 1915, lignite was extracted at opencast mines near the towns of Eygelshoven and Hoensbroek. These deposits were located on the north-west fringe of the large German lignite basin to the west of Cologne. Lignite mining ceased in 1968 with the closure of the Carisborg site.

The Netherlands is home to the main trans-loading ports for coal imports into Europe. Rotterdam and Amsterdam ports, along with Antwerp in Belgium, constitute the ARA trading area – the most important for imported coking coal and steam coal in north-west Europe.

Just over 10% of the Netherlands' primary energy demand is met by coal. In 2012, the country imported 12.4 million

tonnes, comprising 9 million tonnes of steam coal, 2.5 million tonnes of coking coal and 1 million tonnes of PCI coal. The main supplier countries were Colombia, the USA and Russia.

Most imported coal is used for coal-fired power generation. Coal had a 27% share of the Dutch power generation market, which totalled 102 TWh in 2012, and a smaller share of the heat supply market. Large coal-fired plants are located at Geertruidenberg (Amer 1 245 MW), Borssele (426 MW), Nijmegen (Gelderland 635 MW), Amsterdam (Hemweg 630 MW) and Rotterdam (Maasvlakte 1 040 MW). All these plants co-fire coal with biomass, to a greater or lesser extent. Ownership is very diverse, with ESSENT (a subsidiary of RWE), ELECTRABEL (a subsidiary of GDF-SUEZ), E.ON, EPZ and NUON (a subsidiary of VATTENFALL) being the major players in coal-fired generation. The 253 MW Buggenum plant - one of the world's few integrated coal gasification combined cycle (IGCC) plants - was closed in 2013 by its owner NUON.

TATA STEEL owns the IJmuiden integrated steel works which has a steel production capacity of 7.6 million tonnes and consumes most of the coking and PCI coal imported by the Netherlands. A pilot project at IJmuiden

# Norway

Norway, Europe's northernmost country, opted to stay out of the EU by referendum in 1994, but is a significant supplier to the EU of coal, oil and natural gas. In 2011, 27% of EU gas imports came from Norway, the world's second largest gas exporter after Russia. In April 2010, Norway and Russia signed an historic agreement dividing the Barents Sea and defining maritime boundaries that clear the way for future oil and gas exploitation.

In 2012, Norway consumed 796 thousand tonnes of mainly imported coal and imported 0.4 million tonnes of coke for use in the metallurgical industry, chemicals production and cement manufacture.

Coal mining on Spitsbergen, the largest and only permanently populated island of the Svalbard archipelago, serves multiple government goals, not all related to energy. Without continued peaceful economic activity on Spitsbergen, Norwegian sovereignty might be weakened by foreign economic activity since the Svalbard Treaty of 1920 grants rights to all 39 signatories. To this end, the state-owned STORE NORSKE SPITSBERGEN KULKOMPANI (SNSK) operates the most northerly coal to demonstrate a new iron-making process, called Hisarna, aims to reduce CO<sub>2</sub> emissions from steelmaking.

In the power sector, the Netherlands has a progressive policy on coal and the government has supported CCS demonstration projects. As a result, three large ultra-supercritical coal-fired power plants are now being built. In the north, at Eemsmond near Groningen, RWE/ESSENT's 1 600 MW coal- and biomass-fired Eemshaven power plant is under construction with commissioning scheduled for 2014. A planned CCS project at Eemshaven was submitted, through the Dutch authorities, for EU funding from the New Entrants' Reserve 300 under the EU Emissions Trading Scheme. However, like many other CCS projects in the EU, progress has stalled.

In the Rotterdam area, two new coal-fired power plants are under construction and will be commissioned in 2013/2014: ELECTRABEL's Maasvlakte plant (800 MW) and E.ON's MPP3 (1 100 MW). Both include preparatory work for CCS. Trials of  $CO_2$  storage in North Sea oil and gas fields will be undertaken as part of the ROAD project (Rotterdam Opslag en Afvang Demonstratieproject) whilst the CINTRA consortium has proposed a  $CO_2$  hub with ship transport of  $CO_2$  to offshore operations for enhanced oil recovery.

mines in the world with 300 employees: the Svea Nord longwall mine and the Gruve 7 room-and-pillar operation.

Annual production over the last decade has averaged 2.4 million tonnes, but reserves are close to exhaustion at Svea Nord and production fell to 1.2 million tonnes in 2012. Coal is sold on the international market with Germany being the largest customer; however, SNSK cannot provide a year-round supply of coal because the sea port at Sveagruva is frozen for much of the year. Spitsbergen's 10 MW coal-fired combined heat and power plant takes coal from Gruve 7.

At the end of 2011, SNSK gained approvals from the Norwegian government to open a new longwall mine at Lunckefjell. The mine boasts probable reserves of bituminous coal totalling 8.4 million tonnes, 60% of which is expected to be suitable for metallurgical purposes (PCI). Construction began in March 2012 and first output is scheduled for 2015 by which time production from Svea Nord will have ceased, although its coal transport infrastructure will serve Lunckefjell mine until production ends there in 2019. SNSK and its subsidiaries have located coal and mineral deposits in large parts of Svalbard. Its concessions not in operation are held in reserve for future operations. Under the company's long-term plan to 2028, annual coal production will be between 1.5 and 2 million tonnes.

Political guidance for SNSK's operations is laid down in a government White Paper (No. 22 to the Storting, 2008-2009), establishing that SNSK and its coal mining operations are – and will remain – important for maintaining a Norwegian community in Longyearbyen on Spitsbergen.

#### Portugal

Portugal has limited indigenous energy resources, leading to 78% energy import dependence in 2012. Its last coal mine, Germunde in the Castelo de Paiva region, was closed in 1994, leaving behind reserves of 3 million tonnes. The country also has some lignite deposits: reserves and resources total 66 million tonnes.

In 2012, 42% of Portugal's electricity production came from renewable energy sources: wind, hydro, solar PV, geothermal and wave. Nevertheless, coal-fired electricity generation remains crucial to cover those periods when wind and solar are not available and to balance the annual variation in hydro electricity production on the Iberian Peninsula. Imported coal accounted for 13% of total primary energy supply in 2012 with 5.2 million tonnes coming mainly from Colombia and the USA, but also from South Africa. This is almost entirely consumed at Portugal's two coal-fired power plants located at Sines (1 180 MW) and Pego (628 MW) which together produced 29% of the country's electricity in 2012. Both are fitted with flue gas desulphurisation (FGD) and selective catalytic reduction (SCR) for SO<sub>x</sub> and NO<sub>x</sub> control. Despite generating 97% of its electricity needs from hydro sources in 2012, Norway's per capita  $CO_2$  emissions at 8 t $CO_2$ /capita are no lower than the EU average. The government is also conscious that end-use emissions from the country's exports of oil and gas are very substantial. In response, Norway has been a pioneer in the field of carbon capture and storage: at the Sleipner natural gas field and at the Snøhvit LNG project. The  $CO_2$  Technology Centre Mongstad was inaugurated in May 2012 to develop  $CO_2$ capture technologies for both gas- and coal-fired power plants. Since 2007 at Longyearbyen, the UNIS  $CO_2$  Lab has drilled a series of test wells and injected water to prove the  $CO_2$  storage potential of Svalbard's deep saline aquifers.

Sines power plant, adjacent to a coal import terminal on the Atlantic coast, was built in the late 1980s and is owned by ENERGIAS DE PORTUGAL (EDP). The inland Pego power plant which was fully commissioned in 1995 is owned by INTERNATIONAL POWER PLC, a subsidiary of GDF-SUEZ, and ENDESA GENERACIÓN SA, a subsidiary of ENEL. The National Laboratory on Energy and Geology (LNEG) has completed a project (KTEJO) to examine the feasibility of retrofitting CCS at Pego power plant. Although there are currently no plans for new coal-fired power plants in Portugal, both coal and gas have been proposed as fuels for a possible new 800 MW plant at Sines.

By 2020, Portugal intends to be generating 60% of its electricity from renewable resources, in order to satisfy 31% of its final energy consumption. Although Portugal has this aggressive target, it is also facing severe austerity measures which mean that the government has had to scale back the support offered for renewable energy and revise capacity payments.

#### South East Europe

The countries of South East Europe not covered in earlier chapters include Albania, Bosnia and Herzegovina, Croatia, Kosovo, the Former Yugoslav Republic of Macedonia and Montenegro.

*Albania* produces very small volumes of lignite and imports further volumes to meet demand totalling an estimated 300 thousand tonnes at industrial and residential customers, who use the fuel for heating purposes, and at the Antea cement works which opened in 2010. The country produces all of its electricity at hydro plants. With reserves of 522 million tonnes and a further 205 million tonnes of resources, the country has the potential to support a much larger lignite mining industry. During the 1980s, annual production of around 2.4 million tonnes came from mines in central Albania near Valias, Manëz and Krrabë; at Mborje and Drenovë in the Korçë district; in northern Tepelenë at Memaliaj and in Alarup to the south of Lake Ohrid. In *Bosnia and Herzegovina*, brown coal and lignite make a large contribution to primary energy supply (67% in 2011), consumed mainly at power plants near to mines. In 2012, the country produced a total of 6.3 million tonnes of lignite and a further 6.3 million tonnes of sub-bituminous brown coal. Of this total, roughly two thirds were from underground mines and one third from opencast mines – some being subsidiaries of the major electricity utilities. The country also imported 1.2 million tonnes of hard coal in 2012. At 1 272 million tonnes, Bosnia's reserves of lignite are substantial and further resources of 1 801 million tonnes are reported. Brown coal reserves total 827 million tonnes.

The largest coal deposits are located in the north-east of the country around Tuzla in the Kreka-Banovići coal basin. These are worked by KREKA at the Sikulje and Dubrave opencast lignite mines, and at the Mramor and Bukinje underground mines.

Other deposits in central Bosnia are worked by KAKANJ (Vrtlište opencast mine, the Haljinići undergound mine and the new Begići–Bištrani underground mine opened in July 2013), BREZA (underground mines at Sretno and Kamenice), ZENICA (underground mines at Stara Jama, Raspotočje and Stranjani) and ABID LOLIĆ. BILA operates the Grahovčići opencast mine, and GRAČANICA operates the Dimnjače opencast mine. ĐURĐEVIK operates opencast brown coal mines at Višća II and Potočari, and an underground mine at Đurđevik. RMU BANOVIĆI operates large opencast mines at Grivice and Čubrić, employing shovel dredgers and 170-tonne trucks to mine a 17-metre seam, and has developed a third opencast mine at Turija. The company also operates one partly mechanised underground mine at Omazići.

The Gacko deposits in the south-east are worked by RiTE GACKO to supply the 300 MW Gacko supercritical power plant owned by the public enterprise ELEKTROPRIVREDA REPUBLIKE SRPSKE. Other production sites in Bosnia and Herzegovina include Livno and Ugljevik, the mines of Tušnica, which supply the Ugljevik power plant, and the Stanari mine at Doboj.

The total production capacity of the country's power plants is 3 824 MW. 54% of this is hydro-electric based, while the remaining 46% is provided by thermo-electric installations. The Tuzla power plant has three operating blocks, with an installed capacity of 715 MW. The plant also supplies heat for Tuzla and Lukavac, process steam for nearby industries and fly ash for the cement factory at Lukavac. After the Bosnian war of 1992-95, major overhauls were completed at the plant, including boiler upgrades and the installation of new precipitators. The Kakanj power plant has three operating blocks, with a total capacity of 450 MW and, like Tuzla, is owned by the public enterprise ELEKTROPRIVREDA BOSNE I HERCEGOVINE. The Ugljevik and Gacko power plants, each 300 MW, are operated by state-owned enterprise ELEKTROPRIVREDA REPUBLIKE SRPSKE.

In general, coal mining in Bosnia and Herzegovina faces many challenges. For years, poor geological conditions and a lack of funding for maintenance and investment have hindered mining. The government plans to restructure the industry by merging coal mines and power plants to attract new investment. To that end, many new projects are on the horizon.

RMU BANOVIĆI proposes a new 300 MW power plant with a circulating fluidised bed combustor and supplied with brown coal from its existing mines from 2017. ELEKTROPRIVREDA HRVATSKE ZAJEDNICE HERCEG BOSNE, a state-owned enterprise, has proposed the construction of a new 2 x 275 MW lignite-fired mine-mouth plant near Tomislavgrad. The plant would be supplied with lignite from a new mine in the Kongora deposit. There are many other potential mine and power plant projects in Bosnia and Herzegovina: the new Kotezi mine would supply a new 350 MW power plant near the town of Bugoino; a new 300 MW plant adjacent to the existing Stanari mine; a 600 MW expansion of the Ugljevik power plant; the potential Miljevina brown coal mine; a 300 MW expansion of the Kakanj power plant; a new 450 MW block at Tuzla; and a possible 430 MW two-unit plant at Kamengrad mine. Bosnia and Herzegovina is already a net electricity exporter to neighbouring countries and exports could grow in the future as these projects are materialised.

*Croatia* became the newest member state of the EU-28 on 1 July 2013. The county does not produce coal, but imported 1.3 million tonnes in 2012. Over three quarters of this are used for power generation at the 335 MW Plomin power plant, owned by HRVATSKA ELEKTROPRIVREDA (jointly with RWE in the case of unit B), while the balance is used for cement production and food processing. HRVATSKA ELEKTROPRIVREDA has invited bids to construct a third coal-fired unit at Plomin which is seen as a priority by the government. The new 500 MW unit C would replace unit A and thus increase the plant's overall capacity to 710 MW.

*Kosovo* is governed by the United Nations Interim Administration Mission in Kosovo (UNMIK), following the violent conflict of 1996-99. It has very large lignite resources, totalling 10.8 billion tonnes and fourth only to Poland, Germany and Serbia in Europe. Reserves are located in the Kosova, Dukagjini, Drenica and Skenderaj basins, although mining has been limited to the Kosova basin to date. Lignite production in 2012 was 8.9 million tonnes.

For electricity, Kosovo is almost entirely dependent on lignite, with just over 2% coming from hydro plants and imports in 2011. The state-owned KORPORATA ENERGJETIKE E KOSOVËS (KEK) has a monopoly position in lignite mining and electricity generation. Kosova A (5 units totalling 800 MW) and Kosova B (2 x 339 MW) power plants near Pristina are supplied with lignite from the adjacent Mirasha and Bardh opencast mines, in production since 1958 and 1969 respectively, and from the smaller Sitnica mine. These mines are nearing exhaustion and the new Sibovc Southwest mine near Obilig was opened in 2010 to secure future lignite supplies for Kosova power plants until 2024. The plants operate at a reduced capacity of 910 MW and the plan is to retire A units by 2017 and B units by 2024. A new 600 MW Kosova C or Kosova e Re power plant is proposed as a replacement and this would improve the reliability of electricity supply in Kosovo and, at the same time, significantly reduce emissions.

#### The Former Yugoslav Republic of Macedonia

is a significant lignite producer: 7.5 million tonnes in 2012 from the state-owned Suvodol-Brod Gneotino and Oslomej-Zapad surface mines, and from a number of smaller privately owned surface mines. It has lignite reserves of 332 million tonnes in the Pelagonija and Kicevo deposits with further potential in the Mariovo and Tikves deposits - new mines at Mariovo, Zhivojno, Negotino, Popovjani, Lavci, Zvegor-Stamer and Star-Istevnik/Pancarevo could add to supply. The country also imports sub-bituminous coal (168 thousand tonnes in 2012). Most coal and lignite is used for power generation, around 90% on an energy basis. The balance is used almost entirely by the steel industry, including DUFERCO MAKSTIL's integrated steel works at Skopje and ARCELORMITTAL's steel mill, also at Skopje. The state-owned ELEM Bitola (675 MW) and ELEM Oslomej (125 MW) lignite-fired power plants generated 77% of Macedonia's electricity in 2011. With hydro, total production was 6.9 TWh. The government plans to build a new 300 MW lignite-fired power plant at Mariovo - conditional upon the part privatisation of ELEM.

*Montenegro* produced and consumed an estimated 2 million tonnes of lignite in 2012. It is used mainly for power generation – over half of the country's electricity comes from coal. Although not currently exploited, Montenegro boasts hard coal reserves of 142 million tonnes.

#### Sweden

There are very limited hard coal deposits in Sweden: reserves and resources are reported at just 5 million tonnes. In the past, small-scale coal mining took place in southern Sweden. In 2012, 630 thousand tonnes of peat were extracted.

In the 1930s, coal met more than half of Swedish energy demand, with imports of around 7 million tonnes per year. Today, at just over 4%, coal has just a minor share of the country's total primary energy supply.

Since the mid 1990s, demand for coal imports had been stable at close to 3 million tonnes per year, but declined in 2012 to 2.2 million tonnes as coal is replaced with biofuels. Steam coal is now only used at a few combined heat and power (CHP) plants, including at Fortum's efficient and clean Värtan plant in Stockholm – site of the world's first commercial pressurised fluidised bed combustor. The majority of coal demand comes from Sweden's speciality steel industry which uses mainly high-quality coking coal. Some coal is used by the cement industry, but the sector is increasing its use of alternative fuels. The pulp and paper industry uses mainly biofuels with small quantities of coal.

In a typical year, almost half of Sweden's electricity demand is met by hydropower and almost half by nuclear power. The balance is met by CHP plants, firing either solid waste, biofuels or fossil fuels. Wind power production is increasing with a share of 4% in 2012. In 2010, the Swedish parliament agreed that new nuclear power plants could replace old ones at existing locations. Government support schemes exist for the construction of biofuelled CHP and wind farms. The national energy mix for power generation is well balanced and Sweden has good interconnections with its neighbours. More interconnectors are under construction to enable a future increase of cross-border power trade. For the coming years, Sweden is expected to be a net exporter of electricity.