INTERNATIONAL ENERGY AGENCY



## Energy Policies of IEA Countries



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# SPAIN 2009 Review

## Energy Policies of IEA Countries

SPAIN 2009 Review

Since the last IEA in-depth review in 2005, Spain has made significant progress in improving its energy policy. In Europe, the country is now leading in gas diversification and LNG development. Together with Portugal, it has set up the common Iberian electricity market, MIBEL, and has strong ambitions in developing it further. It has also become prominent in developing wind and solar energy technology, and succeeded in integrating large amounts of intermittent power in the electricity grid.

Along with other IEA member countries, Spain has set ambitious climate and energy security targets. Achieving these will require a transition to a low-carbon economy. Spain will need to increase its efforts to reduce CO<sub>2</sub> emissions, particularly in the transport but also the critical power sector. As fossil fuels still provide more than half of electricity, Spain will need to keep open all the options – including nuclear, renewables, and the technology of carbon capture and storage – for making its power sector less carbon-intensive. The country should also increase its efforts to limit peak electricity demand through energy efficiency.

Spain has substantially de-regulated its electricity and gas tariffs, and developed a financial plan to end the large deficit that had built up under the previous tariff regime. Prices for many small electricity users, however, are still regulated and low enough to potentially distort the market. In addition, the still remaining subsidies for domestic coal production should be eliminated and replaced by direct social policy measures.

> This review analyses the energy challenges facing Spain and provides critiques and recommendations for further policy improvements. It is intended to help guide Spain towards a more sustainable energy future.

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## INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty-eight of the thirty OECD member countries. The basic aims of the IEA are:

- To maintain and improve systems for coping with oil supply disruptions.
- To promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations.
  - To operate a permanent information system on international oil markets.
    - To provide data on other aspects of international energy markets.
      - To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use.
        - To promote international collaboration on energy technology.
          - To assist in the integration of environmental and energy policies, including relating to climate change.

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Luxembourg

Netherlands

New Zealand

Norway

Poland

Portugal

**Slovak Republic** 

Spain

years 974.200

Sweden

Switzerland

Turkey

United Kingdom

United States

The European Commission also participates in the work of the IEA.

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#### ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of thirty democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

#### **IEA member countries:**

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Italy

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## EXECUTIVE SUMMARY AND KEY RECOMMENDATIONS

## **EXECUTIVE SUMMARY**

Since the last in-depth review in 2005, Spain has made substantial progress in its energy policy. It is in full compliance with IEA oil security requirements and leads in gas diversification and LNG development in Europe. Together with Portugal, it has set up the common Iberian electricity market, MIBEL, and has strong ambitions in developing it further. It has also improved the system of end-user tariffs for gas and electricity. Spain is determined and successful in promoting renewable energy and puts increasing emphasis on improving energy efficiency. In short, the IEA is impressed with the strong positive developments of the past four years.

Spain's natural gas market development deserves particular praise. The roles of the transmission system operator (TSO) and other market players are clearer than before. The market is more open and less concentrated. Gas supplies are more diversified and secure, thanks to heavy investment in liquefied natural gas (LNG). The share of imports from any given country has been reduced to 50% of the total. Since the end of 2007, Spain has also been working with Portugal on building a common Iberian gas market.

Spain is exemplary also in developing wind power. Its generating capacity is the third-highest in the world and will continue to grow fast. It has succeeded in developing a well-integrated system to balance the inevitable variations in wind power generation. A key tool is the world-class Renewable Energy Control Centre operated by the TSO. To ensure that maximum wind generation can be utilised or stored at any given time, the government, the TSO and industry are developing ways to increase the use of electric vehicles and pumped storage. The government has recently set a target of one million hybrid and electric cars by 2014. New interconnections will also help, by allowing more exports. The IEA applauds Spain's success in promoting wind power.

Energy policy in Spain in the coming decade will be shaped by the European Union targets for 2020 on greenhouse gas (GHG) mitigation, renewable energy and energy efficiency. The country will have to cut emissions from the sectors outside of the EU EmissionsTrading Scheme by 10% below their 2005 levels. It will also have to increase the share of renewable energy sources in gross final energy consumption from 8.7% in 2005 to 20% in 2020. Spain and other EU member states also have a separate binding target for renewable energy to cover 10% of transport fuel demand in 2020. Also, Spain will have

to increase energy efficiency to help reduce energy demand in the EU by 20% below the business-as-usual level by 2020.

The ambitious aims that Spain and other IEA member countries are setting for climate change and energy security will require a transition to a low-carbon economy, a revolution in the way in which energy is supplied and used. New technology and increased government spending on energy research and development (R&D) are needed. The IEA applauds the steady increases in Spain's energy R&D spending since 2004, and encourages its government to raise this spending further. The IEA also commends Spain for the lead it is taking in R&D on wind and solar power, and carbon capture and storage.

Spain and other countries have in recent months pledged to increase spending to speed up economic recovery. Investing in energy efficiency and clean energy should be placed at the heart of every economic stimulus package. The IEA also encourages Spain to ensure that any spending contributes to the overall cost-effectiveness of energy policy. For example, subsidies on renewable energy are a means for reaching the broader energy policy goals of economic growth, environmental protection and securing supplies of energy. So are subsidies on energy efficiency and these often bring the same environmental and energy security benefits at a lower price. Energy efficiency measures to reduce the use of fossil fuels will also help Spain to reach its 2020 goal regarding the share of renewable energy in gross final consumption of energy. The IEA encourages the Spanish government to fully implement and enforce the Action Plan 2008-2012 under the 2004-2012 Energy Saving and Efficiency Strategy.

Driven by strong economic growth, Spain's  $CO_2$  emissions are substantially higher than its target under the Kyoto Protocol. Spain is commendably using the potential of the EU-ETS for obliging power and heat generators and several process industries to reduce emissions. Outside the EU-ETS sector, transport is by far the largest emitter and the logical choice of focus. For road transport, Spain is using tax incentives to promote biofuels and low- $CO_2$ -emitting cars. Plans to expand the high-speed rail network and facilitate shifting freight from road to rail are also encouraging. In a welcome move, Spain has adopted a strategy for sustainable mobility in April 2009. This strategy should be implemented without delay.

By international comparison, Spanish diesel and gasoline prices are low, and low prices tend to increase demand. In its efforts to limit  $CO_2$  emissions from transport, the government should also consider revenue-neutral taxation. Taxes are typically much simpler and more cost-effective than other measures, although it is challenging to sell them to the public and overcome the resistance from pressure and interest groups, particularly in times of economic distress. For this reason, these taxes should be revenue-neutral, *i.e.* some other taxes should be lowered accordingly to keep the overall tax burden on citizens unchanged.

Low-carbon technologies must also be the goal for electricity generation. This includes renewable energy sources, nuclear power and the capture and storage of  $CO_2$  from fossil fuels. Much work remains to be done, as fossil fuels continue to supply some three-fifths of electricity in Spain. The government is encouraging strong increases in renewable electricity, and it is also funding R&D on nuclear power and carbon capture and storage (CCS). It aims to progressively reduce the share of nuclear power in the energy mix, while ensuring security of supply and reducing GHG emissions. This should leave room for maintaining the current capacity until the end of its operational life, which is to be encouraged. Indeed, it is difficult to see how phasing out nuclear energy could serve Spain's energy and climate policy goals. This is particularly so because most electricity generation causes  $CO_2$  emissions and climate change is projected to raise temperatures and increase droughts, thus reducing water availability for hydropower in the coming decades.

Spain should keep open all options for low-carbon power generation. It should also increase efforts to limit peak electricity demand through energy efficiency measures. This would bring clear economic and environmental benefits. Power demand peaks at times of high use of air-conditioners or electric heaters, *i.e.* when temperatures rise or drop to their extremes. Normally, this is during high pressure and, therefore, when there is little wind. As a result, Spain needs expensive backup capacity, typically gas-fired, to make up for this unavailability of renewable energy. Peak demand could be reduced by more efficient heating and cooling appliances, by better insulating buildings and using light colours for roofs and pavements, as well as natural shading, to reduce the need for these appliances.

Spain has traditionally capped end-user prices of electricity to several consumer groups under a regulated tariff system. With the generation costs rising faster than the tariff in the past several years, this system has created a huge tariff deficit that the government owes to the utilities, estimated at EUR 14 billion in May 2009. Commendably, the government has gradually reduced the eligibility for the tariff, and since the beginning of 2009 revised the whole tariff system to ensure it covers costs. The IEA applauds this improvement.

In a welcome move to solve the tariff deficit, the government and the utilities agreed in spring 2009 on how to settle the accrued debt. As part of that agreement, however, electricity prices for some five million households with either low use or low income will be frozen from July 2009 until 2012. As this new tariff does not reflect, nor necessarily cover, the costs of electricity generation, it distorts the market and is hardly conducive to energy saving and efficient use of electricity.

Another area of traditionally strong, but weakening government intervention is domestic coal production that depends on subsidies. All domestic coal is used for power generation, where it contributed some 8% to total power supply in 2007. It is therefore part of the electricity security equation and its future should be considered in this context. Electricity supply can be secured by many measures that are more cost-effective than subsidies, such as through energy efficiency, demand response, system integration, gas storage, interconnections, or stocks of imported coal from diversified sources. The IEA encourages the government to continue to liberalise energy markets and develop social policies in such a way as to minimise and, where possible, eliminate distortion to energy markets.

## **KEY RECOMMENDATIONS**

The government of Spain should:

- ▶ Continue to stimulate a transition to a low-carbon economy by implementing and further enforcing its ambitious plans to save energy, reduce CO₂ emissions and promote renewable energy, including investments in technology deployment and R&D.
- Keep open all options for low-carbon electricity supply and increase efforts to limit peak electricity demand through energy efficiency measures.
- Continue to liberalise energy markets and develop social policies in such a way as to minimise and, where possible, eliminate distortion to energy markets.

# PART I POLICY ANALYSIS





## COUNTRY OVERVIEW

The Kingdom of Spain (population 45 million, area 505 000 km<sup>2</sup>) covers most of the Iberian peninsula and also includes the Canary Islands, Balearic Islands and the cities of Ceuta and Melilla in North Africa. Owing to its size and geography, the country's climate can vary substantially by region.

Exceptionally for a developed country, Spain's population has grown by more than 11% since 2000, almost entirely because of immigration. The economy has grown much faster, by around two-thirds, and per-capita GDP (estimated at USD/PPP 31 200 in 2008) has risen to slightly below the OECD average.

As in all developed economies, services are the largest sector (66% of GDP in 2007). Tourism is particularly important, and Spain is the world's third-most popular tourist destination after the United States and France. Retailing and banking are also prominent. The country's industry (30% of GDP) was for a decade dominated by construction, accounting for some 14% of GDP in 2007. Other large subsectors are vehicle manufacturing, energy industries and food-processing. The primary sector (mostly agriculture and fishing) accounts for 4% of GDP.

After more than a decade of rapid economic growth, the outlook has changed with the bursting of the housing bubble and the international credit crunch. Growth slowed from 3.7% in 2007 to 1.2% in 2008 and the economy is expected to contract by several percentage points in 2009. Unemployment has increased from 9% in January 2008 to more than 17% in May 2009.

Since 1978, Spain has been a constitutional monarchy. The king has a limited role in day-to-day politics. The Socialist government led by Prime Minister José Luis Rodriguez Zapatero took office in mid-April 2008 for the second consecutive four-year term. A fairly decentralised country, Spain is divided into 17 autonomous regions, each with its own parliament. In the energy sector, the autonomous regions are responsible for *e.g.* authorising power plants and energy networks. Spain joined the EU in 1986 and adopted the euro<sup>1</sup> as its currency in 2002.

## SUPPLY AND DEMAND

## SUPPLY

According to preliminary IEA data, Spain's total primary energy supply (TPES) was 138 million tonnes of oil equivalent (Mtoe) in 2008. From 1990 to 2008, TPES increased by 53%, while the economy grew by 65%, led by

<sup>1.</sup> On average in 2008, EUR 1 = USD 1.462.

Figure 2 Total Primary Energy Supply in IEA Member Countries, 2008\*



\* estimates.

\*\* includes geothermal, solar, wind, and ambient heat production.

Source: Energy Balances of OECD Countries, IEA/OECD Paris, 2008.

strong growth in services and construction. Reflecting a change in economic conditions, energy supply decreased by 4% from 2007 to 2008, the first annual decline since the mid-1990s.

Fossil fuels accounted for 83% of TPES in Spain in 2008, almost equal to the IEA median and average (see Figure 2). Oil remains the largest energy source, providing 47% of TPES. It is followed by natural gas (25%), nuclear energy (11%) and coal (10%). Renewable energy sources and waste provided 7.5% of TPES. Spain depends on imports for 78.5% of its TPES, including for practically all oil and natural gas and most coal.

Natural gas has grown the most since 2000, by 20 Mtoe. As in many other countries, it has become the fuel of choice for power generation in Spain. Another fast-growing source for electricity is wind. From 2000 to 2008, electricity generation from natural gas increased by 101 TWh and from wind by 27 TWh. Generation from renewable energy sources other than wind increased by 5 TWh, whereas all other electricity sources were in decline, as total generation grew by 84 TWh (see Chapter 9). In 2008, fossil fuels provided three-fifths of power supply, and nuclear and renewable sources 20% each.

In the government's business-as-usual scenario, TPES would increase by 17% from 2008 to 2016 (see Figure 3). Biofuels for transport and natural gas are projected to grow the most. These estimates, however, were made before



Sources: Energy Balances of OECD Countries, IEA/OECD Paris, 2008 and country submission.

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the economic downturn and are likely to be revised in the future. The government is working on long-term energy scenarios to 2030. The Ministry of Industry, Tourism and Trade is leading this cross-sectoral effort. Completing the task has been recently complicated by the change in economic outlook.

## DEMAND

In 2007, Spain's total final consumption of energy (TFC) was 103 Mtoe, up 69% from 1990. Transport was the largest user, accounting for 38% of the total. Industry's share was 33% and the other sectors (residential, services and the primary sector) used 29% of the total. In comparison, the IEA averages in 2006 were close to a third each for industry, transport and other sectors. Over the past two decades, the share of transport has remained fairly stable, while industry has seen its share decline from more than 40% and the other sectors have correspondingly gained ground.

On an energy source basis, oil provided 57% of TFC in 2007, electricity 22%, natural gas 16%, biomass and waste 4% and the other sources 1%. The share of natural gas has doubled since 1990 and that of electricity has grown markedly from 18% in the mid-1990s (see Figure 4). Following a long-term trend since the first oil crisis, oil has lost most ground, down from 65%



#### \* negligible.

Sources: Energy Balances of OECD Countries, IEA/OECD Paris, 2008 and country submission.

in the mid-1990s. In its projections made before the economic downturn, the government foresaw TFC increasing by 17% from 2007 to 2016, with almost all growth coming from the use of natural gas, electricity and biofuels.

## INSTITUTIONS

The Ministry of Industry, Tourism and Trade leads energy policy formulation. Within the ministry, this work is delegated to the State Secretaríat for Energy. Its responsibilities include:

- Issuing regulations concerning energy and mining matters.
- Making proposals to regulate the tariff structure, prices of energy products and tolls.
- Making proposals to save energy, promote renewable energy and develop new energy and mining technologies.
- Introducing and, if appropriate, adopting measures to ensure energy supply.

The ministry is supported by several semi-independent bodies, including the following:

The *National Energy Commission* (CNE) is the sectoral regulator for the electricity, natural gas and oil markets. CNE has several functions. It proposes access and end-user tariffs and can even propose new legislation. It participates in drafting the national energy infrastructure investment plan and monitors its implementation. It solves disputes over third-party access and monitors several aspects of market functioning and infrastructure use. CNE also monitors competition in the energy market and reports to the Competition Authority (CNC). Its role, however, is mainly consultative, and final decisions on regulations or tariffs are taken by the Ministry of Industry, Tourism and Trade.

CNE is financed from the electricity and natural gas tariffs and by a levy on the wholesale of oil. It has around 200 staff. Attached to CNE will be the Consumer Protection and Information Office for energy products which the government has decided to launch by July 2009.

The *Institute for Energy Diversification and Saving* (IDAE) runs activities to increase public knowledge and awareness. It provides technical advice, and runs and finances example technology innovation projects with potential for replication. It led in developing the 2004-2012 Energy Saving and Efficiency Strategy (E4) and is responsible for co-ordinating its implementation among the autonomous regions.

The *Strategic Reserves Corporation* (CORES) is the stockholding agency in charge of managing and maintaining minimum security stocks of crude oil, oil products and natural gas.

The *Nuclear Safety Council* (CSN) is the competent body in matters of nuclear safety and radiation protection. It is directly accountable to the Spanish Parliament, and formally independent of the Administration.

Other ministries and bodies involved in energy policy in Spain are described below:

The *Ministry of the Environment and Rural and Marine Affairs* is responsible for several energy-related policies, such as air pollution and climate change. Within the ministry, the Secretariat of State for Climate Change is responsible for formulating and co-ordinating climate change policies. Within the Secretariat of State, this work is delegated to the Spanish Climate Change Office.

The *Ministry of Science and Innovation* is in charge of Spain's research and development (R&D) policy. It co-ordinates the implementation of the national energy R&D policy with the *Ministry of Industry, Tourism and Trade*, the *Ministry of Transport* and the *Ministry of Housing*.

The *Ministry of Public Works* covers the development of transport infrastructure and is in charge of managing transport demand.

The *National Competition Authority* (CNC) is in charge of implementing competition policy in all sectors. It also co-ordinates work of the competition authorities of the autonomous regions. CNC has around 30 staff. Since 2005, it has investigated more than 35 cases of allegedly anticompetitive practices in the energy sector, such as cartel agreements and abuses of dominant position. It has issued more than EUR 67 million in fines.

The autonomous regions have a variety of powers relating to energy, primarily in the area of authorising installations. They are also strongly involved in designing and implementing climate change, energy efficiency and renewable energy policies at the regional level.

## **KEY POLICIES**

Spain's energy policy strives to support sustainable development and ensure energy supply that allows for economic growth and competitiveness, while reducing the impact on the environment of energy production, transformation and end use.

Today, many of Spain's energy policy goals are derived from the EU level. For example, EU law sets requirements for electricity and natural gas markets, and

for energy efficiency in appliances and buildings. The EU member states have non-binding targets for energy saving by 2016, and for the share of renewable energy in TPES, electricity supply and transport fuels by 2010. But they have binding targets for total GHG emissions and, through the EU Emissions Trading Scheme (EU-ETS), for  $CO_2$  emissions from heavy industry and power and heat generation.

The EU targets for 2020 on GHG mitigation, renewable energy and energy efficiency will shape Spain's energy policy in the coming decade. Under the target to reduce GHG emissions in the EU by 20% from 1990 level to 2020, Spain will have to cut emissions from the sectors outside the EU-ETS by 10% below 2005 levels. It will also have to increase the share of renewable energy sources in gross final energy consumption from 8.7% in 2005 to 20% in 2020. In addition to this overall target, Spain and other EU member states have a separate binding target for renewable energy to cover 10% of demand for transport fuel in 2020. Spain will also have to increase energy efficiency to contribute to the EU target of reducing energy demand by 20% from the business-as-usual level by 2020.

## SECURITY OF SUPPLY

As Spain depends on imports for some four-fifths of its energy supply, securing these supplies is crucial for the country. Oil supplies are well diversified by country of origin and Spain holds slightly more oil stocks than required under the IEA obligation. Moreover, Spain has raised the minimum stock requirement to 92 days from 90 days as of the beginning of 2010.

Diversification of natural gas sources through liquefied natural gas (LNG) has been particularly successful and Spain is now the world's third-largest LNG user, after Japan and South Korea. It receives gas from more than half a dozen countries and has limited the maximum share of any given country to 50% of total imports.

Renewable energy policy is partly motivated by security of supply concerns. Spain supports renewable energy development through premiums for electricity, investment subsidies and tax incentives for biofuels in transport.

Security of electricity supply is closely linked to variations in intermittent renewable power, mainly wind. Wind power generation has grown fast and will continue to do so, and as Spain has relatively low cross-border capacity, variations in wind power generation have to be dealt with in the Spanish system. Spain has successfully focused on developing a well-integrated system to balance these variations. Natural gas is the most common backup option for wind power. Spain's current policy on nuclear power is to gradually reduce its share in the energy mix while ensuring security of supply.

### National Infrastructure Investment Plan

Investments in electricity and natural gas infrastructure are obligatory and follow a national infrastructure investment plan. The plan concerns the regulated section of the electricity and natural gas markets, and therefore includes transmission networks, LNG facilities and oil and gas storage facilities. The investments are guaranteed a reasonable return, currently around 7% net of tax per year.

The plan is prepared by the government in consultation with industry, transmission system operators (TSOs) and regulators, and it is based on projections of energy consumption and intensity. The plan also complies with the government's quantitative goals for energy saving and efficiency, and renewable energy. The current plan was approved in May 2008 and applies to investments from 2008 to 2016. It foresees annual average investments of EUR 2 billion, half in electricity and half in natural gas infrastructure.

## CLIMATE CHANGE MITIGATION

Spain's target under the EU Burden-Sharing Agreement related to the Kyoto Protocol is to limit its GHG emissions to an average of 15% above their 1990 level from 2008 to 2012. In 2007, emissions were 53% higher than in 1990. More reductions will be needed after 2012: emissions from the sectors not covered by the EU-ETS must be 10% below the 2005 levels by 2020. For the ETS sector in the EU as a whole, the reduction target is 21% below the 2005 level by 2020.

Domestic efforts to limit CO<sub>2</sub> emissions have focused on promoting energy efficiency and renewable energy sources through various measures. These measures are listed in the 2007 Climate Change and Clean Energy Strategy, which builds upon the 2004-2012 Energy Saving and Efficiency Strategy (E4) and the Action Plan 2008-2012 under this Strategy, and the Renewable Energy Plan 2005-2010. New measures on transport, a heavy-emitting sector and a particular focus area, are included in the Sustainable Mobility Strategy, adopted in spring 2009. Domestic measures in the ETS and non-ETS sectors are expected to deliver most, but not all, of the needed emissions reductions. Meeting the GHG targets will also strongly rely on the use of the Kyoto flexible mechanisms: joint implementation (JI) and clean development mechanism (CDM).

## MARKET REFORM

A major development since the last IEA review in 2005 is the establishment of the all-Iberian electricity market, MIBEL, in 2007. The regional market increases security of supply and competition in both Portugal and Spain. The Spanish market remains concentrated, although less so than previously. Virtual sales of capacity since 2007 are reducing the market share of Iberdrola and Endesa, and interconnection capacity to Portugal and France will be increased in the coming years.

The tariff system has been revised and end-user prices are less regulated than ever before. The government and the industry have also agreed to a solution to manage the tariff deficit that resulted from setting the tariff below generating costs. As part of that solution, electricity prices for some five million households with either low use or low income will be frozen from July 2009 until 2012. These customers used 18 TWh of electricity in 2008, accounting for 8% of the total.

The natural gas market has been improved in several aspects. A network code has been adopted and Enagás has been established as the technical system manager. New companies have entered the market and reduced market concentration, partly thanks to open third-party access to LNG facilities. The end-user tariff system for gas has also been revised and regulated tariffs now fully cover costs. A growing share of gas is supplied in the competitive part of the market, as regulated tariffs are only applied to small users and eligibility for this tariff is declining over time.

## TAXATION

Spain levies excise taxes on oil products and electricity. Energy products are also subject to a 16% value-added tax, but it is fully refunded for industry, electricity generation, and automotive diesel used for commercial purposes. Biofuels are exempted from tax. Generally, taxes are used for fiscal purposes and do not include a specific environmental component.

Excise tax on electricity use in industry and households amounts to close to 5% of total end-user price. Excise taxes on gasoline and diesel are relatively low. Spain has a derogation of the EU timetable to raise minimum taxes on automotive diesel. Excise tax has been EUR 0.302 per litre since the beginning of 2007 (beginning of 2010 for Spanish truckers), three years later than the EU. It will rise to EUR 0.33 per litre by 1 January 2012, as opposed to 1 January 2010 in the EU. Spain abolished the system of additional regional taxes on motor fuels in summer 2008.

## CRITIQUE

Since the last in-depth review in 2005, Spain has made substantial progress in its energy policies, from a starting point that was already quite sound regarding the IEA "three Es" (energy security, economic growth and environmental sustainability). It is the leader in gas diversification and LNG development in Europe and is in full compliance with the IEA oil security

requirements. Together with Portugal, it has set up the common Iberian electricity market, MIBEL, and has strong ambitions in developing it further. Spain is also determined and successful in promoting renewable energy and puts increasing emphasis on improving energy efficiency. In short, the IEA is impressed with the strong positive developments of the past four years.

Through the successful development of its energy infrastructure and access to diverse sources of gas supply, Spain has coped well with exceptionally strong growth in energy demand. In the future, it will need to continue to decouple economic growth from the growth of energy demand, if it is to meet its environmental objectives.

Security of energy supply is of particular importance, as the country depends on imports for almost all forms of fuels and this dependence is set to continue in the long term. For instance, gas demand, which more than doubled from 2000 to 2008, continues to expand. Much work has been done to respond to this situation. Among the different measures taken, the diversification of gas supplies and increasing renewables play major roles. Nevertheless, Spain depends on fossil fuels for some four-fifths of its primary energy supply. Interdependence between the gas and power sectors is growing and this requires close co-ordination and optimisation of the networks, and appropriate risk management.

Climate change obligations are becoming stricter and renewable energy targets very challenging for the country. Regulatory certainty in turn is vital for sufficient and appropriate investment in generating capacity and energy infrastructure beyond the current 2008-2016 time-frame. It is, therefore, very positive that the government is preparing long-term energy scenarios to 2030. The scenarios should form a solid and well-researched basis for mid- and long-term energy policy. Reaching a wide political consensus on future energy policy, including nuclear, would be very welcome for Spain.

To respond to the climate change and energy security challenges, Spain is focusing strongly on developing its renewable energy supply. This has brought clear results, but at a cost. At the same time, energy intensity in Spain has only started to decline since 2005 – later than in most IEA countries, as economic growth and the increased volume of energy use have crowded out improvements in specific energy intensities. The government should increase the use of cost-effectiveness as a criterion for focusing its efforts on policies and measures. For example, in the long term it is often much cheaper to reduce GHG emissions and import dependence through better insulation of buildings and more efficient vehicles, lighting and air-conditioning than by new electricity capacity or increasing the use of biofuels in transport. The government should also raise public awareness of a stronger need for improving energy efficiency and decreasing GHG emissions. Responding to these challenges also calls for effective co-ordination within the government, as measures will be needed in several sectors.

The transition of the Spanish energy market towards a more open and competitive one has progressed substantially since the last in-depth review. The electricity and gas wholesale markets have become less concentrated and more interconnections are set to continue this trend. Thanks to further liberalisation, the Spanish energy market is becoming more competitive and provides an adequate framework for sound economic growth.

Social policies pursued by the government have, to some extent, inhibited the development of fully competitive energy markets. Electricity prices to several end-user groups have been regulated at levels that do not encourage efficient use, and therefore do not improve energy security or help mitigate climate change. Instead, the government has accrued a large debt, and energy market development has been hampered. It is very welcome, then, that the government and the utilities in spring 2009 agreed on how to solve the problem and how to settle the debt. However, domestic coal production continues to receive large subsidies. The government is encouraged to minimise and, where possible, eliminate such distortion to energy markets.

The role of the National Energy Commission (CNE), the sectoral regulator for energy, has been reinforced since 2005. CNE now has a stronger role on interconnections, remuneration of transmission and distribution activities, certification of origin for electricity from renewable sources, efficiency labelling, and monitoring the oil market. CNE's resources of qualified staff must be enhanced to keep pace with its growing role. But the main concern remains that CNE has mainly a consultative role, and that final decisions on regulations or on tariffs must be approved by the Ministry of Industry, Tourism and Trade. The IEA encourages the government to continue to strengthen the CNE by giving it more decision- and rule-making power.

## RECOMMENDATIONS

The government of Spain should:

- Raise public awareness of energy issues, including electricity pricing, energy source options and the need for stronger efforts to improve energy efficiency and decrease GHG emissions.
- Ensure a co-ordinated and integrated approach to devising a long-term energy strategy, making cost-effectiveness a key criterion for developing and prioritising policies and measures.
- Continue to strengthen the National Energy Commission (CNE) by giving it more decision- and rule-making power.

## **OVERVIEW**

Spain is a party to the Kyoto Protocol. The related EU Burden-Sharing Agreement (2002/358/EC) limits its greenhouse gas (GHG) emissions to an average of 15% above their 1990 level from 2008 to 2012.

Spain's total emissions of the six GHGs have increased strongly since 1990. According to the Spanish national inventory submission to the United Nations Framework Convention on Climate Change (UNFCCC), total GHG emissions in 2007 amounted to 442 million tonnes of CO<sub>2</sub> equivalent (Mt CO<sub>2</sub>-eq), which is 109 Mt CO<sub>2</sub>-eq more than Spain's emission cap under the Kyoto Protocol, and 53% more than in 1990. Emissions of nitrous oxides (N<sub>2</sub>O) have remained fairly stable, whereas other emissions have increased substantially, particularly those of carbon dioxide (CO<sub>2</sub>). In 2007, CO<sub>2</sub> accounted for 83% of GHGs, methane (CH<sub>4</sub>) for 9%, N<sub>2</sub>O for 7% and the F-gases (hydrofluorocarbons, perfluorocarbons and sulphur hexafluorides) for 1% (see Table 1).

## CO2 EMISSIONS FROM FUEL COMBUSTION

 $CO_2$  emissions from fuel combustion increased by two-thirds from 1990 to 2007, to 345 Mt. In 2007, fuel combustion accounted for 94% of all  $CO_2$  emissions and 78% of all GHG emissions in Spain.<sup>2</sup>

The CO<sub>2</sub> intensity of the Spanish economy has remained virtually flat since the late 1980s. In 2007, Spain emitted 0.32 kg of CO<sub>2</sub> per USD of GDP (in 2000 prices and purchasing power parities), roughly equalling the IEA Europe average (see Figure 5). GDP grew by 67% from 1990 to 2007, but increased car use and electricity generation offset its positive impact on CO<sub>2</sub> intensity. As the country has become wealthier, private car use has grown and so has oil use in road transport, by around 87%. In the electricity sector, generation has doubled since 1990, while its CO<sub>2</sub> intensity has decreased by only around 10%, but varies annually according to the hydrological conditions. Spain's CO<sub>2</sub> emissions per capita, at 7.7 tonnes in 2007, were close to the OECD Europe average, and 45% higher than in 1990.

<sup>2.</sup> The analysis in the section is based on estimates done by the IEA by using the IPCC default methods and emission factors. In the Spanish submission to the UNFCCC,  $CO_2$  emissions from fuel combustion in 2007 were reported to be 336 Mt.

Emission	s (Mt CO <sub>2</sub> -eq)						
GHG	1990	1995	2003	2004	2005	2006	2007
C0 <sub>2</sub>	228.4	255.3	334.0	351.4	368.0	358.4	366.4
CH <sub>4</sub>	28.6	31.8	38.3	38.1	37.9	38.5	39.1
N <sub>2</sub> 0	27.7	26.5	32.4	31.4	29.7	30.0	30.5
HFC	2.4	4.6	5.0	4.7	5.0	5.5	5.8
PFC	0.9	0.8	0.3	0.3	0.2	0.2	0.2
SF <sub>6</sub>	0.1	0.1	0.2	0.3	0.3	0.3	0.3
Total	288.1	319.2	410.3	426.0	441.2	433.1	442.3
Breakdov	vn by gas (%)						
CO <sub>2</sub>	79.3	80.0	81.4	82.5	83.4	82.8	82.8
CH <sub>4</sub>	9.9	10.0	9.3	8.9	8.6	8.9	8.8
N <sub>2</sub> O	9.6	8.3	7.9	7.4	6.7	6.9	6.9
HFC	0.8	1.5	1.2	1.1	1.1	1.3	1.3
PFC	0.3	0.3	0.1	0.1	0.1	0.1	0.1
SF <sub>6</sub>	0.0	0.0	0.1	0.1	0.1	0.1	0.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Index of	emissions (ba	se year = 10	0)				
CO <sub>2</sub>	100	112	146	154	161	157	160
$CH_4$	100	111	134	133	133	135	137
N <sub>2</sub> O	100	96	117	113	107	108	110
HFC	52	100	108	101	108	120	126
PFC	106	100	32	33	29	30	30
SF <sub>6</sub>	62	100	192	234	251	299	314
Total	100	111	142	148	153	150	153

### Greenhouse Gas Emissions in Spain, 1990 to 2007

\_\_\_\_\_ Table 🚺

Source: Spain's 2009 national inventory submission to the UNFCCC.



Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2008 and *National Accounts of OECD Countries*, OECD Paris, 2009.

By sector, transport and power and heat generation were the two largest emitters of energy-related  $CO_2$  emissions in 2007, each accounting for around one-third of the total. Manufacturing accounted for 16% of all emissions, and residential, other energy industries (mainly refineries), and other sectors 5% to 6% each (see Figure 6). Since 1990, emissions have grown rapidly in all sectors, and more than average in transport, power and heat generation, and other sectors (services, agriculture and fishing).

On a fuel basis, oil remains the dominant source of  $CO_2$  (see Figure 7). In 2007, it accounted for 55% of emissions, a relatively stable share since 1990. Emissions from coal use (23% of the total) were slightly higher than those from natural gas use (23%). Natural gas has become the fuel of choice for the growing power generation and has seen its share increase strongly in recent years, partly because of EU Emissions Trading Scheme (ETS), while emissions from coal use have varied within a wide but stable range according to the availability of other sources of power supply, mostly hydropower. Data on fuel use for electricity generation do, however, point to a steep decline in  $CO_2$  emissions from coal use since 2007 (see Chapter 9 on Electricity).



\* estimated using the IPCC Sectoral Approach.

\*\* includes emissions from commercial and public services, agriculture/forestry and fishing.

Source: CO<sub>2</sub> Emissions from Fuel Combustion, IEA/OECD Paris, 2009.

— Figure 6



– Figure 7

\* estimated using the IPCC Sectoral Approach.

\*\* includes industrial waste and non-renewable municipal waste (negligible). Source: *CO<sub>2</sub> Emissions from Fuel Combustion*, IEA/OECD Paris, 2009.

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## POLICIES AND MEASURES

## INSTITUTIONS

The Ministry of the Environment and Rural and Marine Affairs, and concretely its Secretariat of State for Climate Change, is responsible for formulating and co-ordinating climate change policy in Spain. Within the Secretariat of State, this work is delegated to the Climate Change Office which also functions as the secretariat for the National Climate Council and the Commission for the Co-ordination of Climate Change Policies. The National Climate Council prepares, evaluates and follows up on the national climate strategy. It consists of representatives from the relevant ministries, autonomous regions, municipalities, non-governmental organisations, academia, trade unions and industry.

The Commission for the Co-ordination of Climate Change Policies co-ordinates the work of the central government and the autonomous regions on climate change policy, and it is involved in preparing and monitoring the implementation of the national climate strategy from this perspective. It is chaired by the Ministry of the Environment and Rural and Marine Affairs.

There are two additional institutions for interministerial co-ordination within the government: the government's Delegated Commission for Climate Change made up of nine ministers and nine state secretaries that monitors the implementation of the national climate strategy at the highest level; and the Interministerial Group on Climate Change that includes other high-ranking representatives (state secretaries or secretaries-general, and directors-general) with preparatory functions for the work of the government's Delegated Commission for Climate Change.

For the formulation of specific policies and measures on national climate change, the government may set up specific working groups. They are usually co-chaired and co-ordinated by the relevant sectoral ministry together with the Ministry of the Environment and Rural and Marine Affairs.

## POLICY OVERVIEW

The bases of Spain's climate policy were outlined in the 2007 Climate Change and Clean Energy Strategy (horizon 2007-2012-2020). The Strategy includes 198 measures on 11 areas, such as energy efficiency, renewable energy, R&D, carbon sinks, CCS and use of flexible mechanisms. It also contains an Urgent Measures Plan with more than 80 measures, which, if fully implemented, would avoid emitting on average 12 Mt  $CO_2$ -eq each year from 2008 to 2012. More details of these measures are given below and in the relevant chapters of this book.

Moreover, the current government has reinforced its climate policy by approving six concrete Strategic Lines for Climate Change, *i.e.* actions in: sustainable mobility, sustainable construction, sustainable energy, waste and manure management, forestry policy and sinks, and innovation.

Spain plans to reach its +15% target primarily through domestic measures. The initial projections for the compliance pathway were included in the second National Allocation Plan, and updated in December 2007. They show a 50.9% increase from the base year to 2010. Spain expects to bridge the gap between the projected emissions and the +15% objective through the EU-ETS, other domestic measures, the Kyoto flexible mechanisms and carbon sinks (see Table 2).

	GHG Emissions Projections in Spain (October 2008)					
	Emissions	Relative to				
	(Mt CO <sub>2</sub> -eq/year)	Base year				
Base-year emissions	289.8	0.0%				
Kyoto target	333.2	+15.0%				
2006 emissions	433.3	+49.5%				
Average annual emissions, 2002 to 2006	422.6	+45.8%				
Projected emissions in 2010 (existing measures)	437.3	+50.9%				
Projected effect of EU-ETS	-26.1	-9.0%				
Projected effect of other planned new measures	-27.6	-9.5%				
Projected effect of carbon sinks use	-5.8	-2.0%				
Projected use of Kyoto mechanisms	-31.8	-11.0%				
Projected total emissions in 2010	346.1	+19.4%				

\_ Table 2

Source: Ministry of the Environment and Rural and Marine Affairs.

The October 2008 projections in Table 2 were updated in March 2009. The update takes into account new measures approved during 2008 and revisions in future economic growth. It projects average emissions for 2008-2012 to be 39.8% higher than in the base year, instead of 50.9%. The projected effect of other planned new measures will be -3.2%, instead of 9.5%. With the EU-ETS, sinks and Kyoto mechanisms unchanged, the projected total emissions in 2010 would be 14.6% above the base-year emissions, making Spain comply with its Kvoto target.

After 2012, the ETS sector in the EU as a whole will have to cut emissions by 21% from 2005 to 2020 (see below). As a result of the effort-sharing of the EU GHG target of -20% from 2005 to 2020, Spain will have to reduce emissions from the non-ETS sectors by 10% from their 2005 levels by 2020. To this end, it can use international flexibility mechanisms to cover an amount equalling 4% of the non-ETS sector emissions in 2005.

## EU EMISSIONS TRADING SCHEME (EU-ETS)

The EU-ETS limits the amount of  $CO_2$  emissions from installations in nine energy-intensive industries: combustion installations, hydrocarbon refineries, coke ovens, metal ore roasting or sintering installations, production of pig iron and steel, production of cement clinker, manufacture of glass, manufacture of ceramic products and production of pulp and paper. Each installation is allocated emission allowances and must surrender allowances to cover its total  $CO_2$  emissions. If its emissions are higher than expected, it shall purchase more allowances on the allowance market to cover the shortfall between allocation and actual emissions. If, in turn, it needs fewer allowances than it holds, it can sell them. Allocation in the first two phases of the EU-ETS is based on a National Allocation Plan that is prepared by the national government and approved by the EU Commission. Allocation criteria are laid out in Annex III to the EU Emissions Trading Directive (2003/87/EC).

The EU-ETS was launched in 2005 and its first commitment period ran until the end of 2007. For 2008-2012, the second commitment period, Spain can allocate 145.97 Mt of  $CO_2$  allowances per year to incumbents, and in addition to this it has an annual reserve of 6.28 Mt for new entrants. Total annual allocation for 2008-2012 is 18.4% smaller than for the first commitment period and 19.8% less than the ETS sector emissions in 2005. All allowances are allocated free. Main activity producers of electricity and heat are allowed to use credits gained through joint implementation (JI) and clean development mechanisms (CDM) to cover 42% of their emissions obligation, whereas the limit for autoproducers and installations in other sectors is 7.9% of their obligation.

Spain had around 1 100 installations in the ETS sector in 2008. In 2005, this sector accounted for 56% of the country's energy-related  $CO_2$  emissions. The EU-ETS sets a roughly similar burden on electricity and heat generation in Spain as in the EU as a whole. In 2005, electricity and heat generation accounted for 60% of the emissions in the trading sector in the EU as a whole, and 64% in Spain.

As from 2013, new rules for EU-ETS will apply. For example, all allowances for the power sector will have to be auctioned with temporary exemptions for certain countries, whereas process industries can still receive part or, if

subject to carbon leakage, all of their allowances for free at the level of the benchmark of the best technology available. Flexible mechanisms can be used to cover up to 50% of the required reduction between the emissions verified in 2005 and the average cap over 2008-2020. At the time of writing (May 2009), the maximum share for flexible mechanisms and many other details remained to be confirmed by the EU member states and the EU Parliament.

## DOMESTIC MEASURES OUTSIDE THE EU-ETS

Under the general framework provided by the Climate Change and Clean Energy Strategy, the government approved six new concrete Strategic Lines for Climate Change, *i.e.* domestic measures in sustainable mobility, sustainable construction, sustainable energy (promotion of renewable energy, energy efficiency in general, and CCS), waste and manure management, forestry policy and sinks, and innovation. The government has also increased its funding for clean energy and climate change R&D, and is carrying out campaigns and programmes for raising public awareness of climate change. These measures are detailed in the respective chapters of this book. Some clearly CO<sub>2</sub>-related measures on transport are detailed below.

Energy efficiency improvements under the Energy Saving and Efficiency Action Plan 2008-2012 are expected to help avoid 67 Mt  $CO_2$  annually in 2012 as compared to business-as-usual. The Renewable Energy Plan 2005-2010 is expected to avoid emitting 27 Mt  $CO_2$  in 2010 and 77 Mt  $CO_2$  from 2005 to 2010.<sup>3</sup>

Transport accounts for roughly two-thirds of emissions in the non-ETS sector, and is therefore the prime focus of mitigation efforts. In the Energy Saving and Efficiency Action Plan 2008-2012, it is expected to account for around half of the total  $CO_2$  emissions avoided. The government adopted in April 2009 a national strategy on sustainable mobility to reduce the environmental impact of the transport sector. The strategy includes proposals for congestion charging schemes, cuts in public transport fares, measures to encourage the purchase of electric and hybrid vehicles, and greening the government's transport infrastructure plan for 2005-2020, including building an extensive high-speed rail network.

To encourage buyers to favour low-emission cars, Spain introduced at the beginning of 2008 a  $CO_2$ -based vehicle registration tax on new cars. Before

<sup>3.</sup> The calculation refers to  $CO_2$  emissions in a case where the Renewable Energy Plan 2005-2010 would not exist and a corresponding amount of electricity would be generated at a combined-cycle gas turbine plant.

the reform, the tax depended on the size of the motor. As shown in Table 3, low-emission cars are fully exempt from the tax. Annual tax on car use, in turn, varies according to municipality, but the government and the autonomous regions are working towards moving to  $CO_2$ -based taxation. The government is also encouraging the uptake of biofuels-driven cars by exempting biofuels from excise taxes.

Table 3 Vehicle Registration Taxation in Spain, 2008					
CO <sub>2</sub> emissions. g per km Tax rate %					
<120	0				
≥120, <160	4.75				
≥160, <200	9.75				
≥200	14.75				

Source: Ministry of the Environment and Rural and Marine Affairs.

## INTERNATIONAL MEASURES

To fill the significant gap between expected emissions reductions from domestic measures and the required total reductions, Spain will be using the Kyoto flexible mechanisms (emission allowance trading/clean development mechanism/joint implementation). In line with the plan for reaching the Kyoto commitment (see Table 2), the government is targeting 159 Mt  $CO_2$  of credits for the years 2008-2012. From 2005 to 2007, it has allocated funds to purchase 57 Mt  $CO_2$ -eq of credits.

The government has signed bilateral agreements with host countries (particularly in Latin America) and is participating in bilateral projects and buying emission credits. It is also already participating in the following multilateral funds:

#### World Bank

- Spanish Carbon Fund: EUR 170 million (34 Mt CO<sub>2</sub> of credits)
- Community Development Carbon Fund: EUR 20 million (4 Mt CO<sub>2</sub>)
- Bio-Carbon Fund: EUR 10 million (2 Mt CO<sub>2</sub>)

#### CAF (Corporación Andina de Fomento)

• Iniciativa Iberoamericana de Carbono (IIC): EUR 47 million (9 Mt CO<sub>2</sub>)
European Bank for Reconstruction and Development/European Investment Bank

- Multilateral Carbon Credit Fund: EUR 35 million (5 Mt CO<sub>2</sub>)
- Green Fund: EUR 25 million

#### Asian Development Bank

• Asia-Pacific Carbon Fund: USD 30 million

Inter-American Development Bank: USD 10 million

#### CRITIQUE

Climate change is the most serious global energy-related environmental problem and is also a challenge in Spain. Under the EU Burden-Sharing Agreement related to the Kyoto Protocol, the country must limit its average annual GHG emissions in 2008-2012 to 15% more than in 1990. Largely because of exceptionally strong economic growth, the emissions have grown fast, and in 2007, they were 53% higher than in 1990. The government is aware of the urgency of the challenge and has devised a climate strategy that includes a wealth of measures to meet the Kyoto target. As 2012 is approaching, the government should accelerate efforts to implement these measures.

The current plan to reach the Kyoto target focuses on improving energy efficiency and promoting renewable energy. Spain has commendably used the potential of the EU-ETS for setting stringent emissions reduction obligations on power and heat generation and several process industries in the National Allocation Plan for 2008-2012. Outside the EU-ETS sector, transport is the logical choice of focus. For road transport, the government is using tax incentives to promote biofuels and low-CO<sub>2</sub>-emitting cars. In particular, moving to a  $CO_2$ -based vehicle registration tax in 2008 deserves to be applauded. In another commendable development, a national strategy to promote sustainable mobility was adopted in April 2009. This strategy should be implemented without delay. Greening the transport infrastructure offers multiple benefits for Spain in terms of job creation, energy efficiency, climate change mitigation and energy security. Plans to expand the high-speed rail network and facilitate shifting freight from road to rail are particularly encouraging.

As domestic measures from the EU-ETS and non-trading sectors are not expected to be enough, Spain plans to close the gap in targeted and actual emissions by purchasing international emission credits (through JI, CDM and possibly emissions trading). The government estimates that it needs a total of 159 Mt CO<sub>2</sub>-eq of these credits from 2008 to 2012. So far, between 2005 and 2007, the government has allocated funds to purchase 57 Mt CO<sub>2</sub>-eq of credits, but it now needs to step up efforts to obtain the remaining 102 Mt CO<sub>2</sub>-eq. It will also need to remain aware of the considerable near-term funding requirements for complying with the Kyoto target. This estimated gap, however, is based on the assumption that all planned measures in the non-trading sector will be effective. This may well turn out to be so, and the economic downturn may significantly reduce total emissions, but in order to provide for flexibility, the government should consider the target amount of 159 Mt CO<sub>2</sub>-eq as a minimum.

Spain's climate policy after 2012 will be defined by the EU goals for 2020. The ETS sector will move further away from the government's sphere of influence, as free allocation to the largest sub-sector, power and heat generation, will be phased out. In the non-ETS sector, Spain should pursue ambitious emissions reductions, as there is no guarantee that the economy, and therefore energy use and emissions, will not return to rapid growth. Furthermore, ambitious policies on energy efficiency typically bring benefits beyond emissions reductions: they save money, reduce import dependence and, in the case of transport, improve air quality. Generally, Spain is well advised to quickly update and revise its climate strategy now that the 2020 targets have been adopted. This strategy should include cost-effectiveness as a key criterion to help prioritise the various policies and measures.

## RECOMMENDATIONS

The government of Spain should:

- Increase efforts to reach the Kyoto target.
- Ensure both the availability of funds for the eventual purchases of international emission credits and the institutional capacity for handling these purchases.
- Prepare a strategy for meeting the post-2012 targets, using cost-effectiveness as a key criterion when prioritising measures.

#### **OVERVIEW**

Spain's total final consumption of energy (TFC) was 103 Mtoe in 2007, up 69% from 1990. Transport was the largest user, accounting for 38% of the total. Industry's share was 33% and the other sectors (residential and services, and the primary sector) used 29% of the total. In comparison, the IEA averages in 2006 were a quarter for industry and 37% for both transport and other sectors. Over the past two decades, the share of transport has remained fairly stable, while industry has seen its share decline from more than 40% and the other sectors have accordingly gained ground. Energy use in all sectors has increased substantially since the mid-1990s (see Figure 8), reflecting strong economic growth.



 $^{\ast}$  includes residential, commercial, public service, agricultural, fishing and other non-specified sectors.

Sources: Energy Balances of OECD Countries, IEA/OECD Paris, 2008 and country submission.

Spain's energy intensity remained virtually flat from 1990 to 2005. The positive effect of rapid GDP growth on energy intensity was offset by the effects of increasing wealth on energy use. As Spaniards have become richer,

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private car use has grown and so has oil use in road transport, by around 87%. Also, electricity use in services and households increased at an above-average rate, and more than doubled in the period. Since 2005, however, intensity has decreased, and in 2007 was slightly below the IEA Europe average (see Figure 9). In 2007, for each thousand USD of gross domestic product (GDP), the country needed 0.13 tonne of oil equivalent (toe) of primary energy.



\* excluding Luxembourg and Norway throughout the series, as forecast data are not available for these countries.

Sources: Energy Balances of OECD Countries, IEA/OECD Paris, 2008; National Accounts of OECD Countries, OECD Paris, 2008 and country submissions.

## POLICIES AND MEASURES

### **OVERVIEW**

Spain's energy efficiency policy is laid out in the 2004-2012 Energy Saving and Efficiency Strategy (E4) and the Action Plan 2008-2012 under this Strategy. The measures in the Action Plan target energy efficiency improvements in all sectors. Full implementation of the plan would save a total of 60 Mtoe of TFC and 88 Mtoe of TPES over the 2008-2012 period. This would also lead to avoiding 238 Mt  $CO_2$ -eq of emissions. Savings in 2012 would amount to 24.8 Mtoe of primary energy (13.7 % of total TPES) and to 16.9 Mtoe of

final energy (12.4% of total TFC) as compared to business-as-usual. Half of these savings would come from the transport sector, 29% from industry, 13% from the building sector and the rest from changing appliances in homes and offices, and taking measures in agriculture and the public sector.

Public funding for the Action Plan 2008-2012 from the government and the autonomous regions would total EUR 2.4 billion, and private-sector investment is expected to amount to EUR 22.2 billion. Annual average spending will be clearly higher than under the 2005-2007 Action Plan for which total public funding was estimated at EUR 0.7 billion and private-sector investment at EUR 7.9 billion.

In addition to the Action Plan 2008-2012, measures to save energy are included also in the Saving and Energy Efficiency Stimulation Plan of August 2008. The Plan contains 31 urgent measures, including establishing a stable legal and financial framework for Energy Service Companies (ESCOs); a pilot project for introducing electric cars; reducing speed limits; distributing free low-energy bulbs to households; and increasing the budget for energy efficiency projects to EUR 120 million in 2009.

Energy efficiency policy is increasingly guided by EU directives and nonbinding goals which, however, leave room for Spain to decide how to attain them. The most important directives are described below.

### EU TARGETS AND DIRECTIVES

The Directive on Energy End-Use Efficiency and Energy Services (2006/32/ EC) contains an indicative national energy savings target of 9% to 2016, to be reached by way of energy services and other energy efficiency improvement measures in the sectors that are not part of the EU-ETS. The reduction is calculated against the annual average TFC in the non-ETS sectors over the most recent five-year period previous to 2008 for which official data are available.

The *Directive on the Energy Performance of Buildings* (2002/91/EC) sets requirements for a more energy-efficient building code, including minimum performance standards and energy certificates. Requirements for energy labelling of household appliances, in turn, are based on several directives adopted over the past 15 years. They also include compulsory minimum efficiency requirements. Over the longer term, the *Directive Establishing a Framework for Setting Ecodesign Requirements for Energy-Using Products* (2005/32/EC) will improve the energy efficiency of new products outside the transport sector. Furthermore, the EU-ETS has an indirect, but strong effect on energy efficiency in heavy industry and the heat and power sector.

In addition to the -9% target by 2016, Spain and other EU member states have also agreed to a non-binding -20% target for 2020. This 2020 target is

calculated as savings in TPES from the business-as-usual scenario. As explained in more detail in Chapter 8 on Renewable Energy, Spain will also have to meet a binding EU target for renewable energy in 2020. This target is for a 20% share of renewable energy in gross final consumption in 2020, against 8.7% in 2005. Success in improving energy efficiency will, therefore, be essential for reducing GHG emissions and increasing the share of renewable energy in final consumption of energy.

#### BUILDINGS

Three laws set the framework for energy efficiency in buildings. They are the Royal Decree approving the Technical Code of Buildings (CTE) of March 2006; the Royal Decree on the Basic Procedure for Energy Performance Certification of New Buildings of January 2007; and the Royal Decree approving the review of the current Regulations for Thermal Installations in Buildings (RITE) of August 2007.

Minimum energy requirements for new buildings are described in the CTE; they vary according to the 12 climate zones in the country. CTE includes requirements for energy efficiency and the use of renewable energy, such as maximum U-values<sup>4</sup> for building components; minimum efficiency performance standards for thermal installations and lighting; minimum natural lighting contribution; as well as a minimum level of solar contribution to power and domestic hot water supply.

Energy performance certification of new buildings is based on the "basic procedure" set by the Royal Decree of January 2007, but the details can vary from one autonomous region to another. A National Advisory Commission is responsible for advising on the various regional systems and co-ordinating them. Certification of existing buildings is expected to be introduced in 2009.

Measures on existing buildings focus on refurbishing the building shell to reduce energy demand for heating and cooling, and improving lighting, heating, cooling and hot water systems. The government is subsidising refurbishments with EUR one billion from 2008 to 2012. Subsidies can be used to cover up to 35% of eligible cost. Subsidies for refurbishments are capped at EUR 10 000 for single-family houses and EUR 300 000 for blocks of flats and other buildings. Subsidies for improving internal lighting are capped at EUR 10 000 for blocks of flats and EUR 30 000 for blocks of flats and EUR 10 000 for blocks of flats and EUR 300 000 for other buildings.

The government also subsidises constructing and retrofitting buildings to certificate level A and B standards. Subsidies for single-family houses are

<sup>4.</sup> The U-value represents the rate of heat loss, *i.e.* how much energy passes through one square metre of a material by a difference of one degree in temperature. It is measured in watt (W) per degree Kelvin (K) per m<sup>2</sup>.

capped at EUR 30/m<sup>2</sup> for B label and EUR 50/m<sup>2</sup> for A label. Subsidies for blocks of flats are capped at EUR 20/m<sup>2</sup> for B label and EUR 35/m<sup>2</sup> for A label, and for other buildings, at EUR 15/m<sup>2</sup> for B label and EUR 30/m<sup>2</sup> for A label. Moreover, 75% of the planning costs can be subsidised.

#### **APPLIANCES**

Mandatory energy labelling of domestic appliances is based on the EU directives. It covers lamps, ovens, refrigerators, freezers, washing machines, tumble-dryers and dishwashers. Appliances are classified from A to G, where class A is for the most energy-efficient appliances. In 2004, two new classes were introduced: compared to class A, electricity use in class A+ is 25% lower and in class A++ 40% lower.

In the coming years, minimum energy efficiency standards for appliances will be introduced in Spain and other EU member states. These standards will be set by EU regulations based on the Ecodesign Directive (2005/32/EC). Since autumn 2008, the EU Commission is gradually proposing such standards for close to 20 product groups.

In the area of household appliances, Spain subsidises the replacement of inefficient appliances with new efficient ones (labelled A or higher) through the Renove programme. Since 2006, some 1.8 million appliances have been replaced, mostly washing machines and fridges, but also dishwashers and freezers. The programme has managed to help raise general awareness of energy efficiency and introduce higher-efficiency appliances into the Spanish market. It is now being expanded to include air-conditioners, boilers and windows. In the area of lighting, Spain is also subsidising the replacement of traffic lights with light emitting diodes (LED) technology in some 600 municipalities, affecting a quarter of all traffic lights in the country. The annual electricity savings are estimated at 90 GWh.

#### INDUSTRY

Spain supports energy efficiency improvements in industry by subsidies. The Institute for Energy Diversification and Saving (IDAE) grants direct subsidies for companies to invest in improving energy efficiency. These grants are expected to amount to EUR 370 million over 2008-2012 and stimulate some EUR 1.7 billion in private-sector investment. All this should result in saving 7.9 Mtoe of primary energy over the five-year period. Other measures included in the 2008-2012 Action Plan are maximising the number of voluntary energy-saving agreements with industry, and subsidising energy audits by 75% of the costs.

## COMBINED HEAT AND POWER (CHP)

In 2007, Spain had 6.1 GW<sub>e</sub> of installed combined heat and power (CHP) capacity at 874 plants. Some 90% of CHP is industry-related and industry consumes around 40% of all CHP generated. Electricity generation at CHP plants amounted to 35 TWh in 2008, accounting for close to 12% of total electricity supply in Spain.

CHP electricity generation at high-efficiency plants<sup>5</sup> qualifies for feed-in tariffs/premiums (see Chapter 8 on Renewable Energy). The Action Plan 2008-2012 has a target to raise Spain's CHP capacity to 8.4 GW<sub>e</sub> by 2012. Implementing the Action Plan's measures on CHP is planned to save around 0.5 Mtoe of primary energy in 2012. Four-fifths of these savings would come from retrofitting existing CHP installations, and the government is providing subsidies for this purpose. The government estimates the technological potential for CHP to lie close to 17 GW<sub>e</sub>, but Spain's mild climate limits the demand for heat outside industry.

#### TRANSPORT

Private cars remain the dominant form of passenger travel in Spain (see Table 4). Traffic volume by passenger cars doubled from 1990 to 2007, and so did bus use, while railway use for passenger transport grew by 41%. Spain has now 10 million more passenger cars than in 1990, with car density rising from 309 in 1990 to 481 per 1 000 inhabitants in 2007, as compared to the EU15 average of 500. During the last decade, the road network has been developed dramatically and Spain now has 20 km of motorway per 1 000 km<sup>2</sup> versus an average of 15 km in the EU15. This strongly favours road transport over other modes.

	Breakdown of Pa	Table <b>4</b>	el by Mode	2007
	Car	Bus	Train	Tram and metro
Share, %	79.7	13.7	5.1	1.5

Source: EU Energy and Transport in Figures – Statistical Pocketbook 2009.

Freight is mostly transported by road. It accounted for 96% of the total of tonne-kilometres in 2007. International haulage accounted for 26% of all haulage by heavy-duty vehicles registered in Spain. Freight volumes are closely linked to developments in the overall economy, and are currently declining.

Following the criteria laid out in Annex III of Directive 2004/8/EC, high-efficiency CHP saves at least 10% of primary energy as compared to separate generation of heat and power. It includes small-scale and micro CHP.

The Action Plan 2008-2012 includes fifteen categories of measures on transport. Full implementation is expected to save 9 Mtoe of TFC in 2012, or more than 50% of the total savings in all sectors, as compared to business-asusual. Two-thirds of the savings are expected to come from measures in four areas: management of transport infrastructures; urban mobility plans; greater rail participation; and renewal of the passenger car fleet. Many of these policies and measures are reflected in the national strategy for sustainable mobility the government adopted in April 2009.

Measures for managing transport infrastructures include raising public awareness, improving the use of passenger interchanges and logistics centres for goods, lowering speed limits, and reserving lanes for public transport and vehicles with high occupancy.

Urban mobility plans include measures to shift passenger transport from private cars to public transport, including by rail and incorporating sustainable mobility objectives in urban planning. Other examples of measures include congestion charging schemes, cuts in public transport fares, parking regulation and fees, promoting walking and bicycle use.

Greater rail participation will be stimulated by investment in the high-speed rail network. Spain has a Strategic Plan for Infrastructure and Transport 2005-2020 (Plan Estratégico de Infraestructura y Transporte, PEIT) that aims to decouple economic growth from demand for transport. Investments in railways are planned to amount to EUR 7.4 billion per year, or 48% of the PEIT budget. Expansions in the Spanish high-speed rail network account for some three-fifths of total expansion in the EU from 2008 to 2012. The goal is to have the high-speed railway network cover the entire country so that, in 2020, 90% of the population would live within 50 km from a station.

PEIT will also foster shifting to lower-carbon transport options and more sustainable modes of transport. In addition to rail, freight transport by sea will be supported by several measures, including infrastructure investment.

To stimulate renewal of the passenger car fleet, in January 2008 Spain revised its car registration tax to reflect  $CO_2$  emissions. Energy performance labelling for cars was introduced in 2009, and IDAE is subsidising purchases of alternative fuel cars, including 2 000 electric vehicles.

Moreover, a recently adopted EU regulation caps  $CO_2$  emissions from new passenger cars at 130 g/km from 2015 onwards. This requirement will be phased in so that in 2012, 65% of each manufacturer's newly registered cars must comply on average with the limit value. This will rise to 75% in 2013, 80% in 2014, and 100% from 2015 onwards. Although the law focuses on  $CO_2$  emissions, it is also expected to greatly improve overall energy efficiency in new passenger cars.

## CRITIQUE

Spain has raised its ambition to improve energy efficiency since the last review in 2005. It has revised legislation to give stronger incentives and impose more stringent requirements for higher energy efficiency. It has also substantially increased funding for energy efficiency projects. The IEA welcomes all these improvements.

In the past two years, the government has announced an impressive number of planned measures to improve energy efficiency in all sectors. Full implementation of the Action Plan 2008-2012 would save 13.7% of TPES and 12.4% of TFC in 2012, as compared to business-as-usual. In addition to this Action Plan, the government announced in summer 2008 a Saving and Energy Efficiency Stimulation Plan 2008-2011 that includes additional urgent energy efficiency measures.

These plans need now to be implemented, and the IEA encourages Spain to intensify efforts in this respect. As in all countries, there is in Spain more room for public awareness of the benefits of efficient use of energy. The government should also step up its efforts in this area, especially because an economic downturn tends to make citizens more willing to save energy, if it helps them to save money.

The current Action Plan runs until 2012, so there will soon be a need to prepare for post-2012 policies and measures. These should be based on a thorough cost-benefit analysis of the results of the current Action Plan. The government should also finalise its energy scenarios for demand forecasting. The autonomous regions are strongly involved in implementing the national energy efficiency plans and contribute about one-quarter of total public funding. Closer harmonisation of measures could help save energy at least cost and the IEA encourages IDAE to continue its efforts in this area.

Energy efficiency standards for new buildings have been improved, and a certificate system for the energy performance of new buildings has also been introduced and is expected to be extended to existing buildings in 2009. The IEA applauds these improvements and encourages measures now to be focused on improving energy efficiency in the existing buildings. Particularly now that the long construction boom is over and demand for new buildings will likely remain low for several years, more can be achieved in the existing buildings. Intensified refurbishment efforts could also help restore employment in the building sector. At the same time, however, national targets could be set to ensure a certain market share for passive houses, zero-energy buildings and other ultra-low energy-consuming new constructions by 2020.

Energy demand for air-conditioning is likely to continue to grow, also in light of climate change projections. There are several low-cost measures that the government should consider for limiting this demand, such as natural shading and the use of light colours for roofs and pavements. As these measures would reduce the consumption of electricity for air-conditioning, they would also save the money that the government is spending on subsidising both electricity generation and consumption.

Spain has a successful incentive programme – Renove – for replacing inefficient appliances. The argument for saving money through energy efficiency measures justifies expanding this programme, and the government should consider it. The IEA also welcomes Spain's plans to establish a stable legal and financial framework for Energy Service Companies (ESCOs). With regard to utilities, Spain should consider measures to encourage them to play an active part in funding and/or delivering end-use efficiency improvements among their customer base. These measures could also include placing energy efficiency obligations on utilities. Spain still has untapped CHP potential and is subsidising high-efficiency CHP generation to realise that potential to increase energy efficiency.

Transport is a crucial sector for energy efficiency, as it accounts for 38% of TFC and its share is still growing. Spain's strategy for sustainable mobility was adopted in April 2009 and has a strong element of energy efficiency. The IEA commends the government for this strategy and encourages the country to implement it without delay.

Spain has ambitious plans for promoting public transport and shifting freight transport from road to rail and sea. Expanding the high-speed rail network and increasing the use of railways in general are to be applauded. The government should also encourage the local and regional authorities to further integrate sustainable mobility considerations in urban planning and envisage congestion charges.

As mentioned in Chapter 5, Spain should consider the use of fiscal instruments to internalise the environmental externalities of oil use, in particular because transport fuel prices are among the lowest in Europe. Spain's move to differentiate vehicle registration tax as a function of  $CO_2$  emissions in 2008 is an important example of a step in this direction. Revenue-neutral taxes on transport fuels are another example of such incentives.

To improve energy efficiency, the IEA also urges the government to continue its work in making the national and EU policies fully consistent with the energy efficiency policy recommendations the IEA presented to the Group of Eight (G8). The IEA energy ministers endorsed the initial 16 measures in 2007. Since then, nine new recommendations have been added (see Box 1).

#### Box 1

# IEA G8 Energy Efficiency Recommendations

At the Group of Eight\* (G8) Summit in 2005 in Gleneagles, Scotland, the G8 countries asked the IEA to assist in developing and implementing energy efficiency policies. Responding to this request, the IEA subsequently prepared a set of energy efficiency policy recommendations covering 25 fields of action across seven priority areas: cross-sectoral activity, buildings, appliances, lighting, transport, industry and power utilities. These 25 recommendations were presented to the Summit of the G8 in Hokkaido, Japan in July 2008. The fields of action are outlined below.

1. The IEA recommends action on *energy efficiency across sectors*. In particular, the IEA calls for action on:

- Measures for increasing investment in energy efficiency.
- National energy efficiency strategies and goals.
- Compliance, monitoring, enforcement and evaluation of energy efficiency measures.
- Energy efficiency indicators.
- Monitoring and reporting progress with the IEA energy efficiency recommendations themselves.

2. *Buildings* account for about 40% of energy used in most countries. To save a significant portion of this energy, the IEA recommends action on:

- Building codes for new buildings.
- Passive energy houses and zero-energy buildings.
- Policy packages to promote energy efficiency in existing buildings.
- Building certification schemes.
- Energy efficiency improvements in glazed areas.

3. *Appliances and equipment* represent one of the fastest growing energy loads in most countries. The IEA recommends action on:

- Mandatory energy performance requirements or labels.
- Low-power modes, including stand-by power, for electronic and networked equipment.

- Televisions and set-top boxes.
- Energy performance test standards and measurement protocols.

4. Saving energy by adopting efficient *lighting* technology is very costeffective. The IEA recommends action on:

- Best-practice lighting and the phase-out of incandescent bulbs.
- Ensuring least-cost lighting in non-residential buildings and the phase-out of inefficient fuel-based lighting.

5. About 60% of world oil is consumed in the *transport* sector. To achieve significant savings in this sector, the IEA recommends action on:

- Fuel-efficient tyres.
- Mandatory fuel efficiency standards for light-duty vehicles.
- Fuel economy of heavy-duty vehicles.
- Eco-driving.

6. In order to improve energy efficiency in *industry*, action is needed on:

- Collection of high-quality energy efficiency data for industry.
- Energy performance of electric motors.
- Assistance in developing energy management capability.
- Policy packages to promote energy efficiency in small and medium-sized enterprises.

7. *Energy utilities* can play an important role in promoting energy efficiency. Action is needed to promote:

• Utility end-use energy efficiency schemes.

Implementation of IEA energy efficiency recommendations can lead to huge cost-effective energy and  $CO_2$  savings. The IEA estimates that, if implemented globally without delay, the proposed actions could save around 8.2 Gt  $CO_2$ /yr by 2030. This is equivalent to one-fifth of global energy-related  $CO_2$  emissions in 2030 under the IEA Reference Scenario, in which no new policies are adopted or implemented. Taken together, these measures set out an ambitious road-map for improving energy efficiency on a global scale.

The IEA will shortly publish its evaluation of the performance of all member countries, including Spain, on these recommendations.

<sup>\*</sup> The Group of Eight is an international forum for the governments of Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States.

# RECOMMENDATIONS

The government of Spain should:

 Intensify efforts to ensure effective implementation of ambitious energy efficiency programmes and raise public awareness of the benefits of saving energy.

#### **Buildings and appliances**

- Promote energy efficiency refurbishments in buildings, including to limit the need for air-conditioning.
- Consider expanding the Renove programme.

#### Industry

- Encourage the utilities to promote the introduction of demand-side measures by their customers, including the use of ESCOs.
- Continue to encourage the uptake of high-efficiency CHP technology.

#### Transport

- Move to implement the strategy for sustainable mobility without delay.
- Strengthen fiscal instruments in the transport sector.

# PART II SECTOR ANALYSIS

## SUPPLY AND DEMAND

#### SUPPLY

Oil continues to be the most important energy source in Spain. In 2008, oil supply amounted to 64.6 Mtoe, accounting for 46.9% of TPES. Its share has been slowly declining from 51% in 2000, but remains above the IEA average (39% in 2007).

Domestic production is negligible and in 2008, 99.8% of all oil was imported. Crude oil imports totalled 58.5 Mt and came from more than 20 countries. Russia had the largest share (15%), followed by Mexico (13%), Iran (12%), Saudi Arabia (11%), Libya (10%) and Nigeria (9%). OPEC provided 52% of all imports. Spain is also a net importer of oil products and its oil products trade reflects the strong dieselisation of the country's vehicle fleet. In 2008, imports amounted to 26.7 Mt (46% of which was diesel) and exports to 10 Mt (mostly gasoline and fuel oil). Spain imported oil products from more than 30 countries and exported them to some 20 countries.

#### DEMAND

In 2007, oil accounted for 57% of TFC, amounting to 58.2 Mt. Oil use grew from the late 1980s until 2005, but has levelled off since then (see Figure 10). Transport is by far the largest user (65% of the total in 2007) and it is also the only sector where oil consumption has continued to grow, up 27% from 2000 to 2007. With the economic slow-down, this pattern has changed, however. According to CORES, the stockholding agency, in the first quarter of 2009 diesel use decreased by 7.0% year-on-year to 8.7 Mt, and gasoline use by 6.9%, to 1.4 Mt.

Oil use in industry accounted for 22% of the total in 2007. It increased from the mid-1990s until 2001, and since then has declined by 14%. Oil use in the other sectors (13% of the total in 2007) peaked in 2004, and since then has declined by 17%, reflecting higher oil prices, but also the replacement of liquefied petroleum gas (LPG) by natural gas in cooking and heating. The government projections until 2016, dating from before the current economic downturn, see oil use increase slightly from current levels.

Within the transport sector, diesel use has been rising particularly fast. Diesel cars' share of all new registrations surpassed the 50% level in 1999 and

has gradually risen to around 70% in 2007. The government is addressing the rapid growth in oil use in the transport sector with a wide range of measures (see Chapters 4 on Energy Efficiency and 8 on Renewable Energy). Many of these measures are included in the national strategy on sustainable mobility, adopted in April 2009, including proposals for congestion charging schemes, cuts in public transport fares, measures to encourage the purchase of electric and hybrid vehicles and greening the government's transport infrastructure plan for 2005-2020.



\* Total primary energy supply by consuming sector. Other includes other transformation and energy sector consumption. Industry includes non-energy use. Commercial includes residential, commercial, public services, agriculture/forestry, fishing and other final consumption.

Sources: Energy Balances of OECD Countries, IEA/OECD Paris, 2008 and country submission.

## INDUSTRY AND INFRASTRUCTURE

#### REFINERIES

There are ten refineries in Spain, nine of which are on the coastline (including one on the Canary Islands) and receive their crude oil directly by ship. Puertollano is the only inland refinery. Out of the ten refineries, four are fully-owned and one is partly owned by Repsol YPF (about 56% of total refining capacity), three by Cepsa (about 33%) and one by BP (see Table 5). The bitumen-producing refinery in Tarragona is owned by Asphaltos Españoles SA, or Asesa (50% by Repsol YPF and 50% by Cepsa). Total refining capacity is about 1.3 million barrels/day (mb/d).

Spanish Refining Capacity, 2008									
Name	Owner	Capacity, Mt per year	Share of total capacity						
Cartagena	Repsol YPF	5.0	7.8%						
La Coruña	Repsol YPF	6.0	9.3%						
Puertollano	Repsol YPF	7.0	10.9%						
Tarragona	Repsol YPF	8.0	12.4%						
Bilbao	Petronor*	11.0	17.1%						
Tenerife	Cepsa	4.5	7.0%						
Algeciras	Cepsa	12.0	18.6%						
Huelva	Cepsa	5.0	7.8%						
Castellón	BP	6.0	9.3%						
TOTAL		64.5	100%						
Tarragona	Asesa**	1.1	Bitumen only						

Table 5

\* 85.98% Repsol YPF, 14.02% BBK.

\*\* 50% Repsol YPF, 50% Cepsa.

Sources: Oil Industry Association (AOP); company websites.

### PIPELINES AND STORAGE

Spain has one crude oil pipeline 358 km-long which links the inland refinery of Puertollano with the port of Cartagena; it has a capacity of roughly 151 thousand barrels/day (kb/d), or 7.5 Mt/yr.

An extensive network of pipelines for oil products is operated by Compañia Logistica de Hidrocarburos S.A. (CLH). The system links the eight main peninsular refineries and the main import terminals. CLH pipelines have a combined length of 3 837 km. The 29 pumping stations are operated from the CLH control centre at Torrejón, just outside Madrid. This pipeline network covers the whole peninsular territory and is available to every agent operating in the Spanish market. CLH transports more than 80% of motor fuels in Spain and thus reduces transport by tank trucks and other means.

The refineries have a storage capacity of 58 mb (9.2 mcm) for crude oil and other raw materials and 51 mb (8.1 mcm) for oil products. The CLH has 37 storage facilities with 42 mb (6.7 mcm) capacity and another 29 depots for airports with a storage capacity for petroleum products of 0.9 mb (0.144 mcm). In addition to CLH facilities, another 23 companies have

43 storage and distribution plants with a total capacity of 23 mb (3.7 mcm). The seven most important storage and distribution plants of these other companies are also connected to the CLH pipeline network.

CLH is owned by oil companies and institutional investors. Because of the strategic importance of the company, a Royal Decree was passed in 2000 to prevent any one company from holding more than 25% of the shares, and stipulates that refiners' combined shares must not exceed 45%. Compliance with this decree has resulted in several adjustments to the shareholding structure in recent years. Oil companies hold three-fifths of the shares. The biggest shareholder is Repsol YPF with 15%, followed by Cepsa with 14.15% and Disa and Oman Oil with 10% each. Eight other shareholders, including oil companies BP and Galp, each hold a 5% stake.

Spanish legislation guarantees third-party access to oil transport and storage facilities through a negotiated procedure on an objective, transparent and non-discriminatory basis. The National Energy Commission (CNE) is the sectoral regulator for the oil market.

#### **RETAIL MARKET**

The Spanish oil retail market is fully open to competition. The number of wholesale operators has increased from 49 at the end of 2005 to 84 in February 2008. Despite the many new entrants, retail market remains dominated by Repsol YPF which sold 41% of all motor fuels in 2007 and Cepsa (18% of sales). Market concentration, as measured by the Herfindahl-Hirschman index, has been steadily declining in recent years and in 2007 was 16% lower than in 2001.

At the end of 2007, Spain had close to 9 200 filling stations, operated by 14 oil wholesalers and several hypermarket chains and co-operatives. The three largest networks were those of Repsol YPF (3 603 stations), Cepsa (1 518), Galp (725) and BP (644).

Repsol YPF is listed on the Madrid, Buenos Aires and New York stock exchanges. Its largest shareholder is the Spanish construction company Sacyr Vallehermosa (20% of shares), and over 60% of the shares are free-float, *i.e.* held by investors with less than 5% of shares each. Cepsa is more than 90% owned by Total and the International Petroleum Investment Company (IPIC) of Abu Dhabi which bought out Unión Fenosa and Banco Santander in spring 2009.

### PRICES AND TAXES

Transport fuels are relatively cheap. In the first quarter of 2009, Spain had the fourth-lowest gasoline prices and the third-lowest diesel prices in IEA Europe (see Figures 11 and 12). Comparatively low excise taxation explains these

	(	Ex-tax price	Tax component	(tax as a percentage	of total price)										lic		rance	.4% Finland	1.3% Germany	72.5% Netherlands	1.5 1.6 1.7 1.8
OECD Unleaded Gasoline Prices and Taxes, First Quarter 2009	23.2% United States	26.6% Mexico	36% Canada	42.4% Australia	60.3% Korea	63.2% Poland	60% Hungary	57.5% Greece	59.2% Spain	63.9% Czech Republic	56% Japan	62% Switzerland	68.1% Austria	72.1% United Kingdom	67.3% Slovak Republic	69.1% Sweden	70.9% Fra	71.40	71.3		0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1

- Figure

Note: data not available for Belgium, Denmark, Ireland, Italy, Luxembourg, New Zealand, Norway, Portugal and Turkey. Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2009.

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Note: data not available for Belgium, Canada, Denmark, Ireland, Italy, Luxembourg, New Zealand, Norway, Portugal and Turkey. Source: Energy Prices and Taxes, IEA/OECD Paris, 2009. retail prices. Spain has a derogation of the EU timetable to raise minimum taxes on automotive diesel. Excise tax is EUR 302 per m<sup>3</sup> since the beginning of 2007 (beginning of 2010 for truckers), three years later than the other EU members. It will rise to EUR 330 per m<sup>3</sup> by 1 January 2012 in Spain, as opposed to 1 January 2010 in the EU.

In addition to excise taxes, oil products are levied a 16% value-added tax, but it is fully refunded for industry, electricity generation and truckers. Freight transport in Spain is traditionally by road, and low taxes have maintained the sector relatively competitive.

Spain abolished the system of additional regional taxes on motor fuels in summer 2008, at the request of the EU Commission. From 2002 until the abolishment, the autonomous regions had been allowed to apply an additional tax on oil products to finance their health systems. Six regions (Asturias, Catalonia, Castille La Mancha, Galicia, Madrid and Valencia) applied such taxes, which ranged from EUR 0.017 to 0.024 per litre for gasoline and EUR 0.012 to 0.024 per litre for diesel. Taxes in the Canary Islands continue to be lower than on mainland Spain, owing to application of a 5% special tax instead of the 16% VAT.

## SECURITY OF SUPPLY

Spain meets both its IEA and EU stockholding requirements by placing minimum stockholding obligations on CORES, the stockholding agency, and on oil industry (in practice, refiners and wholesalers). Spanish law requires minimum stocks of gasoline, middle distillates and fuel oil to equal 90 days (20 days for LPG) consumption or sales during the previous twelve months. However, industry has the option of holding stocks in the form of crude oil or semi-finished products, equalling a maximum of 40% of gasoline and distillates and 50% of fuel oil.

Spain revised its security of supply legislation with the Royal Decree 1766/2007 that increases the stockholding obligation from 90 to 92 days of sales of the previous 12 months as of 1 January 2010. It also obliges CORES to hold a larger share, as from the end of 2010, equalling 45 days of consumption, up from 37 days since October 2007. This is to cover at least 40 days of the obligation of each oil industry participant. CORES must also be prepared to hold more stocks on behalf of industry, if they request additional storage capacity. This additional obligation on CORES is capped at 35 days' consumption, but is subject to the availability of storage space. The law also requires companies to provide detailed information on their stocks.

CORES began operations on 31 March 1995, as a public corporation under the authority of the Ministry of Industry, Tourism and Trade. However, it is not part of the general administrative structure of the State. It has compulsory



Logal Bablo for on ood						
Legislation	Powers					
Royal Decree N° 1766/2007 on Regulating	Emergency response organisations					
Maintenance Obligation of Minimum Security Stocks, Natural Gas Diversification of Supply Provisioning and Stockholding Agency (CORES).	These Royal Decrees and Law provide the government of Spain with powers to set up a NESO, under control of a ministerial committee called the Government Delegate Commission for Crisis Situations (CDGSC).					
Royal Decree N° 1194/2004 on Establishing the Composition of the Commission for Crisis Situations.						
Law N° 34/1998 on the Hydrocarbons Act.						
Royal Decree N° 1766/2007 on Regulating	Stockholding					
Maintenance Obligation of Minimum Security Stocks, Natural Gas.	The Royal Decree and Law stipulate stockholding obligations in the following manner:					
Diversification of Supply Provisioning and Stockholding Agency (CORES).	<ul> <li>Companies are obliged to hold 53 days of consumption of three product categories, plus a 10% margin</li> </ul>					
	<ul> <li>The public stockholding agency CORES is obliged to hold 37 days of consumption of three product categories, plus a 10% margin.</li> </ul>					
Royal Decree N° 1766/2007 on Regulating Maintenance Obligation of Minimum Security	Implementation of stockdraw and other emergency measures					
Stocks, Natural Gas. Diversification of Supply Provisioning and Stockholding Agency (CORES).	The Royal Decrees and Law provide the government of Spain with the statutory power to release the reserves held by CORES and					
Royal Decree N° 1194/2004 on Establishing the Composition of the Commission for Crisis Situations.	companies in crisis situations.					
Law N° 34/1998 on the Hydrocarbons Act.						

#### Legal Basis for Oil Security Measures in Spain

Sources: Ministry of Industry, Tourism and Trade; Oil Supply Security: Emergency Response of IEA Countries 2007. IEA/OECD Paris, 2007.

membership for all companies authorised to distribute oil products in Spain. CORES has three main roles:

- To set up and manage strategic stocks.
- To monitor the minimum stockholding obligation of the industry (currently 53 days).

• To store (for a fee) the compulsory stockholding of any retailer or importer lacking suitable storage capacity on Spanish territory.

Historically, CORES has hired storage within the existing Spanish distribution infrastructure of logistic companies and refiners. New, purpose-built storage (commissioned by CORES) became operational in 2006. Spain has bilateral stockholding agreements with France, Italy and Portugal, thereby allowing Spanish operators to place part of their security stocks within these territories.

#### STOCK DRAWDOWN

The government has authority to draw stocks during an emergency under a wide range of situations. To do so, the Council of Ministers must first declare a crisis situation. Once a crisis is declared, the government can lower the stockholding obligation on industry and/or impose a direct intervention scheme upon CORES.

CORES would then release the emergency stocks either through a tender to all operators, at market prices, or directly by the operators following the instructions of the authorities. Its proposals are subject to approval by the Ministry of Industry, Tourism and Trade. CORES is also responsible for producing a procedure manual to cover emergency stock releases.

In the case of an international emergency situation – officially declared by the IEA – the Ministry of Industry, Tourism and Trade shall establish the necessary measures to meet Spain's international commitments.

### CRITIQUE

Oil remains the most important energy source in Spain, accounting for 47% of TPES in 2008. Transport uses almost two-thirds of all oil, and, unlike in other sectors, oil demand in transport has continued to increase until the beginning of the current economic slow-down.

As explained in Chapter 4, road transport accounts for more than 93% of passenger transport and 96% of goods transport. Together with the power and heat sector, transport is also the largest  $CO_2$ -emitting sector, accounting for one-third of emissions in 2007. The government is addressing oil use in the transport sector with a wide range of measures. These include investing some EUR 7.4 billion per year in railway infrastructure from 2005 to 2020 and promoting alternative energy sources, including electricity. The government has also adopted a national strategy on sustainable mobility in April 2009. The IEA welcomes these developments, and encourages the government to increase its efforts to promote a more efficient use of oil, for example by increasing motor efficiency through EU standards and R&D, driver awareness

and tax incentives. It should also work towards reducing the use of oil in transport by encouraging the use of alternative fuels, such as advanced biofuels and electricity, and rail and public transport, whenever possible.

By international comparison, diesel and gasoline prices are low in Spain, and low prices tend to increase demand. If the government means to steer oil use, it should consider revenue-neutral taxes as a way to do it. Taxes are typically much simpler and more cost-effective than any other measure. It is, however, challenging to sell them to the public, and overcome the resistance from pressure and interest groups, particularly in times of economic distress. For this reason, these taxes should be revenue-neutral, *i.e.* some other taxes should be lowered accordingly to keep the overall tax burden on citizens unchanged.

Spain's oil market is fully liberalised and market concentration is decreasing, but Repsol and Cepsa still sold almost three-fifths of all motor fuels in 2007. The government should continue to monitor the state of competition in the wholesale and retail oil markets.

Security of supply has been reinforced by the Royal Decree 1766/2007. The IEA particularly applauds the decision to raise the total obligation for minimum security stocks of oil products from 90 to 92 days from 1 January 2010. The government should continue this policy of ensuring compliance with the stockholding obligations. Import structures for both crude oil and oil products are well diversified geographically and logistically, which further improves security of supply. To address the lack of suitable sites for oil storage, Spain has also signed bilateral agreements with France, Italy and Portugal to hold stocks in these countries. The IEA applauds.

# RECOMMENDATIONS

The government of Spain should:

- Continue to monitor the state of competition in the wholesale and retail oil market.
- Increase its efforts to promote a more efficient use of oil, for example by increasing motor efficiency, driver awareness and tax incentives.
- Work towards reducing oil use in transport by encouraging the use of renewable energy as a fuel and by promoting rail and public transport, whenever possible.
- Continue to ensure compliance with the stockholding obligation.

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#### SUPPLY AND DEMAND

Natural gas is the second most important fuel in Spain, after oil. In 2008, it provided 25.3% of TPES. From 2000 to 2008, natural gas supply more than doubled, from 15.2 Mtoe to 34.9 Mtoe, making Spain one of the fastest-growing gas markets in Europe. Supply increased by 9.6% from 2007 to 2008 alone.

Domestic gas production is negligible, and Spain imports more than 99% of its gas needs. In 2008, 32% of gas imports came from Algeria, followed by Nigeria (20%), Qatar (13%), Trinidad and Tobago (12%), Egypt (11%) and Norway (7%). Gas supplies have been strongly diversified since 2001, when Algeria accounted for 70% of imports (see Figure 13). This diversification has relied on LNG. Spain is the largest LNG importer in Europe, approaching half of European LNG imports. It is the third-largest LNG importer in the world after Japan and Korea. In 2007, LNG supplied 72% of total imports, up from 50% in 2000. Pipeline gas was imported from Algeria and Norway.

Industry was the largest gas user in 2008, accounting for 44% of total demand. Power generation consumed 42% of all gas, households 10% and other sectors 4%. Industrial demand has remained fairly even over the past years. Demand growth has been driven by the power sector which more than doubled its gas use from 2001 to 2008, multiplying its share of total gas use from 5% in 2000 (see Figure 14). Consumption has also increased in the residential sector, as 60% more households were connected to the gas grid in 2008 than in 2000.

Seasonal gas demand in Spain fluctuates less than in other European countries, because of milder weather and consequently lower residential gas use. However, gas consumption for power generation depends on the availability of wind and hydropower, a fact that partly explains gas consumption patterns in 2007 and 2008. A wet and windy first half of 2007 increased wind power by 37% and hydro generation by 22% year-on-year, and reduced the need for natural gas. The second half of the year was drier and less windy, and the winter 2007/08 was colder than the previous one. Driven by record consumption for power generation, gas demand increased sharply during the last months of 2007 and the first quarter of 2008. However, demand weakened considerably during the last quarter of 2008, and especially during the first quarter of 2009. According to the TSO, consumption declined by 31% in power generation and by 9% in other sectors year-on-year in the



\* includes France, Egypt, Malaysia, the United Arab Emirates and countries not specified elsewhere. Source: Natural Gas Market Review, IEA/OECD Paris, 2009. first quarter of 2009. The economic crisis is having an impact on industrial demand, whereas demand in the power sector was reduced also because of higher hydro levels, increased wind output and improved price competitiveness of coal.



\* Total primary energy supply by consuming sector. Other includes other transformation and energy sector consumption. Industry includes non-energy use. Commercial includes residential, commercial, public services, agriculture/forestry, fishing and other final consumption. \*\* negligible.

Sources: Energy Balances of OECD Countries, IEA/OECD Paris, 2008 and country submission.

### **REGULATORY FRAMEWORK**

The Spanish gas market is a highly transparent system that complies with the EU legislation. The Second Gas Directive (2003/55/EC) concerning common rules for the internal market in natural gas was transposed into Law 12/2007. Many of the elements of this directive had already been included in the Spanish legislation.

The gas sector is regulated by the Ministry of Industry, Tourism and Trade and the National Energy Commission (CNE). The ministry holds regulatory powers such as price-setting and carries out the infrastructure investment planning under which most energy infrastructure in gas and electricity is built (see Chapter 2). The CNE holds substantial information-gathering powers and can act as an arbitrator in cases where conflicts about third-party access or other matters relating to regulated activities occur.

Since January 2003, all customers are free to choose their supplier. Spain gradually scaled down the system of regulated end-user tariffs and finally phased it out on 1 July 2008. Since then, the smallest customers are eligible to a cost-covering last-resort tariff (see below under Prices and Tariffs) and gas supply to all other customers is open to competition. All companies active in more than one sector of the natural gas supply chain have to apply legal, functional and accounting unbundling.

Regulated third-party access to all basic gas infrastructures (pipelines, LNG facilities, and underground storage) is founded on cost-based tariffs. These tariffs are set by the Minister of Industry, Tourism and Trade and are published in the official gazette (BOE). Entry-exit single-zone tariffs apply in the whole gas system.

Enagás is the transmission system operator. It is responsible for the operation and management of the transmission network and the secondary transport networks as defined in the 1998 Hydrocarbons Act. The procedures and mechanisms for the technical management of the system are established in the network code that follows the principles of objectivity, transparency and non-discrimination. The code is approved by the Ministry of Industry, Tourism and Trade in co-operation with Enagás and the gas industry.

Enagás is a fully independent company that was floated on the Madrid stock exchange in June 2002. No shareholder is allowed to have more than 3% of voting rights, or 1% if the shareholder is active in the natural gas sector. TSO activities are separated from the other activities of Enagás on the accounting and functional levels, as stipulated in Law 12/2007.

Although Spain does not have a spot market for gas, Enagás operates an informal daily over-the-counter (OTC) market for bilateral transactions through its MS-ATR platform. This secondary market has grown fast and, in 2007, trading volume exceeded national gas consumption by 8%. As of February 2009, 33 companies were licensed to operate in this market. The OTC market is particularly important for small gas suppliers that have access only to LNG and lack a large customer base.

In March 2007, the governments of Spain and Portugal decided to create several working groups in order to develop a common Iberian Gas Market (MIBGAS) and, taking into account the significant LNG capacity in the peninsula, to create an Iberian hub at international level. Current work, under the umbrella of the South Gas Regional Initiative of the European Regulators' Group for Electricity and Gas (ERGEG), focuses on harmonising licences and tariffs and co-ordinating network planning.

## INDUSTRY STRUCTURE

Spain's gas retail market has seen a decline in the share of Gas Natural, the traditional incumbent, from 64% in 2002 to 46% in 2008 (see Table 7). This is mostly the result of electricity companies entering the gas market to secure their own gas supplies and is reflected both in their share of imports and in the retail market. In 2007, these electricity companies supplied 73% of the gas for their power plants.

The retail market for the 5 000 industrial customers is fairly competitive. In 2008, 17 companies supplied gas to industry. Competition in the residential market is much more limited, only five companies supplied gas to the 6.9 million households.

Capturing market share is fairly straightforward among the large industrial users, but costly in the residential segment where economies of scale favour large suppliers. In 2007, 80% of households were under regulated tariffs. Households also tend to remain loyal to the incumbents and often accept offers for combined electricity and gas deliveries from companies operating in both sectors, such as Gas Natural, Endesa, Iberdrola and Unión Fenosa.

Breakdown of Gas Sales and Infrastructure Ownership by Company, 2007										
	Imports	Retail market (2008)	OTC market	Distribution grid	Transmission grid	LNG capacity				
Gas Natural	52%	46%	12%	86%	6%	4%				
Iberdrola	12%	13%	13%	-	-	10%				
Unión Fenosa	11%	12%	19%	-	-	16%				
Endesa	8%	9%	13%	9%	3%	8%				
Naturgas	4%	5%	11%	5%	2%	4%				
Shell	2%	3%	6%	-	-	-				
Cepsa	5%	4%	12%	-	-	4%				
BBE/BBG	2%	2%	4%	-	-	-				
BP	1%	1%	3%	-	-	-				
GDF	3%	2%	5%	-	-	-				
Enagás	-	-	-	-	89%	50%				

\_ Table 7

Source: CNE (Annual report to the European Commission 2008; Supervision del mercado minorista de gas natural - año 2008).

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Industry structure will look different once Gas Natural has finalised its takeover of Unión Fenosa in the first half of 2009. Gas Natural had long sought to strengthen its position in the electricity market, and unsuccessfully bid for Endesa before the company became the target of EON and Enel. The competition authorities have approved Gas Natural's acquisition of Unión Fenosa on the condition that Gas Natural sells 2 000 MW of power capacity and around 9% of its gas supply points in Spain, and that it transfers 600 000 small clients to its competitors.

#### INFRASTRUCTURE

Spain's gas grid reached a total length of 63 199 km in 2007, including 7 700 km of transmission grid operated at 72/80 bar. Transmission grid is mostly owned by Enagás, the TSO, whereas Gas Natural owns the majority of the distribution grid (see Table 7). Total investment in the gas infrastructure since liberalisation in 1998 had reached around EUR 9.5 billion by 2007.

The development of the gas networks is still ongoing and, at the moment, there are several infrastructures in the administrative phase or under construction. The Spanish transmission infrastructure for gas is developed under the regulated system allowing for full cost recovery by the developer. The government is using an infrastructure planning approach to assess the need for new developments in gas transmission and regasification. Companies building the required plant or pipelines will be guaranteed a return on their investment, but will have to make it available for use by third parties. While it is possible to develop infrastructure outside the regulated system, nobody has chosen to do so because of the higher risk incurred by developing without the guaranteed cost recovery.

#### **INTERCONNECTIONS**

Spain's gas grid is connected to Portugal, France and Morocco. The two interconnections with Portugal, at Tuy and Badajoz, have spare capacity, whereas the capacity of the two interconnections with France, at Larrau and Biriatou, face congestions. The capacity of these interconnections is expected to be enhanced in both directions and open seasons are scheduled for 2009 and 2010.

Co-operation between the TSOs in France and Spain has been promoted within the framework of ERGEG South Gas Regional Initiative and this has resulted in enhancing the two current interconnections as well as plans to develop a third one. On the eastern side of the Pyrenees, the MidCat project is at the planning stage and aims at building a 6.5 bcm two-way pipeline by 2015.

Pipeline gas from Algeria is imported through the Tarifa connection. A new connection, the Medgaz pipeline, is expected to be commissioned in 2009



– Figure **(B** 

he boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the IEA. Source: Natural Gas Information, IEA/OECD Paris, 2008.

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# LNG Terminals in Spain

Terminal	Capacity (bcm/y)	Mt∕ year	Storage (m³)	Start	Status	Owner
Barcelona	14.5	10.6	540 000	1969	Operational	Enagás
Barcelona expansion	1.3	1.0		2008	Operational	Enagás
Barcelona expansion (No. 7 & 8)	1.3		150 000	2010	Construction	Enagás
Huelva	11.8	8.7	460 000	1988	Operational	Enagás
Huelva expansion No. 5			150 000	2010	Construction	Enagás
Cartagena	10.5	7.7	287 000	1989	Operational	Enagás
Cartagena expansion No. 4	1.3	1.0	150 000	2008	Operational	Enagás
Cartagena expansion No. 5			150 000	2010	Construction	Enagás
Bilbao	7.0	5.2	300 000	2003	Operational	BBG, Repsol, EVE, BP, Iberdrola
Bilbao expansion No. 3	2.5	1.8	150 000	2012	Planned	
Bilbao expansion No. 4			150 000		Planned	
Sagunto	6.0	4.4	300 000	2006	Operational	Saggas: Unión Fenosa (42%), Iberdrola (30%), Endesa (20%), Oman (8%)
Sagunto expansion	1.8	1.3		2008	Operational	
Sagunto expansion No. 3			150 000	2009	Planned	
Sagunto expansion No. 4			150 000	n.a.	Planned	
Mugardos (El Ferrol)	3.6	2.6	300 000	2007	Operational	Reganosa: Endesa 21%, Unión Fenosa Gas 18.9%, Unión Fenosa 2.1%, Tojeiro 18%, Sonatrach 10%, the Galician government

10%, Caixa Galicia 10%, Banco Pastor 5%,

Caixanova 5%

LNG Terminals in Spain (continued)									
Terminal	Capacity (bcm/y)	Mt∕ year	Storage (m³)	Start	Status	Owner			
Mugardos expansion	3.6	2.6		2013	Proposed				
El Musel, Gijon	6.8	5.0	300 000	2011	Construction	Enagás			
El Musel, Gijon				2016	Planned	Enagás			
Gran Canaria	1.3	1.0	150 000	2012	Planned	GasCan (Endesa∕ Canary Islands)			
Tenerife	1.3	1.0	150 000	2012	Planned	GasCan (Endesa/ Canary Islands)			

Sources: Natural Gas Market Review 2008, IEA, Paris, 2008 and company information.

and will have an initial capacity of 8 bcm per year. Medgaz would link Algeria (Beni Saf) directly with Spain (Almeria), thus bypassing the historical transit through Morocco. Part of the gas entering Spain could also transit north to France. The Medgaz consortium is led by Sonatrach (32% of shares) and includes Cepsa (20%), Iberdrola (20%), Endesa (12%) and Gaz de France (12%).

#### STORAGE

Spain has two underground storage facilities, both depleted gas fields operated by Enagás, in Gaviota and Serrablo, with a total capacity of 2.166 bcm – around 6% of annual demand which is low compared to other countries. New underground facilities are planned: Enagás is converting a third depleted gas field at Yela into storage with a capacity of 1.05 bcm. Yela should be operational by 2011. Three other projects (Castor, Marismas and Reus) are being developed and will double storage capacity to 5.76 bcm by 2016, according to the 2008-2016 infrastructure plan. The modest underground storage capacity requires using LNG storage at the terminals. This capacity is also being expanded (see below).

## LNG FACILITIES

Spain has six LNG facilities, three of which are owned and operated by Enagás, one by BBG (Bilbao), one by Reganosa (El Ferrol) and the other by Saggas (Sagunto). Regasification capacity increased by 14 bcm from 2006 to 2008 and is being further increased in almost all facilities. Moreover, three new LNG

terminals (one on the northern coast of Spain and two in the Canary Islands) are committed according to the 2008-2016 infrastructure investment plan (see Table 8).

Spain has been able to attract many spot LNG cargoes in the past because of third-party access (TPA) to key infrastructure. A quarter of the capacity of regasification, storage, transportation and distribution system intake installations is set aside for short-term contracts, less than two years long, to respond to demand peaks. This often results in under-utilisation of the LNG terminals. The Enagás terminals in Barcelona, Huelva and Cartagena were used at 30-40% in 2008, compared with 50-70% for the terminals in Bahía de Bizkaia, Reganosa and Sagunto. This also reflects the use of locational tariffs since 2006 to encourage the use of the northern terminals.

## PRICES AND TARIFFS

#### PRICES

Import prices of natural gas are mainly linked to oil prices and have therefore fluctuated heavily in the past few years. In 2007, more than 80% of gas was supplied under long-term take-or-pay contracts (more than 10 years until expiry) and its price was indexed to oil. According to CNE, import prices of natural gas roughly doubled from the summer of 2005 to late 2008 and since then are strongly declining.

Natural gas prices for end-users increased sharply from 2002 to 2008. This trend has turned in late 2008 and, as reported by Enagás, enduser prices for industry and the power sector are decreasing with the declining demand and oil prices. According to Enagás, these prices dropped by more than a third from the beginning to the end of the first quarter of 2009. By international comparison, Spanish end-user prices are about the average, and prices for industry below average (see Figures 16 and 17).

#### TARIFFS

Until 1 July 2008, Spain was operating a dual system of regulated and freely negotiated end-user prices. Law 12/2007 abolished the final tariff system, whereby distribution companies were responsible for regulated supply, and introduced a new system of last-resort tariffs (maximum regulated price) for small customers. End-user tariffs to industrial consumers had been abolished in two phases in July 2006 and July 2007.


Note: Tax information not available for the United States. Data not available for Australia, Austria, Belgium, Canada, Denmark, Germany, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Sweden and the United Kingdom.



Note: Tax information not available for the United States. Data not available for Australia, Belgium, Canada, Denmark, Germany, Italy, Japan, Luxembourg, New Zealand, Norway and Sweden. Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2009.

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Gas Prices in Spain and in Other Selected IEA Member Countries, 1980 to 2008



Source: Energy Prices and Taxes, IEA/OECD Paris, 2009.

Initially, from 1 July 2008, the last-resort tariff applied to low-pressure customers (4 bar or less) with an annual use of 3 GWh or less. From 1 July 2009, the limit will be reduced to 2 GWh and, one year later, to 1 GWh. The government has nominated five companies as last-resort shippers: Gas Natural,

Endesa, Iberdrola, Naturgas and Unión Fenosa. Tariffs are cost-covering and set by the Ministry of Industry, Trade and Tourism for three months at a time. To improve price transparency and encourage supplier switching, the government set up a separate Customer Switching Office in 2008.

### SECURITY OF SUPPLY

The Hydrocarbons Act of 1998 first established the basic principles of the security of supply in the Spanish natural gas market as a requirement for natural gas companies to store minimum security stocks. A certain amount of this stock is considered "strategic", which only the government is entitled to use. Subsequent legislation, such as Royal Decrees of July 2004 and December 2007, has further developed and strengthened security of supply measures by setting out the requirements to maintain minimum stocks of natural gas and to diversify the sources of imported gas.

Regarding the maintenance of minimum stocks, shippers have to keep strategic stocks equalling ten days of previous year's sales at any given moment; these are under governmental control. Shippers also have to keep commercial stocks equalling two days of previous year's sales. Every year in October, they also have to keep an additional eight days of commercial stocks. The TSO allocates available storage volumes to companies, which pay regulated fees for the storage. These fees cover the variable cost of storage. The fixed costs are reimbursed separately at regulated conditions.

With regard to diversification of supply sources, no more than 50% of gas may be imported from one source or country. Large companies, with more than a 7% share of the market, must diversify their contracts to comply with this requirement.

Other legislation concerning security of supply includes the Resolution of July 2006 of the Ministry of Industry, Tourism and Trade, which defined the interruptibility process and the allocation procedure in times of emergency.

The Network Code of the Spanish natural gas system regulates the normal operation of the system and its operation in exceptional situations, including supply disruptions. These rules are continuously revised and updated by a panel comprising representatives of the gas industry and public organisations.

Each year, the Ministry of Industry, Tourism and Trade updates its Winter Action Plan. This plan includes mandatory provisions for all shippers to strengthen security of supply during the winter season, a minimum entry flow in the Spain-France interconnection at Larrau, mandatory minimum stock levels in LNG terminals, and certain restraints on the use of underground storage in order to build up stock levels. The government also carries out an annual revision of the mandatory planning in order to ensure that the necessary infrastructure to transport, store and supply natural gas to consumers is built in accordance with the requirements of demand forecast. The 2008-2016 Infrastructure Investment Plan includes more underground and LNG terminal storage capacity (see above).

Finally, Spanish legislation provides the means to survey and monitor security of supply. The Ministry of Industry, Tourism and Trade, in collaboration with CORES, the agency in charge of managing natural gas minimum stocks, regularly audits natural gas stocks held by the industry.

#### CRITIQUE

Since 2005, Spain has implemented several commendable policies and measures to improve its natural gas sector. The market has become more liberalised and less concentrated. Heavy investment in LNG has led to impressive diversification of supply sources and made these supplies more secure. The roles of the TSO and other market players have been clarified by new legislation. The share of imports from any given country has been capped lower than previously. Since end-2007, Spain has also been working with Portugal on building an Iberian gas market – MIBGAS.

As one of the fastest-growing natural gas markets in Europe, Spain has been expanding its natural gas infrastructure in parallel with the increase in demand. According to the Energy Infrastructure Investment Plan 2008-2016, most investment is to be allocated to expanding the domestic pipeline system and regasification facilities. Regasification plants will represent two-thirds of the total incremental entry capacity to 2016. This mandatory planning, based on a system of guaranteed returns, imposes no risk for the investors. Proceeding with the current scheme rather than introducing a market-based mechanism requires close monitoring of the investments so that economic sustainability can be ensured and under- or over-capacity in the gas infrastructure can be avoided.

Since the last in-depth review in 2005, Spain has made significant progress in various segments of the natural gas market and continued to enhance competitiveness. One important development is to have established Enagás as the technical system manager and diversified its ownership structure. The network code has been adopted and was modified, taking into account both the bottlenecks and the developments in the infrastructure. Fundamental issues, such as metering, have been addressed. Congestion is likely to become a challenge in the near future with gas demand increasing in the residential sector and with the commissioning of new regasification terminals and envisaged interconnections with France. Continuous monitoring of the transmission system and modification of the network code are essential for the optimal use of the infrastructure.

Spain has also made clear progress on the wholesale market and on the industrial segment of the retail market, with commendable rates of consumer switching. There has been an increase in the number of new players, mostly shippers, and their share in sales. In 2007, almost 90% of gas demand was supplied under free market conditions, outside of the regulated tariff system. The share of the regulated tariff system in the market has halved since 2005. Spain replaced the regulated retail price with a last-resort tariff system (LRT) in 2008 and defined a concrete time-frame to 2010 for gradual reduction in the consumption threshold which defines the LRT boundary. As in the electricity sector, Spain should continue to reduce and eventually eliminate regulated retail tariffs in the gas sector.

The market share of Gas Natural, the main operator, has decreased significantly to the current 50% of total gas imports. Other companies have consolidated their positions by using the entry capacity of LNG terminals with third-party access that has proven to be crucial to ensure competition. However, although all customers are legally eligible to switch supplier, competition has remained weaker in the residential segment of the retail market. Further action seems appropriate in order to foster effective competition in the residential market. The recent merger of Gas Natural and Unión Fenosa underlines the importance of continued vigilance in ensuring sufficient competition.

Natural gas demand varies significantly owing to seasonality, working characteristics of CCGT plants, and the growing interrelation with the electricity market. Gas demand will continue to be highest in industry and power generation, and these sectors are also the logical focus for stronger demand-side measures to improve security of supply and overall efficiency of the market. The development of the secondary market, in which a significant number of transactions are taking place mainly for balancing purposes, into a competitive liquid spot market would also be very positive for Spain's efforts to create one of the leading natural gas markets in Europe.

Since the last in-depth review, Spain has revised the framework concerning security of supply measures. The minimum stock requirement was reduced, taking into account the physical limitations of the existing storage facilities. CORES, the stockholding agency, regularly audits the stocks held by the industry, making a clear distinction between strategic and commercial stocks. Spain adopted the first Winter Action Plan in 2006 as a security of supply measure that has been updated annually, decreasing progressively in importance as the ordinary system rules are being consolidated. Encouragingly, the 2008-2016 Infrastructure Investment Plan calls for the increase of annual underground storage capacity from 2 bcm to 4.5 bcm. Together with the new regasification plants, working storage capacity would significantly increase

to improve the country's security of supply but also to facilitate a more competitive market.

Another change in the security of supply framework is the reduction in the share of imports from any single country from 60% to 50% in 2007. In the light of the current demand prospects, this reduction seems consistent with Spain's diversification policy to limit the total share of Algerian imports to a defined level. This also means that LNG will continue to be the major element of its supplies. New and enhanced interconnection with Algeria (Medgaz) and France will also integrate Spain more closely with the neighbouring natural gas markets and eventually the EU internal market.

# RECOMMENDATIONS

The government of Spain should:

- Monitor closely the development of domestic infrastructure, investigate the applicability of market-based options for the national gas system and develop strategies for demand-side participation.
- Continue to strengthen the management and operation of the transmission infrastructure and facilitate its optimal use.
- Improve the regulatory framework towards more competition in the retail market.
- Encourage the development of a liquid spot and balancing market.
- Continue to improve security of supply by ensuring development of storage capacity, revising the stock obligations accordingly, and reinforcing interconnections.

# SUPPLY AND DEMAND

#### SUPPLY

In 2007, coal use in Spain accounted for 20.0 Mtoe, or 14% of TPES. Both the volume and the share are close to the average since 2000. Imports accounted for 73% of coal supplies in 2007 and domestic production for the remaining 27%. The preliminary figures for 2008 are much lower (13.7 Mtoe and 10% of TPES), mainly because many units were taken temporarily out of use for installing pollution control equipment (see below).

Steam coal imports amounted to 20.8 Mt and came from 13 countries, led by South Africa (42% of total imports), Indonesia (22%) and Russia (13%). Coking coal imports amounted to 3.7 Mt and came from Australia (63% of the total), the United States (33%) and Canada (4%).

Domestic coal production (apart from lignite) is subsidised and as subsidies are being gradually reduced, production is declining (see Table 9). From 1990 to 2007, total coal production in Spain decreased by 53% to 17.2 Mt (5.5 Mtoe). Production of lignite largely ended in December 2007, with a residual production of just 0.2 Mt from the Meirama mine in January 2008.

		_ Table 9			
Total Co	al Produc	tion by Typ	e of Coal,	1998 to 20	07
	1998 Mt	2002 Mt	2005 Mt	2006 Mt	2007 Mt
Hard coal	6.1	5.4	4.8	3.8	3.5
Anthracite	5.9	4.4	3.3	4.6	4.4
Sub-bituminous coal	3.9	3.6	3.7	3.2	3.1
Lignite	9.8	8.7	7.6	6.9	6.2

Source: Ministry of Industry, Tourism and Trade.

#### DEMAND

Around 90% of coal is used for generating electricity, and some 10% for industrial processes, mostly to produce iron and steel, but also cement. Residential heating accounts for 1% of coal use (see Figure 18).

Coal provided 74 TWh of power in 2007, accounting for 24.8% of total generation. Some 8% of total generation came from local coal. These figures dropped dramatically in 2008, when coal accounted for only 15.3% of total generation, or 47 TWh. As coal is often used to supplement hydropower, its use for power generation varies annually according to hydrological conditions. In recent years, however, coal use has been more affected by competition with natural gas, and pollution control requirements. According to UNESA, the electricity industry association, coal-fired power plants in Spain have an average efficiency of 36% to 37% and emit 930 kg CO<sub>2</sub> per MWh generated, whereas the figures for combined cycle gas turbines (CCGTs) are 52% and 365 kg CO<sub>2</sub> per MWh. Under the EU-ETS, coalfired plants therefore face the highest emissions costs. The merit order of generation in Spain is largely defined by the relative prices of coal, natural gas and CO<sub>2</sub> allowances in a competitive market. Another factor affecting coal use was the need to meet new emission limit values under the EU Directive on Large Combustion Plants, effective since January 2008, which resulted in many units being taken temporarily out of service to retrofit flue gas desulphurisation equipment.



\* Total primary energy supply by consuming sector. Other includes other transformation and energy sector consumption. Industry includes non-energy use. Commercial includes residential, commercial, public services, agriculture/forestry, fishing and other final consumption.

\*\* negligible.

Sources: Energy Balances of OECD Countries, IEA/OECD Paris, 2008 and country submission.

For these reasons, electricity generation from the low-quality domestic coal is particularly affected. According to UNESA, electricity generation from domestic coal amounted to only 2 TWh in the first quarter of 2009, while, according to REE, the electricity transmission system operator, in the first quarter of 2007, it generated more than 13 TWh. Domestic coal use is declining markedly faster than its production capacity. It is also declining much faster than the use of imported coal: in the first quarter of 2009, imported coal provided 6% less power than in the first quarter of 2007. Coal-fired capacity remained roughly unchanged from 2007 to 2009.

# POLICY

Spain's current policy on coal is laid out in the National Coal Plan 2006-2012 (Plan del Carbón, or *Plan nacional de reserva estratégica de carbón 2006-2012 y nuevo modelo de desarrollo integral y sostenible de las comarcas mineras*). It follows the 1998-2005 plan in efforts to gradually reduce coal mining and restructure the economies of the mining regions. The plan outlines production targets, staffing and aid levels, supply guarantees and economic restructuring policies for the coal mining regions. The plan was signed in March 2006 by the Ministry of Industry, Tourism and Trade, the coal producer association (CARBUNIÓN) and trade unions.

A key part of the plan is to guarantee demand for coal and, in this respect, the system is similar to that in use under the previous plan. Use of Spanish coal at power plants is based on volume quotas set by the government. Power producers contract directly with mining companies for the volume and price of coal under their quota. Each power plant sets out the technical and quality characteristics for the coal it purchases in specifications with limits and penalties. Coal prices may vary for the same power plant depending on the supplier and also vary between power generation companies.

### **SUBSIDIES**

Subsidies for producing coal and restructuring the coal industry are subject to EU rules and approval by the European Commission. Under these rules, laid out in Council Regulation 1407/2002 on state aid to the coal industry, the European Commission permitted Spain to grant operating aid and inherited liabilities aid. In 2008, the European Commission approved the state aids for 2006 and 2007 according to Council Regulation 1407/2002 (Articles 4 and 5.3). Moreover, the state aids based upon Article 7 have been approved until 2010.

Spain reduced operating aid from EUR 503 million in 2005 to EUR 450 million in 2007 (see Table 10). These figures include aid to the government-owned HUNOSA from the State Enterprise Participation Organisation (SEPI). From 2006 to 2012, operating aid is to be reduced by 1.25% per year for underground mines and 3.25% per year for opencast mines (a degression of aid is required under Council Regulation 1407/2002). Excluding the SEPI aid to HUNOSA, the 2006-2012 plan foresees operating aid to decline from EUR 345 million in 2007 to EUR 324 million in 2012.

	Table 10		
Operating Aid to C	oal Mining Co	mpanies, 200	5 to 2007
	2005	2006	2007
Private companies	278	271	263
HUNOSA	225	198	187
Total (million EUR)	503	469	450
Aid per tonne (EUR)	44.1	40.4	40.9
Aid per employee (EUR)	61 200	63 700	70 300

Source: Ministry of Industry, Tourism and Trade.

Inherited liabilities aid can be used to pay benefits to former miners and cover the costs of mine closures. To reduce employment in the sector, Spain allows miners to retire early and offers a lump sum of EUR 60 000 to compensate for job loss to those too young for retirement. In 2007, this aid to former workers amounted to EUR 334 million. Aid for mine closures amounted to EUR 42 million in 2007, up from EUR 36 million in 2005. In addition to these aids, from 2005 to 2007 the government spent EUR 150 million per year on industrialisation projects and EUR 250 million on developing infrastructure in the affected mining regions. The government is also spending on R&D to develop clean coal technology, including carbon capture and storage (see Chapter 11 on R&D).

#### POLLUTION CONTROL

Operation of coal-fired power plants depends crucially on pollution control regimes. In Spain, these are largely determined by UNECE protocols and EU directives, notably the National Emission Ceilings Directive (2001/81/EC), the Large Combustion Plants Directive (LCPD, 2001/80/EC) and the Integrated Pollution Prevention and Control Directive (2008/1/EC, a codified version of 96/61/EC). Under the first directive, Spain must reduce its total sulphur dioxide (SO<sub>2</sub>) emissions to below 746 kilotonnes (kt) by 2010. According to a study commissioned by the European Commission, over the three-year period from 2004 to 2006, Spain's annual emissions of SO<sub>2</sub> from large combustion

plants averaged 949 kt, making it the highest emitter of  $SO_2$  among EU member states.<sup>6</sup> Two power plants accounted for more than half of these  $SO_2$  emissions: Puentes As Pontes and Teruel.

Under the LCPD, emissions to air of  $SO_2$ ,  $NO_x$  and particles from installations with a thermal input capacity above 50 MW are regulated. New plants (licensed after 1 July 1987) had to comply with the directive's emission limit values (ELVs) immediately, while existing plants were given until 1 January 2008 to be allowed to operate under a national plan to achieve equivalent pollution reductions. Plants which are operated 20 000 hours or less between 1 January 2008 and 31 December 2015 may opt out. Spain was granted certain special derogations that permit less stringent ELVs or desulphurisation rates for particular plants.

The National Plan for Reducing Emissions from Large Combustion Plants (PNRE-GIC) was adopted by the government in November 2005 and submitted to the European Commission for approval. Following revisions, a final version was published in 2007.<sup>7</sup> All existing coal-fired power plants are included under this plan, with owners choosing to opt out some plants under the 20 000-hour rule.<sup>8</sup> In Spain, the intention is to ensure emission reductions are achieved at the corporate level, thus giving some flexiblity to owners of multiple plants.

In meeting the requirements of the LCPD, Spain will see a sharp fall in  $SO_2$  emissions from large combustion plants following a significant investment in flue gas desulphurisation (FGD) over the last five years: by 2015, annual  $SO_2$  emissions are expected to fall to 168 209  $tSO_2$ , an 81% reduction from 2001 levels. Thirty-five large coal-fired generation plants are covered by the LCPD, comprising a total of 40 generation units with an average age of 30 years by 2007 (see Table 11). Five generation units have been opted out (totalling 807 MW, or 7% of total coal-fired generation capacity); the remaining units have installed or will install pollution control equipment, or reduce their emissions by other means in line with the National Plan.

<sup>6.</sup> Evaluation of the Member States' emission inventories 2004-2006 for LCPs under the LCP Directive (2001/80/EC), Final Report, September 2008, Entec UK Ltd. for DG Environment, Brussels. See Table 4.15.

<sup>7.</sup> Plan Nacional de Reducción de Emisiones de las Grandes Instalaciones de Combustión Existentes, final version, October 2007.

<sup>8.</sup> Only "existing" plants (*i.e.* those commissioned before 1987) can be included in a national plan under the LCPD. Two units at Alcúdia (2x130 MW<sub>e</sub>), the Elcogas Puertollano IGCC plant and the La Pereda waste coal CFBC at Mieres were commissioned after this date and must therefore meet ELVs.

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Coal-Fired Power Plants in Spain in 2009, with Status under EU Large Combustion

		Plants Dir	rective (LC	PD)			
Plant name	Location	Owner	Capacity, MW <sub>e</sub>	Units, MW <sub>e</sub> (commissioned)	Fuel	LCPD	Notes
Aboño	Candás, Asturias	Hidroelectrica del Cantábrico	603	1 x 360 (1974) 1 x 543 (1985) 1 x 800 (planned)	bituminous coal	plan plan	FGD (2006)
Alcúdia	Puerto de Alcúdia, Mallorca Island	Gas y Electricidad SA (GESA)	510	2 × 125 (1982) 2 × 130 (1997)	bituminous coal	plan ELV	∕₂FGD (1998) FGD (1997)
Anillares	Páramo del Sil, León, Castile and León	Unión Fenosa ⁄ Endesa	350	1 x 350 (1982)	bituminous coal	plan	
Cercs	Barcelona, Catalonia	E.ON	160	1 × 160 (1971)	bituminous coal ∕ lignite	opt out	
Compostilla	Ponferrada, León, Castile and León	Endesa	1 030	1 x 330 (1972) 2 x 350 (1981/⁄84)	anthracite ∕ bituminous coal	plan plan	FGD (1996) FGD (2009)
Elcogas	Puertollano, Ciudad Real, Castile-La Mancha	Elcogas	335	1 x 335 (1996)	coal 🗸 petcoke	ELV	ICCC
Escatrón	Escatrón, Zaragoza, Aragon	E.ON		1 x 80 (1990)	bituminous coal $\nearrow$ lignite		PFBC (closed)
Escucha	Escucha, Teruel, Aragon	E.ON	160	1 × 160 (1970)	bituminous coal $\nearrow$ lignite	opt out	

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# Coal-Fired Power Plants in Spain in 2009, with Status under EU Large Combustion

1/2FGD (1997) FGD (2009) FGD (2008) FGD (2009) FGD (2008) FGD (2008) Notes CFBC opt out LCPD plan plan plan plan plan EL< plan plan plan plan plan plan plan bituminous coal bituminous coal bituminous coal bituminous coal imported coal imported coal imported coal imported coal anthracite / waste coal anthracite / Fuel 2 x 550 (1984/87) 1 x 350 (1984) 1 x 350 (1984) 1 x 350 (1984) (commissioned) 1 x 350 (1981) 1 x 550 (1980) 1 × 154 (1969) 1 x 323 (1967) 1 × 165 (1964) 1 x 270 (1971) 1 × 165 (1967) 1 × 550 (1985) 1 x 50 (1994) 1 × 65 (1965) Units, MW<sub>e</sub> Plants Directive (LCPD) (Continued) Capacity, 1 100 MW<sub>e</sub> 515 620 515 550 550 323 50 569 Hulleras del Norte Unión Fenosa Unión Fenosa Unión Fenosa Iberdrola Iberdrola Iberdrola Owner Endesa E.ON <sup>2</sup>alencia, Castile and León Velilla del Rio Carrión, Carboneras, Almeria, Cerceda, La Coruña, Castile and León Sama de Langreo, Algeciras, Cádiz, La Robla, León, Basque County Tineo, Oviedo, Andalusia Guipuzcoa, Andalusia Location Galicia Asturias Mieres, Asturias Asturias Litoral de Almeria Plant name Los Barrios La Pereda La Robla Meirama Pasajes Guardo Narcea Lada

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	Coal-Fired Pow	er Plants in Spain in 20 Plants Directive	09, with Sto (LCPD) (C	atus under EU Large Continued)	<ul> <li>Combustion</li> </ul>		
Plant name	Location	Owner	Capacity, MW <sub>e</sub>	Units, MW <sub>e</sub> (commissioned)	Fuel	ГСРD	Notes
Puente Nuevo	Córdoba, Cordoue, Andalusia	E.ON	324	1 × 324 (1980)	bituminous coal	plan	FGD (2008)
Puentes As Pontes	La Coruña, Puentes de Garcia Rodriguez, Galicia	Endesa	1 400	4 x 350 (1976-79)	imported coal	plan	
Puertollano	Puertollano, Ciudad Real, Castile-La Mancha	E.ON	220	1 × 220 (1972)	bituminous coal	plan	
Soto de Ribera	Ribera Arriba, Oviedo, Asturias	Hidroelectrica del Cantábrico	672	1 x 68 (1962) 1 x 254 (1967) 1 x 350 (1984)	bituminous coal	opt out opt out plan	FGD (2008)
Teruel	Andorra, Teruel, Aragon	Endesa	1050	3 x 350 (1979-80)	bituminous coal∕lignite	plan	FGD (1996 & 2000)
Total			11 906	(807 MW opted out)			
Notes: The last uni	it at Avilés power station clo:	sed in 2005. Unit 1 at Compostil	lla is closed.				

Abbreviations: CFBC - circulating fluidised bed combustion; ELV - emission limit value; FGD - flue gas desulphurisation; IGCC - integrated gasification combined cycle; PFBC - pressurised fluidised bed combustion;

Sources: The National Plan for Reducing Emissions from Large Combustion Plants (PNRE-GIC); Ministry of Industry, Tourism and Trade; UNESA.

Table



- Figure



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# INDUSTRY STRUCTURE

Spain's coal mining industry is consolidating and its production is declining; these processes are set to continue. From 1990 to 2007, the number of coal mining companies has fallen from 234 to 28, the number of workers from 45 200 to 6 700 and coal production from 19.3 Mt to 11.0 Mt. The 2006-2012 plan foresees further reductions, so that in 2012, the companies would produce 9.2 Mt of coal and employ 5 300 people.

Most companies are very small: only seven produced more than 500 kt per year (see Table 12). As for employment, 12 companies had fewer than 25 miners and only three had more than 500. The largest coal mining company is private UMINSA (a result of the merger of 17 independent mining companies), exceeding 2 Mt of production per year with around 1 400 workers. The other major operator is the state-owned HUNOSA, which in 2007 had 2 655 workers and produced 0.951 Mt of coal.

Table 12							
Spanis	h Hard Coal P	Producers by Capacity	, 2007				
Annual production capacity, kt	Number of companies	Total annual production, kt	Share of total production, %				
< 25	7	108	1.0				
25-50	4	130	1.2				
50-100	4	476	4.3				
100-500	6	1 661	15.1				
> 500	7	8 623	78.4				
Total	28	10 998	100				

Source: Ministry of Industry, Tourism and Trade.

#### CRITIQUE

In 2008, coal accounted for 10% of Spain's TPES, and 70% of the coal was imported (on an energy basis). Around 90% of all coal is used for electricity and heat production, and coal-fired power plants produced 15% of all electricity in Spain. Coke production is the other major use of coal. These figures are much lower than in 2007, when coal provided 14% of TPES and a quarter of all electricity. The large decline is partly explained by the need to meet the new emission limit values under the EU Directive on Large Combustion Plants, effective since January 2008, which resulted in many units being taken temporarily out of service to retrofit flue gas desulphurisation equipment.

Although the EU-ETS penalises coal users, coal will likely continue to be an important part of the Spanish power mix, thus helping to balance the growing reliance on natural gas. Developments in carbon capture and storage could also boost coal use in Spain.

The domestic coal-mining industry has long been dependent on subsidies, as it cannot compete with imported coal. Commendably, operation aid to coal mines is gradually decreasing, from some EUR 500 million in 2005 to EUR 450 million in 2007, but it still remains considerable for an industry with fewer than 7 000 active miners.

All domestic coal is used for power generation, where it contributed some 8% to total power supply in 2007. Coal is therefore part of the electricity security equation and the future of domestic coal production should be considered in this context. Electricity supply can be secured by many more cost-effective ways, such as through energy efficiency, demand response, system integration, gas storage, interconnections, or stocks of imported coal.

Since early 2007, for a number of reasons, electricity generation from Spanish coal has collapsed by 37%, whereas domestic coal production is declining by a few per cent per year. As the power companies have an obligation to purchase fixed quantities of domestic coal from 2006 to 2012, they are in practice part of the subsidy arrangement.

The current subsidy scheme runs until 2012, after which the future of coal production in Spain remains open. Timely decisions are needed also because much of Spain's coal-fired capacity is nearing the end of its operational life. Phasing out subsidies is politically always difficult, but in this case, however, it is the recommended line to take, because the economic resources can be used for other purposes to the larger benefit of Spain's citizens and economy. The world coal market is very competitive and liquid, and relying on imported coal would not affect the reliability of coal-fired power generation. Separately, the government can continue to grant substantial aid to alleviate the social impacts of a shrinking coal industry.

# RECOMMENDATION

The government of Spain should:

• Continue to reduce subsidies for coal production and set a date for their complete elimination.

#### SUPPLY AND DEMAND

#### PRIMARY ENERGY SUPPLY

Primary supply of renewable energy has increased rapidly in recent years, from 7 Mtoe in 2000 to slightly over 10 Mtoe in 2008. This growth has been driven primarily by wind power, up from 0.4 Mtoe in 2000 to 2.7 Mtoe in 2008, but also by biomass, mainly biofuels for transport. The share of renewables in TPES has remained fairly stable, varying according to hydrological conditions. In 2008, renewable sources provided more than 7% of total primary energy supply (TPES), up from 6.4% in 2006 (see Figure 20). This puts Spain in the 14<sup>th</sup> position among the 28 IEA countries (see Figure 21). For comparison, renewables account for more than 40% of TPES in Norway (mainly hydro) and around one-third in New Zealand and Sweden. In Spain, biomass and waste typically account for around half of the total renewables supply, and hydro and wind each for almost a quarter, although these shares vary according to hydropower availability.

#### ELECTRICITY AND HEAT

In 2008, renewable sources accounted for 20% of Spain's electricity generation, which is the tenth-highest share among the 28 IEA member countries (see Figure 22). Renewable electricity capacity was estimated at 34 862 MW in 2007, a 13% increase from 2006 (see Table 13). Spain is the world's third-largest wind power generator; its wind power production is expected to continue to grow rapidly. Hydropower generation, in turn, has remained flat and will likely be challenged in the coming decades by climate change as higher temperatures and droughts are projected to reduce water availability.

The Spanish Institute for Energy Diversification and Saving (IDAE) estimates that in 2007 nearly 3.6 Mtoe of heat was produced from renewable sources, corresponding to 2.4% of TPES. This included 3.5 Mtoe from biomass and 0.093 Mtoe from solar thermal installations. Biomass is primarily agricultural and waste from wood industry. It is used in industrial processes (1.4 Mtoe in 2006) and residential heating (2.0 Mtoe in 2006).

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Source: Energy Balances of OECD Countries, IEA/OECD Paris, 2008.





\* estimates. Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2008.

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Renew	Renewable Electricity Generation Capacity, 1990 to 2007 (MW)									
	1990	1992	1994	1996	1998	2000	2002	2004	2006	2007*
Total capacity	16 378	16 575	16 726	17 343	17711	20 472	23 431	27 195	30 965	34 862
Hydro	16 231	16 395	16 456	16 888	16 632	17 960	18 068	18 167	18 314	18 372
Pumped storage	4 911	4 911	4 911	5 095	5 095	5 288	2 518	5 347	5 347	
Solar photovoltaics	3	4	6	7	9	12	20	37	175	642
Solar thermal										11
Wind	2	33	41	227	848	2 206	4 891	8 317	11 736	15 095
Municipal waste	27	29	40	94	94	94	94	189	189	186
Solid biomass	115	114	183	127	128	150	285	344	391	399
Gas from biomass	0	0	0	0	0	50	73	141	160	166
Solar collector surface (1 000 m <sup>2</sup> )	281	295	309	329	341	403	519	689	950	
Capacity of solar collectors (MWth)**	197	207	216	230	239	282	363	482	665	

Table D

\* 2007 data are IDAE estimates.

\*\* Converted at 0.7  $kW_{th}\!/m^2$  of solar collector area, as estimated by the IEA Solar Heating and Cooling Programme.

Sources: Renewables Information, IEA/OECD, Paris 2008; IDAE.

#### **BIOFUELS FOR TRANSPORT**

Biofuels production in Spain grew by 278 kt from 2003 to 2007 (see Table 14). In October 2008, the capacity of operating biofuel plants was reportedly 1.6 Mtoe/year, and projects under development were expected to add another 5.5 Mtoe/year. Biofuels use has increased its share in total transport fuels, and reached 1.15% in 2007, up from 0.32% in 2003

(see Table 14.). Idle production capacity is mostly explained by increasing production costs and bottlenecks in the commercialisation, and in the case of biodiesel, cheap imports from the United States.

Table 🗖

Biofu	uels Production a	nd Cons (kilot	sumption ronnes)	in Spain,	2003 to 2	2007		
		2003	2004	2005	2006	2007		
Bioethanol	Production capacity	220	220	250	420	420		
	Production	160	202	240	317	276		
	Consumption	152	167	177	179	175		
Biodiesel	Production capacity	96	145	186	358	946		
	Production	6	13	74	125	168		
	Consumption	6	9	27	63	290		
Share of tot transport se	al consumption in the ector (%)	0.32	0.38	0.44	0.54	1.15		

Sources: Country submission, based on Ministry of Industry, Tourism and Trade; APPA; IDEA; F.O. Licht's; EurObserver.

#### INSTITUTIONS

The key government institution for developing and implementing renewable energy policy is the Institute for Energy Diversification and Saving (*Instituto para la Diversificación y Ahorro de la Energía*, IDAE). It reports to the Department of Energy within the Ministry of Industry, Tourism and Trade. IDAE involvement in the renewable energy sector includes *i*) advising the government on policy issues; *ii*) co-developing projects in partnerships with private/commercial entities; and *iii*) promoting renewable energy technologies in Spain and abroad.

Regional and local authorities also play a key role in renewable energy development. Some autonomous regions have strong policies to support renewable energy projects, in particular through investment subsidies. The autonomous regions also have varying permitting and siting procedures for renewable energy projects.

# POLICIES AND MEASURES

#### **OVERVIEW**

Spain's renewable energy policy is strongly influenced by several EU quantitative targets. For 2010, they include national non-binding targets for renewable energy to provide 12% of TPES, 29.4% of electricity, and 5.75% of transport fuels.

For 2020, in turn, Spain has a binding national target for renewable energy to equal 20% of gross final consumption of energy. In addition to this overall target, Spain and other EU member states have a separate binding target for renewable energy to cover 10% of transport fuel demand in 2020.

The national government and the autonomous regions see renewable energy as both bringing environmental and energy security benefits, and enhancing local economic development and employment. Renewable energy technology development, especially wind and solar, is a focus area of Spain's industrial policy. Its current policy on renewable energy is laid out in the Renewable Energy Plan 2005-2010.

#### Renewable Energy Plan 2005-2010

Spain's Renewable Energy Plan 2005-2010 is a revised version of the previous Promotion Plan for Renewable Energies 2000-2010.<sup>9</sup> It sets targets that are slightly above the EU 2010 requirements. The targets are:

- 12.1% of primary energy supply;
- 30.3% of electricity production;
- 5.83% of fuel consumption in the transport sector.

To meet these targets, the Plan sets specific objectives for renewable power capacity, as outlined in Table 15. Overall, renewables are expected to contribute 20.2 Mtoe to TPES in 2010, including 2.2 Mtoe of biofuels.

Table 15						
Capacity Targets	in the Renewable Ene	rgy Plan 2005-2010				
Energy technology	Targeted new capacity, 2005-2010, MW	Targeted total capacity in 2010, MW				
Wind	12 000	20 155				
Biomass	1 695	2 039				
Biogas	94	235				
Solar PV	363	400				
Solar thermal	500	500				
Hydro (less than 10 MW)	450	2 199				
Hydro (more than 10 MW)	360	16 778				
Urban waste	0	189				
Total	15 462	42 494				

Source: Renewable Energy Plan 2005-2010.

<sup>9.</sup> For more details on the previous plan, see *Energy Policies of IEA Countries: Spain 2005 Review*, OECD/IEA Paris, 2005.

The government's financial support mechanisms for renewables include premiums and feed-in tariffs for power generation, investment subsidies (more than 90% of them for heat generation) and tax exemptions for biofuels. The 2005-2010 Plan envisages public spending of EUR 8.5 billion, of which around EUR 5.0 billion in premiums on electricity generation, almost EUR 2.9 billion in tax incentives for biofuels and some EUR 0.7 billion in investment subsidies.

The government expects that implementing the 2005-2010 Plan will lead to a total investment of EUR 23.6 billion from 2005 to 2010, of which EUR 0.7 billion would be public funding. The Plan should create 95 000 net jobs and avoid emitting 77 Mt  $CO_2$  that would otherwise come from natural gas combined-cycle power plants. Value for taxpayer money in terms of  $CO_2$  emissions avoided or jobs created is outlined in Table 16.



Public Spending per Tonne of CO<sub>2</sub> Emissions Avoided and per Job Created under the Renewable Energy Plan 2005-2010

Energy technology	Public spending per tonne of CO2 emissions avoided, EUR/tonne	Public spending per net job created, EUR/job		
Wind	78.8-84.5	68 766		
Biomass for electricity	88.7-142.5	85 584		
Biogas	78.8-84.5	159 526		
Biomass (co-firing)	23.2-24.5	145 197		
Solar PV	1100.3-1157.7	59 010		
Solar thermal power	520.8-560.2	48 602		
Hydro	77.0-77.9	141 522		
Biomass for heat (industry)	0	0		
Biomass for heat (residential)	20.2-26.1	58 811		
Solar thermal	11.4-26.1	75 138		
Biodiesel	120.9-127.0	210 042		
Bioethanol	271.8-282.8	210 042		
Average total	110	89 500		

Source: Renewable Energy Plan 2005-2010.

# ELECTRICITY

Since the adoption of the Electric Power Act in 1997, Spain has had a special tariff regime for electricity from renewable sources and combined heat and power (CHP). The cost of this support has been billed to all electricity consumers, proportional to their consumption. In 2004, the Royal Decree 4361/2004 introduced an important change to this system, allowing electricity generators under the special regime to choose between two options: *i*) a regulated tariff, or *ii*) a market price plus a premium. In 2007, the Royal Decree 661/2007 further modified the support system; in particular, it introduced the highest and the lowest price levels (cap and floor) for some technologies.

From 2007, the support scheme functions as follows. Operators of renewablesbased facilities can choose one of the two sales options for a period of at least one year. If they choose to sell electricity to the grid operator, they receive a regulated feed-in tariff. If they choose to sell it on the wholesale market, they receive a market price plus a premium, which will vary according to the hourly wholesale (pool) price. Both the fixed feed-in tariffs and the premiums are calculated taking account of the average cost of each technology to ensure a minimum profitability. Each technology and type of installation has a specific target (maximum limit) for new installed capacity; the support scheme is guaranteed until this target is reached.

Figure 23 illustrates the Spanish support system using wind power as an example. When the pool price is low, the premium increases to guarantee



Source: IDAE.

the generator a revenue equal to the floor price (73.66 EUR/MWh for wind). If the pool price varies between 43.39 EUR/MWh and 57.52 EUR/MWh, the revenue equals the pool price plus a fixed premium of 30.27 EUR/MWh. When the pool price exceeds 57.52 EUR/MWh, the premium decreases so that the total revenue (pool price + premium) does not exceed the cap, 87.79 EUR/MWh. If the pool price is higher than 87.79 EUR/MWh, there is no premium, and the operator receives only the market price. As of September 2008, 95% of wind system operators opted for the market regime, while only 5% for the regulated feed-in tariff.

The levels of feed-in tariffs, premiums, supplements, and cap and floor prices are updated annually using as a reference the consumer price index minus 0.25 until the end of 2012 and minus 0.5 from 2013. The government plans to review the support system in 2010 and then every four years, taking into consideration the results and the cost-effectiveness of the system for each technology. In the future revisions, the government is considering introducing a mechanism that would gradually reduce the cap and floor levels (degression).

The level of public financial support and the total revenues of generators per kWh produced vary significantly between technologies, as shown in Table 17. For example, wind received EUR 0.069-0.086 per kWh, while solar PV almost four times more in 2008.



#### Feed-in Tariffs and Premiums for Electricity from Renewable Sources, 2008

	Fixed price		Market option	
	Average tariff	Average	Average	Total
	received	prenium	market price	average
			paid to the technology	remuneration
	(cent€⁄kWh)	(cent€⁄kWh)	(cent€∕kWh)	(cent€∕kWh)
Solar PV	32.00			
Solar Thermoelectric	27.84	26.45	6.83	33.28
Wind	6.88	2.41	6.16	8.57
Hydroelectric	8.00	2.20	6.42	8.62
Biomass	10.52	4.84	6.53	11.37

Notes:

1. The table shows the average remuneration per technology but the Spanish feed-In tariff system has 16 categories (sometimes with sub-categories). The real remuneration for each category/sub-category may be different from the average.

2. Average market price varies according to generation technology, because of differences in the volume and timing of sales on the wholesale market and, therefore, in the wholesale price received. Source: Country submission.

The level of support for PV power has proven very generous and has generated a real boom of PV development in Spain, while putting pressure on the electricity bill. By September 2007, 85% of the 400 MW capacity target for 2010 had been met and as much more capacity was set to be built, the government decided to modify the support scheme after a 12-month transition period.

Since the end of September 2008, there is a new capacity target of 500 MW per year for 2009 and 2010, with sub-targets for different types of PV installations (roof/ground level). The feed-in tariff has been cut from EUR 0.45 per kWh to EUR 0.32-0.34, depending on the type of installation. By comparison, the weekly average wholesale price at the OMEL electricity exchange ranged from EUR 0.026 to 0.076 per kWh in 2007 and 2008 (see Figure 31).

If the annual limit for new capacity is reached, the feed-in tariff for new capacity to come on-line in the following year will decrease by 10%, while the new capacity limit will also conversely increase by the same amount. With this system, the market will be self-regulated. By the end of 2008, solar PV capacity exceeded the initial capacity target for 2010 more than eightfold.

To harness offshore sources of renewable energy, such as wind and tidal power, Spain adopted in July 2007 the Royal Decree 1028/2007, establishing administrative procedures for the authorisation of offshore electricity generating facilities. The government expects that this will lead to more active offshore wind development in the future. At present, however, onshore wind seems more economically attractive in Spain than offshore.

#### HEAT

Use of renewable energy (biomass) for heat in industry is already competitive and does not need government support. In the residential sector, Spain has a natural advantage in solar heating, and in the 2005-2010 Plan it receives significant government support. Spain's new building code CTE (*Código Técnico de la Edificación*), in force since September 2006, requires new and refurbished buildings to meet a certain share of domestic hot water demand with solar thermal energy. This share ranges from 30% to 70% depending on climate and other local conditions.

New potential for using biomass for residential heating in Spain is fairly small. There are, however, some opportunities for integrated district heating and cooling systems, and a few projects have been implemented in locations with favourable conditions. The new Regulation of Thermal Installations in Buildings (RITE) now includes sections on the installation of biomass systems for heating and hot water in buildings. This measure is aimed at overcoming the long-existing regulatory barrier to the proper development of this technology.

# TRANSPORT

Spain supports the use of renewable energy in transport by a "carrot and stick" approach: fiscal incentives and supply obligations. Since 2002, biofuels have benefited from a specific zero tax rate introduced by the Fiscal, Administrative and Social Measures Act 53/2002.

Law 12/2007 and Ministerial order ITC/2877/2008 set up binding targets and establish a regulatory framework for the use of biofuels and other renewable sources in transport. Fuel suppliers must ensure that 5.83% of their fuel sales to the transport sector come from renewable energy sources in 2010. The transitional target for 2009 is 3.4%. Only biofuels meeting the EU sustainability criteria will be qualified. Under the overall biofuel obligation, there are minimum individual objectives for both bioethanol and biodiesel (2.5% in 2009 and 3.9% in 2010 for each). Fuel suppliers can reach the overall target through different ratios of bioethanol and biodiesel, provided that the minimum individual targets are met.

The National Energy Commission (CNE) administers the compliance system with the biofuels obligation. It is a system of tradable certificates, based on the example of the United Kingdom's Renewable Transport Fuel Obligation run by the UK Renewable Fuels Agency. Each company subject to the obligation has to hold a minimum amount of certificates, which are issued by the CNE. In the case of non-compliance, the company has to pay compensation (not more than 30% of its obligation). Starting from 2010, up to 30% of the obligation can be fulfilled by certificates earned in the previous year.

Under the EU Renewable Energy Directive adopted in April 2009, Spain will have to supply 10% of road transport energy needs from renewable sources by 2020. The directive makes electricity from renewable sources eligible and, by giving its energy content increased weighting, quite attractive. Red Eléctrica de España (REE), the government and industry are studying the option of using electric vehicles to reduce the need to cut wind turbines off the grid at times of strong wind and low demand. Wind power could be used to charge the batteries of electric vehicles, instead.

### CRITIQUE

Over the past years, Spain has become one of the world leaders in renewable energy development, particularly in wind and solar energy. The national government and the autonomous regions see renewable energy as bringing environmental and energy security benefits as well as enhancing local employment and economic development. Renewable energy technology is also a focus area of Spain's industrial policy, with some remarkable success. In particular, Spanish wind and solar technology providers are increasingly important for the country's economic development, job creation and international trade. These developments are commendable and will help Spain tackle the climate change, environmental degradation and energy security risks. Renewable energy use has grown fast in the past years, though not faster than total energy demand. The share of renewable energy in Spain's TPES was slightly more than 7% in 2008, but will need to rise substantially to meet the country's future targets. The targets for 2010 are non-binding, but those for 2020 (a 20% share in gross final energy consumption and 10% share in transport fuels) are binding under EU law. The country will now have to prepare a plan on how to reach the 2020 targets. Reaching them will be particularly challenging, if total energy demand is to return to the high growth rates seen until the beginning of the current slow-down.

Currently Spain supports renewable energy by premiums/feed-in tariffs for electricity paid by final users, tax exemptions on biofuels, and investment subsidies (mostly for heat use in the residential sector). Although these policies have succeeded in rapidly increasing supply, especially of wind, solar PV and biofuels, they do not come for free. The total support on renewable energy is expected to amount to EUR 8.5 billion from 2005 to 2010, implying a cost of EUR 110 per tonne of  $CO_2$  emissions avoided. As renewable energy is not an end in itself, but a means for reaching the broader energy policy goals of economic growth, environmental protection and security of energy supplies, the costs and benefits of promoting it should be seen in a broad perspective. To ensure the overall cost-effectiveness of its energy policy, the government should continue to support renewable energy, but at the same time vigorously encourage energy efficiency improvements that often bring the same environmental and energy security benefits at a lower price. Given that the EU 2020 goal is for a higher share, not absolute volumes, of renewable energy in final energy consumption, making the end-use of fossil fuels more efficient should also be a key means to reach that goal.

Spain has made significant efforts since the last in-depth review to fine-tune its renewable energy policy. In particular, it has taken measures to optimise wind power integration into the electricity system. The Renewable Energy Control Centre, created by REE, the Spanish TSO, is a world-class pioneering initiative to increase the reliability and stability of the electricity system, while giving priority to renewables. It is also very positive that the support schemes have become more market-oriented over the last years. The support mechanisms can now be improved further to provide stronger incentives for cost reduction. Under the current framework, the government can review the level of subsidies every four years to take into account the technology learning curve. It is essential that the government decreases incentives for specific technologies over time, as it has done for solar PV, in order to move them towards full market competitiveness.

One area of particular importance is the predictability of support schemes. In 2008, the government reduced the premium for solar PV, following a "solar boom" which had been driven by initially very high subsidies. This reduction was motivated by the need to foster a price decrease and reduce the government

over-spending, sound reasons for revising any policy. However, reducing the subsidies made PV developers complain about "regulatory instability". Similar cases are familiar to other IEA member countries, underlining the importance of a stable, predictable and transparent framework with a clear time-frame for reducing and phasing out the support schemes. The IEA encourages the government to continue its efforts in this direction.

With its strong financial support, Spain has managed to significantly lower the economic barriers to deploying renewable energy technology. As in most countries, more work remains to be done in the area of non-economic barriers, potentially including administrative hurdles, obstacles to grid access, lack of information and training, and social acceptance issues. The government should identify these and work towards removing them. One specific area for improvement is the large discrepancy in permitting and siting procedures that exist in different autonomous regions, in addition to the requirements at the national level. Although such harmonisation is not entirely within the control of the national government, more efforts could be made in this direction.

As has been mentioned, Spain uses a "carrot and stick" approach of supply obligations and tax exemptions to stimulate biofuels use in transport. Under the recently adopted EU directive, renewable sources have to provide at least 10% of the energy use in transport in each member country by 2020. As environmental benefits from the first-generation biofuels are not highly convincing, the 2020 target gives increased weighting to second-generation biofuels and renewable electricity. The Spanish government, TSO and industry are already moving to develop solutions according to these new rules. In particular, the prospect of using wind energy to charge electric vehicles is a good example of a holistic approach much needed in energy policy and should be encouraged.

# **RECOMMENDATIONS**

The government of Spain should:

- Vigorously pursue support schemes for renewable energy and energy efficiency, while monitoring and reviewing them to ensure that the cost-effectiveness of the overall energy strategy is optimised.
- Continue efforts to ensure a predictable and transparent support framework to attract investments, while creating transitional incentives that will decrease over time, to foster technological innovation and move technologies gradually towards market competitiveness.
- Keep removing non-economic barriers.
- Continue to stimulate the development and rapid market uptake of more sustainable renewable energy sources for transport.

#### SUPPLY AND DEMAND

#### SUPPLY

In 2008, total power generation in Spain reached 306 TWh, up by 38% from 2000. Natural gas fuelled 39% of power generation while nuclear provided 19%, coal 15%, wind 10%, hydropower 8%, oil 6% and solar, biomass and waste 2%.

Spain's generation mix has evolved significantly since 1990, when coal, oil, nuclear and hydro generated 99% of all electricity. In 2008, these four accounted for only about 48% of the total. The rapid development of combined-cycle gas turbines (CCGTs) as well as wind power has diversified the generation mix (see Figure 24). From 2000, gas-fired generation has grown by 101 TWh, driven first by the need for fast capacity increases, but later also by the EU-ETS, and by the need for backup power for wind power capacity. Wind power accounted for almost all increases in renewable electricity generation, and rose from 5 TWh in 2000 to 32 TWh in 2008. CHP is a significant component of generation, amounting to 35 TWh in 2008, up 3% from 2007. Coal and oil, in turn, are declining, penalised by the EU-ETS.



<sup>\*</sup> includes unidentified electricity generation from combusted fuels for 2004, 2005 and 2006. Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2008 and country submission.

Government projections that were made before the economic downturn call for total generation to increase by 72 TWh from 2008 to 2016. Gas-fired generation would grow by 42 TWh and wind power by 33 TWh, whereas coalfired generation would decrease by 23 TWh and oil by 10 TWh. Following the current policy, the share of nuclear power in electricity supply would continue to decline, although generation would remain unchanged.

Spain was a net importer from the introduction of liberalisation in 1998 until 2004 when the flow turned to net exports. This was mainly due to a significant increase in exports to Portugal. Net exports in 2008 totalled 11.2 TWh, mainly reflecting exports to Portugal and Morocco, and partially offset by imports from France (see Table 18).

Table 18							
Spain's Cross-Border Trade in Electricity, 2004 to 2008 (TWh)							
	France	Portugal	Andorra	Morocco	Total		
2004	5.222	-6.419	-283	-1.546	-3.027		
2005	6.545	-6.829	-271	-788	-1.343		
2006	4.410	-5.458	-229	-2.002	-3.280		
2007	5.487	-7.497	-261	-3.479	-5.750		
2008	2.862	-9.586	-280	-4.217	-11.211		

Positive value: import balance; negative value: export balance.

Source: REE, The Spanish Electricity System. Preliminary Report 2008.

#### DEMAND

In 2007, total electricity demand reached 260 TWh (see Figure 25). Demand has grown rapidly since 2000, by 38%, but has lately come to a halt and started to decrease. According to REE, the TSO, demand increased by only 1% from 2007 to 2008, the smallest annual change since 1993. In the first four months of 2009, demand declined by 8.9% year-on-year.

In 2007, industry consumed 38% of electricity, services, agriculture, forestry and fishing 33%, households 28% and transport 1%. As the country has grown richer, electricity consumption has increased particularly rapidly in households and the services sector, by more than half since 2000. Annual use per citizen, at around 6.5 MWh, is a quarter below the OECD average, which is explained by the small size of electricity-intensive industry and low heating needs in a mild climate. Air-conditioners and electric heaters, however, are now widespread, contributing to the rising peak demand in recent years (see Figure 26).



\* includes commercial, public service, agriculture, forestry, fishing and other non-specified sectors. Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2008.





Source: REE, The Spanish Electricity System. Preliminary Report 2008.

Summer demand typically peaks in July owing to air-conditioning load while winter demand usually peaks in December or January owing to residential heating. The ratios of summer over winter peak were 95% in 2006 and 93% in 2008. From 1997 to 2007, winter peak demand increased by 166%, reaching 44 876 MW on 17 December 2007. Reflecting weak economic conditions, winter peak demand dropped to 42 961 MW in 2008.

#### Generating capacity

Total installed capacity reached 94 966 MW by year-end 2008, an increase of 5% over 2007 (see Table 19); 95% of capacity is on the peninsular system and 5% on the extra-peninsular systems. From 2001 to 2008, total capacity increased by 87%, one of the largest increases in IEA member countries, reflecting a significant build-up in CCGTs and wind capacity. Wind capacity has more than quadrupled to 15 576 MW in 2008, the third-highest in the world after the United States and Germany. The heavy investment in gas-fired capacity to serve as backup for wind power is partly explained by the low cross-border transmission capacity that equals only 5% of generating capacity (see below Cross-Border Interconnections). Another factor is the limited availability of hydropower for backup. Hydropower generation has remained flat in recent years, and according the REE, actually fell by 20% in 2008. It may face difficulties in the coming decades as climate change may raise temperatures and increase droughts.

insidiled Generaling Capacity in 2008 and Changes norm 2007									
	Peninsular system		Extra-peninsular system			National total			
	MW	%	08/07	MW	%	08/07	MW	%	08/07
Hydro	16 657		0.0	1		0.0	16 658		0.0
Nuclear	7 716		0.0	-		-	7 716		0.0
Coal	11 359		0.0	510		0.0	11 869		0.0
Fuel/gas <sup>1,2</sup>	4 418		-7.3	2 733		-3.0	7 152		-5.7
Combined cycle	21 667		3.4	1 387		20.7	23 054		4.3
Ordinary regime	61 817		0.6	4 631		3.4	66 449		0.8
Wind	15 576		12.6	146		0.1	15 721		12.4
Rest special regime	12 552		20.6	244		73.7	12 796		21.3
Special regime	28 127		16.0	390		36.2	28 517		16.3
Total	89 944		5.0	5 021		5.4	94 966		5.0

Table 19

Installed	Generatina	Capacity in	n 2008 ar	nd Chanaes	from 2007
manea	Ceneraling	cupacity if	1 2000 ai	na changes	2007

1. IGCC (Elcogás) included.

2. The power from the auxiliary units is included in the Canary Island electricity system. Source: REE, *The Spanish Electricity System. Preliminary Report 2008*.
## Ordinary and special regimes

Generating units can be divided into two groups – ordinary and special regimes – based on how they interact with the competitive electricity market. Generators under the ordinary regime essentially sell electricity to suppliers through the wholesale market pool. They typically receive remuneration for electricity sold in the market, plus capacity payments. These include long-term (10-year) investment payments which depend on the net power of the plant, and variable payments based on the available capacity of the plant. They can also sell electricity to qualifying customers through bilateral contracting.

Generators under the special regime are those using renewable resources with an installed capacity of up to 50 MW and co-generation. Special regime generators are not required to bid in the power pool. They may sell their net electricity production at: *i*) the tariff fixed by a Royal Decree, which is indexed to the average or reference tariff of the Spanish system, or *ii*) the Spanish pool price, plus certain premiums and incentives. In 2008, the peninsular system includes 69% capacity under the ordinary regime and 31% capacity under the special regime. The subsidy system is explained in detail in Chapter 8.

#### Intermittent generation and system integration

Wind power is intermittent and its contribution to electricity supply can therefore vary greatly. On 18 April 2008, a daily record wind power generation of 213.2 GWh was reached, equalling 28.2% of consumption. At a record level, wind power covered 43% of demand at 4:47 on 24 November 2008, delivering 10 273 MW. Demonstrating its intermittency, wind power covered only 1.15% of total demand at 16:22 on 27 November 2008.

The short- and medium-term projections see continued significant investments in gas-fired and wind-based capacity, although these projections are likely to be revised as they were prepared before the economic downturn. The Renewable Energy Plan 2005-2010 projects 20 GW of wind power by the year 2010. The Energy Infrastructure Investment Plan 2008-2016 contemplates 29 GW by 2016. Further increase is expected for 2020 in order to meet the EU target for renewable energy (a 20% share of gross final consumption).

The significant increase in intermittent generation sources has an impact on system operations and reliability, and requires backup power. In this regard, Spain has taken measures to optimise the integration of wind-based generation into its power system. A key worldwide pioneering initiative in this respect is the Renewable Energy Control Centre (CECRE), created by REE, to maintain the reliability and stability of the electricity system. It is an operational unit within the REE Power Control Centre, used to monitor and control electricity generated by wind or other renewable energy sources, and to securely integrate them into the power system. The control system has proved to work well, as strong fluctuations in wind generation have been accommodated in the electricity system without major blackouts. On several occasions, at times of strong wind and low demand, REE has also had to cut wind turbines off the grid. REE, the government and industry are trying to find ways to reduce such occasions, especially in light of strong future increases in intermittent power generation. Possible solutions could include more interconnections to France, using the surplus wind for pumped storage or, in the medium term, for charging the batteries of electric vehicles.

# **REGULATORY FRAMEWORK AND MARKET DESIGN**

Spain was among the first countries to embark on a power sector liberalisation process in 1998. The EU Electricity Market Directive of 1996 was transposed into the Electric Power Law of 1997 (Law 54/1997). The path to liberalisation was ahead of the EU market directive schedule on some aspects, *e.g.* in opening all market sectors to competition, legal unbundling and the introduction of a sectoral regulator, the National Energy Commission (CNE).

CNE has seen its mandate reinforced in 2005, and it now regulates, among other things, the interconnections, remuneration of transmission and distribution activities, and certification of origin for renewables. CNE has, however, only an advisory and consultative role. Its regulatory decisions, for example regarding tariffs, must be approved by the Ministry of Industry, Tourism and Trade.

The liberalisation process has resulted in a hybrid power sector that includes both regulated activities (transmission and distribution networks) and liberalised activities (generation and retailing). Transmission system operations had already been unbundled in 1985 when the transmission system operator Red Eléctrica de España (REE) was formed.

Since January 2003, all Spanish electricity consumers are eligible to choose their supplier. The contract conditions for electricity supply are freely established between parties. Initially, there were two supply options for consumers – liberalised supply or tariff-based supply – but the tariff system has been gradually changed and recently completely revised (see under Prices and Tariffs).

## MARKET DESIGN

The Spanish wholesale market was created on 1 January 1998. The established market framework enables trading in an official organised market (day-ahead and intra-day spot market) and trading outside of it (bilateral contracts between producers, retailers and their qualified consumers, including financial contracts and distribution and power plants capacity auctions). A key aim of this model is to provide different trading possibilities on equal terms for all at the right price.

Management of day-ahead and intra-day markets is the responsibility of the Operador del Mercado Ibérico de la Energía – Polo Español, S.A. (OMEL), which is also responsible for settlement and communication of payment obligations and collection rights deriving from the energy contracted in the day-ahead and intra-day electricity production markets. The intra-day market consists of six sessions which can be attended by all agents who have participated in the daily market or executed a bilateral contract, respecting the limitations set by the system operator in order to avoid constraints.

Once the daily market session is over, the system operator studies the technical viability of the operation schedule in order to guarantee the security and reliability of supply. If the schedule resulting from the daily market plus the bilateral contracts does not meet security requirements, the system operator solves such technical constraints by modifying the production units' schedule.

Spain and Portugal launched the all-Iberian electricity market (MIBEL) on 1 July 2007, with the goal of improving security of supply and economic efficiency. A common price for electricity for both countries applies when the interconnection capacity allows it. In case of congestion, the market is split into two price zones. MIBEL enables any consumer in the Iberian zone to acquire electricity under a free competition regime, from any generator or retailer in Portugal or Spain. The MIBEL spot market functions as explained above and is operated by OMEL. In the MIBEL futures market, standardised contracts are listed by the Portuguese market operator OMIP, located in Lisbon. Currently, only baseload contracts are traded and the daily settlement price normally corresponds to the price in the last trade made in the market. Energy bought in the futures market can be physically settled (in the spot market) or financially settled.

Several agreements within MIBEL have been signed and announced by both governments including tasks to be accomplished by the TSOs and the regulators towards the harmonisation of the grid planning, transmission system operation procedures, independent metering services, data collection provision, and calculation methodology for third-party access tariffs. The congestion management mechanisms in the Spain-Portugal interconnections are being developed.

In Spain, generating plants with an installed capacity of more than 50 MW are required to make offers through the market operator. Smaller plants, with an installed capacity between 1 MW and 50 MW, may opt to make offers through the market operator on their interest. Generators under the special regime may sell their net electricity production to the system at either the tariff set by a Royal Decree, which is indexed to the average or reference tariff of the Spanish system, or at the pool price, plus certain premiums and incentives (see Chapter 8 on Renewable Energy).

New forms of market participation have been developed. Auctions on virtual power plants have been held quarterly since June 2007 in order to promote long-term contracts and make generation markets more competitive. Under the virtual power plant scheme, Iberdrola and Endesa are obliged to auction off a portion of their existing generating capacity to other firms. The auction provides its winners with an option to purchase electricity during peak or base hours at a predetermined price, up to the capacity that they have paid for.



Source: Country submission.

# NETWORK ACCESS

Procedures for access and linking up generation, consumer and distribution systems to the transmission grid are established in Law 54/1997 and developed in the Royal Decree 1955/2000. Transmission, distribution, trading, supply and the steps to authorise electricity facilities are regulated by that Royal Decree. The technical requirements for connecting to transmission networks are developed by the system operator.

Essentially, the transmission and distribution network can be used by consumers under a fixed price that government approves. The TSO can deny

the access to the network, but only in case of capacity shortage. Any conflict on network access will be resolved by CNE.

Any agent (generation utility, distributor or qualified consumer, whether directly or through a trader) must apply to REE, as the system operator responsible for the transmission grid management, to secure access to the 400 and 220 kV transmission grid, regardless of the carrier that owns the node to be accessed. The request will be evaluated by REE to determine whether the requested node capacity is sufficient.

# INDUSTRY STRUCTURE

In 2007, three-quarters of electricity was generated by the top three companies, namely Iberdrola (31% of the total), Endesa (29%), and Unión Fenosa (15%). Their shares in generating capacity are largely similar to the shares in generation (see Table 20). Iberdrola and Endesa together accounted for 62% of total installed capacity. In recent years, they have expanded their operations abroad. Through its subsidiaries, Iberdrola has 49.2 GW of installed capacity worldwide and generated 184 TWh of power in 2007. With total installed capacity of 24.5 GW worldwide, Endesa generates about 50% of its total electricity outside Spain. Unión Fenosa has 13.9 GW of installed capacity worldwide.

The ownership structure of the sector has evolved in recent years. For example, in 2007, the government intervened in E.ON's takeover bid of Endesa, trying to facilitate the creation of a national champion. Its action to stall E.ON's plans was successful but, in the verdict of the EU Court of Justice, illegal. Endesa was bought by ENEL of Italy (65%) and Acciona (25%), a Spanish construction company. Related to this, E.ON acquired Viesgo from ENEL in 2007. In early 2009, ENEL bought Acciona out and owns close to 100% of Endesa. Also in early 2009, Unión Fenosa was acquired by Gas Natural, the traditional gas incumbent.

Table 20						
Breakdown of Generation and Capacity by Company, 2007						
	Share in generation	Share in installed capacity				
Iberdrola	31%	33%				
Endesa	29%	29%				
Unión Fenosa	15%	13%				
Gas Natural	6%	5%				
Other	19%	20%				

Source: Ministry of Industry, Tourism and Trade.

In 2007, Iberdrola and Endesa supplied more than 80% of all electricity to end-users (see Table 21). At 43%, Iberdrola has the leading share in the regulated market, while Endesa had 62% of the competitive market. Overall, in 2007, 29% of electricity was supplied in the competitive market to around 7% of consumers. Because of the subsidised retail prices for low-voltage consumers, supplier switching has hardly developed. The government created a new office in August 2008 to oversee and regulate customer switching in the gas and electricity markets.

Iberdrola, Endesa and Unión Fenosa are also the largest distributors, although there are many small local distributors, for a total of 329 distribution companies. Those with more than 100 000 customers are required by law to be legally unbundled from other activities, whereas smaller distribution companies only need to be functionally unbundled. There are currently 54 registered retailers in Spain. Retailing companies can purchase electricity on the wholesale market, directly from foreign agents or from national producers.

\_ Table 21

#### Market Share of the Three Largest Electricity Suppliers by Company, 2007

Supplier	Market share (%)
Iberdrola	40
Endesa	39
Unión Fenosa	15
Aggregated share of companies selling at least 5% of total electricity consumed	94

Source: Ministry of Industry, Tourism and Trade.

# TRANSMISSION

The transmission network is divided into primary (at least 380 kV) and secondary (220-380 kV) transmission networks composed of over 34 500 km of transmission lines and more than 3 000 sub-stations. Investment in grid expansion has been substantial in recent years to accommodate rapid growth in demand and generating capacity. From 2004 to 2008, the transmission grid increased by 1 414 km to 34 719 km (see Figure 29). Significant investment in networks will be needed in the coming decades to implement the planned large-scale expansion of electricity generation from renewable sources. The Energy Infrastructure Investment Plan 2008-2016 projects developing the 220 kV and 400 kV networks, which would facilitate this integration.



– Figure 28



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REE operates the high-voltage transmission grid as the exclusive transmission system operator. REE plays an important role in the development of the grid, manages it and guarantees third-party access to the grid under equal conditions. Transmission network operation is a regulated activity with costs determined on the basis of planned and approved investments, demand growth, availability of installations and efficiency requirement. REE carries out its duties in co-ordination with the market operator.

REE owns almost the entire 400 kV grid and two-thirds of the 220 kV grid. The Spanish government owns 20% of the shares in REE. BBK, Unión Fenosa, Iberdrola and Endesa own 12% of the REE shares, and the remainder is freely floated on the Spanish stock exchange.



# **CROSS-BORDER INTERCONNECTIONS**

Spain has interconnections with France, Portugal, Morocco and Andorra. Total cross-border interconnection capacity equals some 5% of total generating capacity. Interconnections with Portugal and France are frequently congested. According to REE, hourly transfer capacities in 2008 were as follows:

France-Spain: 50 - 1 400 MW

Spain-France: 0 - 500 MW

Portugal-Spain: 0 – 1 700 MW

Spain-Portugal: 500 - 1 600 MW

Morocco-Spain: 0 - 600 MW

Spain-Morocco: 0 - 700 MW

Additional cross-border capacity is being planned. REE and its Portuguese counterpart REN have begun the studies for two new 400 kV interconnectors to raise minimum capacity to 3 000 MW. In January 2008, France and Spain agreed to expand interconnection capacity, for the first time in nearly 40 years, to up to 4 000 MW. A direct current 400 kV line will be built through the Pyrenees. Because of public opposition, the cable will be placed underground over some 60 km. The line is expected to have a maximum capacity of 1 800-2 000 MW and be commissioned by 2013.

Cross-border congestion management on Spain-France interconnections has been improved. In June 2006, REE and RTE (France) launched a system of joint monthly, daily and intra-day capacity auctions. In December 2006, the operators held the first annual capacity auction to allocate rights for 2007. On 1 July 2007, a new version of the capacity allocation rules for the France-Spain interconnection (the "IFE Rules") went into use. Under the South-West Europe Regional Initiative of ERGEG, the regulators are developing ways to better integrate MIBEL and the Central West Region (France, Germany, the Netherlands, Belgium and Luxembourg). A long-term goal for this integration is market coupling.

# PRICES AND TARIFFS

By international comparison, electricity prices to end-users in Spain are close to average (see Figure 30). Spain has been gradually phasing out the regulated end-user tariffs. High-voltage (more than 1 kV) regulated tariffs disappeared on 1 July 2008 and the tariff system was fundamentally overhauled on 1 January 2009. Until then, there were two types of electricity tariffs: consumers who chose to go to the market and to obtain a negotiated price paid an access tariff which included costs for transmission and distribution, costs for the special regime and other fixed costs in the system; and consumers who did not want to go to the market could stay on the integrated regulated tariff from the local distribution company, covering all these costs and a calculated cost of production according to a formula set annually by the Ministry of Industry, Tourism and Trade.

From 1 July 2009 a last-resort tariff system applies to contracted capacities of less than 10 kW. Electricity under the tariff is supplied by five companies: Endesa, Iberdrola, Unión Fenosa, Hidrocantábrico and E.ON. Under the new rules, all suppliers to the regulated market are able to acquire electricity through auctions of three-month bilateral contracts with generators. The auctioned price covers the costs of generating the electricity, and it can be updated on a quarterly basis. The last-resort tariff, however, includes subsidised network tariffs. In this way, retail prices net of transport costs more closely reflect the actual costs of electricity, eliminating a source of market distortion. Under this system, retail distributors receive the full market price for electricity, but taxpayers will still have to pay down the accumulated tariff deficit.





Note: Tax information not available for Korea and the United States. Data not available for Australia, Belgium, Canada, Denmark, Germany, Greece, Japan, Luxembourg, the Netherlands, Sweden and the United Kingdom.



Note: Tax information not available for Korea and the United States. Data not available for Australia, Belgium, Canada, Germany, Greece, Japan, Luxembourg and Sweden. Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2009. The tariff deficit has accumulated over the recent years, as rising commodity prices have increased generating costs to much above the tariff levels. The government has in effect forced the utilities to sell electricity at a loss. That has resulted in a deficit, estimated at EUR 14 billion in May 2009, which the government owes to Endesa, Iberdrola, Unión Fenosa, Hidrocantábrico and E.ON.

Until recently, the utilities were able to sell this debt to investors (securitisation), helped by an implicit government guarantee to pay it back in 15 years. The credit crunch, however, changed the situation, affecting the financial health of the five utilities. Several months of negotiations led to an agreement with the government and the industry in May 2009. As a solution, the government has agreed to create a fund for the EUR 10 billion of the debt that remains to be securitised, and to guarantee it. As a condition to this agreement, however, the government introduced a new category of end-user tariff that does not cover the costs of generation. This social tariff (*bono social*) freezes electricity prices until 2012 to some five million low-income households. In 2008, these households consumed 18 TWh of electricity, accounting for 8% of the total in Spain. The difference between the last-resort tariff and this new tariff will be paid by the utilities.



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# CRITIQUE

Since 2005, the Spanish electricity sector has continued to develop at a fast pace. An integrated Iberian electricity market (MIBEL) has been established, cross-border interconnections with Portugal increased and plans for more interconnections with France approved. Significant investment in gas-fired and wind-based capacity has diversified the generation mix. End-user prices are less regulated than ever before.

More specifically, the creation of MIBEL in late 2007, for example, has contributed to security of supply and improved regional market efficiency. The ability of customers to switch supplier, and open and non-discriminatory access to transmission have improved competition, and facilitated new entry. Spain has achieved impressive wind-based capacity expansion and has now the third-largest wind-based generating capacity after the United States and Germany.

However, some key challenges remain. Potential challenges resulting from the rapid and large development of renewables need to be monitored and tackled. Cross-border interconnection must be increased. A key role for the government is to balance the objectives of environment, competitiveness, security of supply and efficiency in its policy formulation.

The National Energy Commission (CNE), the energy regulator, has seen its mandate reinforced in 2005. It is now broadly involved in electricity, gas and oil regulation. Regarding electricity, the CNE regulates, among others, the interconnections, remuneration of transmission and distribution activities, and certification of origin for renewables. But the main concern remains that CNE has mainly an advisory and consultative role. Its regulatory decisions, for example regarding tariffs, must be approved by the Ministry of Industry, Tourism and Trade. This lack of independence might impact the level of confidence in markets and in investments. The government should consider giving CNE more independence, including exclusive authority to determine network tariffs.

Spain has capped end-user prices to several consumer groups under a regulated tariff system. Commendably, the government has been working to phase out these regulated retail prices, starting with the elimination of high-voltage business customer tariffs in 2008. From 1 July 2009, a last-resort tariff system applies to contracted capacities of less than 10 kW. Electricity under the tariff is supplied by five companies: Endesa, Iberdrola, Unión Fenosa, Hidrocantábrico and E.ON. The auctioned price covers the costs of generating the electricity, and it can be updated on a quarterly basis. The last-resort tariff, however, includes subsidised network tariffs. In this way, retail prices net of transport costs more closely reflect the actual costs of electricity,

eliminating a source of market distortion. Fixing the threshold of 10 kW is a major contribution to liberalising the electricity market in Spain. This measure is also ahead of the EU directive schedule.

Spain is using capacity payments as a substitute for market-based incentives to build new generating capacity. This, however, tends to lead to inefficient investment decisions, because it provides market participants with the perverse incentive of withholding their plans for new capacity in order to receive the payment. Capacity payments are also complex and difficult to administer. More importantly, the experience of IEA countries (*e.g.* Australia, Canada) reveals that energy-only markets can work, and can generate sufficient capacity to ensure security and reliability of supply. The IEA encourages Spain to end the capacity payments mechanism and concentrate instead on removing barriers to investments and providing clear market-based signals for them.

Retail prices were for long set below cost by the authorities. This accumulated a huge tariff deficit which the government owes to the utilities, estimated at EUR 14 billion in May 2009. It is very welcome, then, that the government and the utilities in spring 2009 agreed on how to solve the problem and how to settle the debt. However, the new tariff does not reflect, nor necessarily cover, the costs of electricity generation; it distorts the market and is hardly conducive to energy saving and efficient use of electricity. The government should study new mechanisms to promote the efficient use of electricity by those consumers affected by the *bono social*.

The government should be commended for its plan to significantly increase the share of renewable sources in power generation, as more renewablesbased generation can reduce  $CO_2$  emissions and the country's dependence on imported fossil fuels. However, rapid and large penetration of intermittent sources of renewable electricity, such as wind power, can pose major challenges to grid operations, including voltage stability and system balancing. High shares of renewables in generation thus require flexible power systems that can quickly balance fluctuations in supply and demand. Spain has shown leadership in setting up such a system. In particular, the REE's Renewable Energy Control Centre is a world-class tool to monitor and optimise renewables-based generation.

Flexibility can be further improved by including larger supply-anddemand balancing areas in the power system, unconstrained cross-border interconnections, additional flexible generation, demand-side measures, trading closer to real-time, and storage. Spain is already taking measures in all these areas, and the IEA encourages the government to continue to develop the electricity system to enable optimal integration of a high share of intermittent renewable energies into the power system. As a cost-effective measure to save energy and reduce load at times of system stress, the IEA also recommends that Spain allow demand-side participation in the wholesale market. During periods of low wind, responsive but probably expensive backup power will be needed. In light of a large expansion of renewable energy capacity, the cost-efficiency of this backup power should be carefully assessed. For example, comparative economics of alternative generation options should include the cost of backup power for wind power and any other operational costs that might occur following its integration in the system.

Policy directions should be clear regarding long-term energy strategies to ensure security and sustainability of supply, while meeting the needs of customers. While there is a clear emphasis on renewable electricity, it is unclear what potential role could be attributed to nuclear power in the future and, for example, whether there is to be a partial or complete nuclear phase-out in electricity generation. Uncertain policies are bound to affect the investment climate and the government should try to avoid this.

Transmission should be considered as a critical part of the mix of solutions to facilitate the transition to a more secure, competitive and sustainable power sector. Several IEA member governments (*e.g.* France, the United States) have adopted initiatives to accelerate investments in transmission as part of an economic recovery package. Because of Spain's weakened economic conditions, it may be appropriate for the government to consider measures to accelerate investments in energy infrastructures, including transmission, both domestically and cross-border.

Investment in cross-border interconnection has key benefits. It enhances energy security and market efficiency through increased possibility for reserve-sharing as well as providing greater potential for moving cheaper and cleaner electricity to neighbouring markets. It is encouraging to see new interconnections with Portugal and France being planned and built. The regulators are co-operating, with the long-term goal of market coupling.

Planning of infrastructure needs to ensure long-term security of supply, competitiveness and sustainability. A long-term outlook that will be updated regularly provides useful guidance to markets, planners, investors, and consumers. This is especially important, given the uncertainties regarding, for example, possible closure of coal plants and phasing out nuclear power.

Spain is planning significant investments in the coming decade, both in new generation and in transmission. There is therefore a clear need to ensure that the siting and permitting process, including that of interconnection to the grid for renewable developers, is effective, efficient and timely. Adding to that need is the fact that, in a decentralised country, many jurisdictions are involved in the permitting process, at various government levels. The IEA recommends the government work together with the regional and local authorities to streamline and harmonise the permitting process.

# RECOMMENDATIONS

The government of Spain should:

- Move progressively towards a more fully market-based and independently regulated system by:
  - giving the regulator more independence, including exclusive authority to determine network tariffs;
  - continuing to gradually eliminate end-user tariffs and ensure that they are cost-covering;
  - minimising the capacity payments mechanism and concentrating instead on removing barriers to investments and providing clear market-based signals for new investment.
- Allow demand-side participation in the wholesale market.
- Continue to develop the electricity system to enable optimal integration of a high share of intermittent renewable energies.
- Streamline and harmonise, together with the regional and local authorities, the permitting process for investments in generation and transmission while ensuring transparency and consistency in the approval process.

# **OVERVIEW**

The eight nuclear units in operation in Spain have a total capacity of some 7.7 GW<sub>e</sub>. Six units are pressurised-water reactors (PWR) and two are boilingwater reactors (BWR). Nuclear power plants represent almost 8.3% of the Spanish installed capacity and generated around 59 TWh, or 19% of the total in 2008. The plants are owned and operated by a small number of private companies, mainly Iberdrola and Endesa (see Table 22).

\_ Table 22

Nuclear Units in Operation in Spain, 2008				
Name	Туре	Capacity (MW <sub>e</sub> )	Commercial operation	Owners
Santa Maria de Garoña	BWR	466	1971	Nuclenor (50% Iberdrola, 50% Endesa)
Almaraz I	PWR	974	1983	53% Iberdrola, 36% Endesa, 11% Unión Fenosa
Almaraz II	PWR	983	1984	53% Iberdrola, 36% Endesa, 11% Unión Fenosa
Ascó I	PWR	1032	1984	Endesa
Ascó II	PWR	1027	1986	85% Endesa, 15% Iberdrola
Cofrentes	BWR	1092	1985	Iberdrola
Vandellós II	PWR	1087	1988	72% Endesa, 28% Iberdrola
Trillo	PWR	1067	1988	48% Iberdrola, 34.5% Unión Fenosa, 15.5% HidroCantábrico, 2% Nuclenor

Source: International Atomic Energy Agency.

Two nuclear units have been shut down: Vandellós I (in 1990) and José Cabrera (in 2006). Vandellós I, a 480 MW<sub>e</sub> gas graphite reactor commissioned in 1972, has been partly decommissioned and is in a latency period up to 2028. José Cabrera, a 160 MW<sub>e</sub> PWR commissioned in 1969, is at the predismantling stage.

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The availability factors of Spain's nuclear units are satisfactory but below their historic values and lower than in most OECD countries. In 2007, the average availability factor of Spanish nuclear units was 81% while it reached 87% in 2006, compared to over 90% in many OECD countries.

The nuclear units in operation are 21- to 38-years old and, according to Spanish regulation, they can remain in service as long as the Nuclear Safety Council (Consejo de Seguridad Nuclear, CSN) remains favourable to their being in operation. The current policy of the government is to progressively reduce the share of nuclear power in the energy mix, while ensuring security of supply.

Ascó I and II, Cofrentes and Vandellós II were refurbished, upgraded and uprated in the last decade and could likely continue to operate safely for many years. Almaraz I and II operators are currently preparing the safety analysis for uprating the capacity of those plants by 8%.

Regarding facilities for the front-end of the fuel cycle, Spain has one plant for producing nuclear fuel assemblies, at Juzbado. The plant has been in operation since 1985 and it has a capacity of 400 tonnes of uranium (tU) per year. It is operated by ENUSA, a state-owned company in charge of the front-end of fuel cycle activities. Domestic uranium production ended in 2000. The former uranium mining and milling facilities are at different stages of decommissioning and environmental restoration of the sites is ongoing. Spain has no domestic enrichment capacity and imports the enriched uranium needed to fuel its nuclear power plants (NPPs).

## INSTITUTIONS

The Nuclear Safety Council (Consejo de Seguridad Nuclear, CSN) is the independent regulatory agency. It has the power, for safety reasons, to suspend the operation of nuclear plants and to initiate procedures to impose sanctions on operators, as well as to cancel licences and authorisations. CSN submits reports to the government on issuing licences for the operation of nuclear plants and other facilities handling radioactive material. CSN statements must be followed up when they are different from those of the applicants. CSN is funded mainly by licensing fees, while some 12% of its funding comes from the general state budget through the Ministry of Industry, Tourism and Trade.

The National Radioactive Waste Corporation (Empresa Nacional de Residuos Radioactivos, ENRESA) is a state-owned company responsible for the activities of the back-end of the nuclear fuel cycle. These activities include spent fuel and radioactive waste management, together with the dismantling and decommissioning of nuclear and radioactive installations. In addition, ENRESA manages the fund for financing the back-end activities of the nuclear

fuel cycle and developing related research and development programmes. ENRESA is funded by the plant operators in proportion to their share of total nuclear power output, and, marginally, by a special levy included in the administrative tariff for electricity.

The Centre for Energy, Environmental and Technological Research (Centro de Investigaciones Energéticas Medioambientales y Tecnológicas, CIEMAT) is an institution attached to the Ministry of Science and Innovation. One of its duties is nuclear research. It collaborates with several institutions in Spain and abroad. CIEMAT is funded from the government's research budget and undertakes contractual research for third parties. Government-funded R&D on nuclear energy focuses on safety, plant life management and radioactive waste. Spain participates in international R&D programmes, in particular through Euratom and in collaborative projects undertaken under the auspices of the International Atomic Energy Agency (IAEA) and of the OECD Nuclear Energy Agency (NEA).

# NUCLEAR SAFETY

Since 2005, each nuclear power plant is required to report annually to the CSN on the results of its life management programme. The CSN inspects these programmes every two years. Also, the life management programme and its results are included in the safety reviews carried out every ten years. The new process of licence renewal adopted in 2005 will be applied in 2009 to Santa Maria de Garoña, Spain's oldest nuclear plant in operation. Safety reviews and, subsequently, decisions of licence renewals of the NPPs will be taken in 2009 (Garoña), 2010, 2011 and 2014.

In 2007, transparency and the participation of the public in nuclear safety issues was reinforced by revising the Law 15/1980 creating the CSN. This revised law introduced a "whistle-blower" rule, requiring workers in the nuclear and radioactive facilities to report any fact that could affect safety at the facilities, and protects the workers from any possible retaliation. The revised law also creates an Advisory Committee to support the CSN in improving transparency, access to information and public participation. Information about nuclear plant operation and safety matters is available on the CSN website (www.csn.es).

# WASTE DISPOSAL AND DECOMMISSIONING

The government is responsible for the policy on radioactive waste management and the dismantling and decommissioning of nuclear and radioactive facilities. The Sixth General Radioactive Waste Plan, adopted by the Spanish government in June 2006, provides the framework and guidance for the implementation of this policy. ENRESA is responsible for implementing the government policy. In particular, ENRESA manages the funds collected from operators of nuclear facilities for covering the costs of decommissioning and waste management and disposal. Since April 2005, operators have to bear all costs from decommissioning the nuclear power plants and managing their radioactive waste.

Low- and intermediate-level waste types are disposed of in the El Cabril facility operated by ENRESA. The facility entered into service in 1992 and its capacity is occupied at 55% at present. It offers an integrated structure for the treatment, conditioning and disposal of low- and intermediate-level waste. Its capacity has been extended recently to receive very low-level waste issued mainly from the dismantling of nuclear facilities.

Spain has adopted the once-through fuel cycle, without reprocessing. Spent fuel downloaded from reactors is stored temporarily at reactor sites for cooling before its eventual disposal in a dedicated repository. ENRESA is carrying out a programme aiming at opening a centralised temporary storage facility for all Spanish spent fuel in 2013. This programme places emphasis on communication with civil society and involvement of all stakeholders in the decision-making process.

# CRITIQUE

The government's policy is to progressively reduce the share of nuclear power in the energy mix while maintaining security of supply and reducing greenhouse gas emissions. The studies on projected medium- to long-term energy demandand-supply balance which are being carried out for the government should provide a basis for developing a concrete programme for substituting NPPs with carbon-free alternatives. At present, however, there is no timetable for shutting down nuclear units and the strategy for replacing them has not been defined. This uncertainty on the future of nuclear energy is detrimental to the industry which cannot take cost-effective decisions in a long-term perspective for ensuring secure electricity supply in the country. And, more importantly, the robustness of the overall national energy policy might be jeopardised if suitable alternatives to nuclear energy are not developed and deployed in a timely manner.

The Spanish NPPs in operation were connected to the grid between 1971 and 1988. Although, according to current practice, all those plants which are less than 40 years old may be expected to remain in service for several decades, their maintenance and lifetime management requires specific attention. The experience of lifetime extension, upgrade and uprate of nuclear power plants has been excellent so far in Spain, but continued attention to safety and technical performance of ageing facilities is a prerequisite to maintaining a safe, reliable and competitive reactor fleet. As the government policy prevents the construction of new nuclear units, the ageing of the Spanish nuclear reactor fleet has to be taken into account and plant life management will become increasingly important for the industry and the safety authority. While the regulatory process for licensing of life extension is well designed, uncertainties on government policy decisions might be detrimental to the industry and eventually to electricity consumers and civil society as a whole. Clear statements on the quantified objectives of the government on targets for reducing nuclear electricity generation would help the industry decision-making process.

Spanish energy policy emphasises renewable energy sources and energy efficiency, and this is commendable. However, comprehensive, holistic assessments should be undertaken in order to ensure that the replacement of nuclear energy by intermittent renewable sources of electricity generation can be achieved in a sustainable manner, at affordable costs, and will result in environmental benefits. In particular, the need to build and operate backup capacity to compensate for the unavailability of intermittent renewable sources should be taken into account. Combined-cycle gas turbines, which have been, and likely will continue to be, the best option for peak-load supply and backup capacity, increase greenhouse gas emissions from the power sector as compared to nuclear, and raise security of supply issues owing to the volatility of international gas markets.

Spain has a well-established legal and regulatory infrastructure for nuclear energy that covers all key aspects, including safety and waste management. Recent evolutions of the legal framework should be commended as an adequate response to civil society requirements and are in line with international best practices. The 2007 law strengthens the CSN and gives it a more prominent role in the field of communication with civil society on nuclear safety issues. However, the persistence of public concerns about nuclear energy indicates that government should consider further improving the transparency of its decisions and the effectiveness of its communication process on nuclear-related matters.

The highly qualified manpower required in the nuclear sector is an issue in most OECD countries. Workforce is ageing and the younger generation lacks interest in some scientific and technical areas. This challenges both the knowledge management and transmission, and the recruitment of adequate manpower required to operate, maintain and control nuclear facilities. This concern may become particularly significant in countries such as Spain, where the future of nuclear energy is uncertain. Therefore, continued attention should be paid to education, training and research programmes in order to ensure their adaptation to industrial and social requirements.

The radioactive waste management policy of Spain is well defined and its implementation is at a rather advanced stage compared with most OECD countries. A repository for low- and intermediate-level waste, including very

low-level waste from dismantling of shut-down nuclear units, is in place at El Cabríl. For high-level waste, Spain has defined a strategy and is undertaking progressive steps towards identifying a site for implementing a long-term storage facility, pending a decision on final disposal. The stepwise approach adopted includes extensive communication with civil society, including the local population and representatives of local and regional bodies. As in most other OECD countries with nuclear power programmes, Spain should pursue the implementation of solution(s) for the disposal of all radioactive waste, including high-level waste and spent fuel.

Spain has a commendable scheme for establishing and managing the funds to cover future financial liabilities associated with decommissioning and radioactive waste management. The country has created a dedicated ENRESA to manage the disposal of radioactive waste and the decommissioning of nuclear facilities. ENRESA also manages the fund for covering all costs related to waste management and decommissioning. An independent body supervises and controls the fund's investments, with six months' periodicity. It is essential to maintain this regular control of the fund and of its management, taking into account the broad context of risks and uncertainties on financial markets.

Spain has a rather comprehensive nuclear energy R&D programme, covering fission and fusion, managed by CIEMAT in co-operation with the nuclear industry. Spain participates in some international R&D activities, in particular under the auspices of the Euratom, the IAEA and the NEA. However, the overall government energy R&D budget is in relative terms more modest than in most OECD countries and this also applies to the nuclear sector. Consequently, prioritisation of topics is especially important. Therefore, the government should continue to emphasise issues such as lifetime management, ageing of materials and instrumentation, and control devices.

# RECOMMENDATIONS

The government of Spain should:

- Clarify its long-term nuclear energy policy (up to 2030) in order to provide economic actors adequate guidance for making technology choices in the power sector and, if a phase-out of nuclear energy is confirmed, develop a strategy for replacing nuclear units, while meeting post-2012 climate policy commitments.
- Continue to be attentive to communication with civil society on nuclear energy issues, including safety and environmental protection, in order to ensure that adequate information is provided to and understood by all stakeholders.

- Continue to monitor the safe operation of nuclear facilities and maintain a strong safety authority.
- Pursue its policy on radioactive waste management and disposal aiming at the timely implementation of repositories for the disposal of all waste types.
- Review on a continuing basis the nuclear energy R&D programme to ensure its adaptation to the role of this technology in the overall policy of the country.

# PART III ENERGY TECHNOLOGY

# ENERGY RESEARCH AND DEVELOPMENT

# POLICY

Energy R&D is an integral part of the 2006 National Strategy for Science and Technology (ENCYT). It is the programming instrument of the Spanish science and technology system that sets out the medium-term objectives until 2015 and priorities for research, development and innovation, as defined in the Science Law of 1986.<sup>10</sup> The ENCYT was drawn up in co-operation with the key players in the Spanish science and technology system, representing the national government, autonomous regions, scientists and technical experts and social partners. It is implemented through the National Plan for Scientific Research, Development and Technological Innovation 2008-2011.

The strategic goals of the ENCYT aim to build a cutting-edge, highly competitive and integrated R&D network, which will include, among others, co-ordinating policies and creating a favourable climate for R&D investment and new communication formats to raise public awareness. Specifically, work will focus on the following four areas:

- Generating knowledge and skills in science and technology
- Promoting co-operation in R&D
- Sectoral technological development and innovation
- Strategic actions

Energy and Climate Change is one of the five strategic actions in the national plan. Apart from nuclear energy R&D that is funded from other public sources, most public funding is made available for projects that fall within the following three groups:

- Group 1: Energy efficiency, renewable energy, clean combustion and emerging technologies
- Group 2: Sustainable mobility and modal shift in transport
- Group 3: Sustainable buildings

<sup>10.</sup> A draft revision of the Science Law 13/1986 to allow for open access to information (cf Art. 33) was made public in February 2009.

Public funding covers the energy R&D path from basic and applied research to pilot and demonstration projects and to facilitating market entry. Public funding comes in two forms: loans and subsidies. The loans are interest-free, with a maximum payback period of 15 years. Subsidy levels are limited by the EU state aid rules and they vary according to the size of the enterprise in charge of the project. Subsidies on applied research projects are capped at 50% of eligible cost for large enterprises, 60% for medium-sized ones and 70% for small ones. Subsidies on demonstration projects are capped at 25% of eligible cost for large enterprises, 30% for medium-sized ones and 40% for small ones. In specific cases, higher subsidy levels can be applied.<sup>11</sup>

The Ministry of Science and Innovation is responsible for Spain's R&D policy. The new ministry was established in 2008, replacing the Ministry for Science and Education. R&D policy is co-ordinated by the policy planning, co-ordinating and monitoring body (CICYT) within the Ministry of Science and Innovation. Responsibility for national energy R&D is divided between the latter ministry and the Ministry of Industry, Tourism and Trade, the Ministry of Transport and the Ministry of Housing.

Proposals for energy R&D projects are screened by the relevant ministries in a two-step process. First, all proposals are reviewed and rated by two bodies within the Ministry of Science and Innovation: the National Agency for Evaluation (ANEP) and the Centre for the Development of Industrial Technology (CDIT). ANEP assesses project proposals for their scientific and technical quality, using at least two independent experts for reviewing a proposal. CDIT, in turn, assesses the proposals for their technological and commercial quality. Secondly, proposals are reviewed and rated by a specific selection commission. There are three commissions, one for each of the three groups of energy R&D projects mentioned above. The commissions use broad criteria, including those outlined in the call for proposals. Each commission has around ten members representing the relevant ministries and agencies, including ANEP and CDIT. Each project is given an overall score, half from the first step of the selection process and another half from the second step. The final decision on project selection lies with the Ministry of Industry, Tourism and Trade for Group 1 projects, with the Ministry of Transport for Group 2 projects and with the Ministry of Housing for Group 3 projects.

To control and manage public funding of R&D programmes, and to make them more transparent by publicising results of the activities, the government uses the Integrated Monitoring and Evaluation System (SISE). Incorporated into the National Plan 2008-2011, it includes *ex ante*, ongoing and *ex post* evaluations, and enables monitoring of indicators used internationally to measure science and technology capabilities. SISE *ex ante* evaluations

<sup>11.</sup> By definition, a small enterprise has less than fifty employees and an annual turnover of EUR 10 million maximum. A medium-sized enterprise has less than 250 employees and an annual turnover of maximum EUR 50 million.

include selecting proposals on the basis of criteria of science and technology excellence. The ongoing evaluations are carried out annually. The results of administrative and funding information collected through questionnaires (projects applied and approved, type of agents' participation, authorised budgets, number of publications, patents, etc.) are summarised in an annual report to the Parliament. The *ex post* evaluation consists of collecting and centralising all ongoing information electronically into the SISE tool, which will enable real-time analysis of productivity, additionality, efficiency and effectiveness to science and technology policy, and a Results Evaluation Programme (PROEVAR) will be elaborated. On a more detailed level, the ministry or agency in charge prepares a final report on each project for the evaluation of results.

# **RESEARCH INSTITUTIONS AND SELECTED PROJECTS**

Publicly funded R&D is conducted by research institutions, universities, technology centres and private enterprises. The government funds several public research institutions that focus on applied research and pilot and demonstration projects, and these institutions often receive also private-sector funding. Three of the primary institutions – CIEMAT, CENER and CIUDEN – and their selected activities are presented below.

# CIEMAT (CENTRE FOR ENERGY, ENVIRONMENT AND TECHNOLOGICAL RESEARCH)

CIEMAT is the major publicly funded energy research institution in Spain. It carries out R&D and demonstration projects primarily on energy, but also on environment and other technology areas. CIEMAT is governed by the Ministry of Science and Innovation and collaborates closely with industry. It also has close ties with the Ministry of Industry, Tourism and Trade and the Ministry of Environment as well as with diverse autonomous and local administrations. CIEMAT also supports and assists ENRESA and the Nuclear Safety Council in radioactive waste treatment and increasing facility safety.

In 2007, CIEMAT had a budget of EUR 146 million. Renewable energy received 29% of the funding, nuclear fusion 28%, environment 18%, basic research 14%, nuclear fission 6% and combustion and gasification technologies 5%. It currently has a staff of 280 working on energy R&D projects.

CIEMAT has facilities in six locations in Spain. The CIEMAT Plataforma Solar de Almería (PSA) in the south-east of the country is a world leader in concentrated solar power (CSP) research since 1977. In 2007, PSA received EUR 20 million, almost half of CIEMAT total funding for renewable energy. R&D activities at PSA focus on improving CSP technologies (parabolic troughs, central receivers, dishes, Fresnel collectors). In addition to electricity generation, areas for R&D activities include solar sensors and solar air-conditioning and cooling, and developing solar thermal applications for industry: production of hot water and steam, industrial cold, desalination, and drying.

# CENER (NATIONAL RENEWABLE ENERGY CENTRE)

CENER was founded in 2001 by the Navarre regional government, the Ministry of Science and Innovation and CIEMAT. CENER carries out applied research and technology transfer in the following areas: wind energy; biomass; solar PV; solar thermal; grid integration; and bioclimatic architecture.

CENER has around 200 staff and an annual budget of EUR 23 million, of which 60% is self-financing. It works closely with Spanish energy companies and, compared with CIEMAT, its activities are closer to the market.

The main CENER activity is on wind energy, and it operates a major wind turbine test facility. With more than EUR 50 million invested, the facility includes test laboratories for blades and power trains, an aerodynamic tunnel, a laboratory for composite materials, and an experimental wind farm (6 x 5 MW). Another major investment is a demonstration plant for second-generation biofuels (more than EUR 33 million invested).

# CIUDEN (FUNDACIÓN CIUDAD DE LA ENERGÍA)

CIUDEN was established in 2006 jointly by the Ministry of Science and Innovation, the Ministry of Industry, Tourism and Trade and the Ministry of Environment. It is located in the coal mining region of El Bierzo and it carries out R&D on clean coal technologies. It also supports the government's other research institutions. CIUDEN had an initial capital of EUR 80 million for 2006-2008.

Together with national and international partners, CIUDEN is constructing a EUR 72 million demonstration plant for  $CO_2$  capture with oxyfuel combustion. The plant will be the largest of its kind in the EU and is expected to start operating in 2010. It will initially focus on oxyfuel combustion technologies for a wide range of coals and biomass. It will include a 20 MW<sub>th</sub> pulverised coal boiler, operating from air-mode to full oxyfuel mode, and a circulating fluidised-bed boiler (15 MW<sub>th</sub> on air-mode, 30 MW<sub>th</sub> on full oxyfuel-mode).

CIUDEN also has an R&D programme on transport and geological storage of  $CO_2$ . This includes designing, constructing and operating a pilot  $CO_2$  storage facility to demonstrate its technical feasibility and environmental safety. Using a life-cycle approach, the programme aims to develop more efficient technologies for  $CO_2$  storage. It will also monitor injected  $CO_2$  movements and model injected  $CO_2$  behaviour. CIUDEN is currently selecting a site for the storage facility.

# FUNDING

Since 2004, public spending on energy R&D has increased year after year to reach EUR 74 million in 2007 (see Figure 32). Out of that total, EUR 30 million was spent on renewable energy projects, EUR 24 million on nuclear power and EUR 7 million on energy efficiency. The rest was spent on fossil fuels, power and storage and other areas. Within the renewable energy group, solar energy projects received EUR 17 million. Total public spending increased to EUR 87 million in 2008 and is expected to amount to EUR 89 million in 2009. Increased spending would go primarily to solar, hydrogen and carbon capture and storage projects.

Compared to other developed countries, public funding for energy R&D remains low in Spain (see Figure 33). In 2007, it was at 0.007% of GDP, while several IEA member countries spent more than five times that share.

# INTERNATIONAL COLLABORATION

To augment its national R&D framework, Spain participates in several international collaborative efforts, including 14 IEA Implementing Agreements. Participation in the Implementing Agreements broadly matches their current share of budgets across the different energy technology areas. Spain participates in the Implementing Agreements on fusion indirectly through the European Atomic Energy Community (Euratom).

Within the EU, Spain participates in several ERA-NETs (European Research Area Networks), mostly in the areas of renewable energy and energy efficiency. ERA-NETs are networks of national science and technology funding organisations in Europe. They identify common priorities and co-ordinate national activities within the European Research Area (ERA), and their co-operation is funded from the EU framework programme for research, technological development and demonstration activities.

Also within the EU framework, Spanish companies participate in several energy-focused technology platforms. The European Technology Platforms bring together stakeholders in industry-led efforts to define medium- to long-term research and technological development. Covering the whole economic value chain, they aim to better align EU research priorities with industry's needs.

# CRITIQUE

Since the last IEA review in 2005, Spain's R&D sector has seen notable policy improvements. The total national budget for R&D has increased in nominal terms from EUR 5 billion to more than EUR 8 billion in 2007. The government









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has restructured the National R&D Plan, and the 2008-2011 Plan has more focus on public-private partnerships and a more rigorous system for evaluating project results. Moreover, a new Ministry of Science and Innovation was created in 2008, partly to improve co-ordination of the Spanish National R&D Plan. These are all encouraging developments.

The ambitious aims that IEA member countries, including Spain, are setting for climate change and energy security will require a revolution in the way in which energy is supplied and used in the coming decades. These challenges are for the long term, whereas the current National Strategy for Science and Technology runs until 2015. Spain should consider developing a long-term plan for energy R&D, in line with its long-term energy strategy. For this purpose, the government should draw up an overview of public energy R&D and invite a senior advisory body, drawn from government, industry, and the energy technology community, to advise on the overall balance. This should also help give Spanish industry a strong position in some of the most important technologies of the future.

Some of the technologies needed to respond to the future energy and climate challenges are still at the development stage and will require large increases in R&D for them to become fully commercial. The steady increases in Spain's energy R&D spending since 2004 are to be applauded. As far as the balance of spending is concerned, Spain is especially to be commended for the lead that it is taking in concentrated solar power. This is a technology in which Spain has a natural advantage and one that has made great strides towards full commercialisation in recent years. Wind, CCS, and photovoltaics are also important low-carbon technologies that it makes sense for Spain to pursue. Public-private partnerships on wind and solar have helped to place Spanish industry in a strong position on these very rapidly growing technologies.

According to the latest IEA statistics, however, Spain's spending on energy R&D, at 0.007% of GDP in 2007, remains a much smaller proportion of national income than that of almost all other large countries in the EU and the OECD. Even more than most other IEA member countries, Spain should consider a large further increase corresponding to the ambitions of its energy strategy. The share of energy in national R&D spending also seems modest and should be increased.

Beyond the successful R&D programmes on renewable energy and the plans for CCS for electricity generation, Spain could consider increasing R&D efforts in other areas where there is a growing need for better technology. Bearing in mind the rapid growth of car ownership in Spain in recent years and the large role that oil demand plays in Spain's  $CO_2$  emissions and energy imports, possible areas for stronger R&D activity are transport efficiency, electric vehicles and battery development. Electric vehicles could also provide solutions to storing some of the wind and solar power Spain is set to generate in increasing quantities in the future. If global climate change and energy security objectives are to be achieved, it is vital that new energy technologies are adopted both in IEA countries and in the rapidly growing developing countries. Spain should consider engaging these countries in the aims of its R&D projects.

# RECOMMENDATIONS

The government of Spain should:

- Draw up an overview of the whole of its engagement in energy RD&D and invite a senior advisory body, drawn from government, industry, and the energy technology community, to advise on the overall balance, also on the basis of the long-term energy strategy to 2030.
- Consider (in the light of this advice) a substantial enhancement of the Spanish energy R&D activity, especially on the demand side, possibly including programmes on electric vehicles, batteries, and vehicle efficiency, but also reinforcing their leading position in key renewable energy technologies.
- Ensure that the need to engage relevant developing countries is taken into account in publicly funded energy RD&D programmes.
## PART IV ANNEXES



#### ORGANISATION OF THE REVIEW

#### **REVIEW CRITERIA**

The *Shared Goals* of the IEA, which were adopted by the IEA ministers at their 4 June 1993 meeting held in Paris, provide the evaluation criteria for the in-depth reviews conducted by the IEA. The *Shared Goals* are set out in Annex C.

#### **REVIEW TEAM**

The in-depth review team visited Madrid from 13 to 17 October 2008. The team met with government officials, energy suppliers, interest groups and various other organisations. The team is grateful for the openness, co-operation and hospitality of the many people it met; they greatly contributed to a successful and productive review. The team wishes to thank in particular Mr. Antonio Moreno-Torres Gálvez, Mr. Luis Hilario Alonso Mijares and Ms. Beatriz Sinobas Ocejo of the Ministry of Industry, Tourism and Trade for their professionalism displayed throughout the review.

The members of the team were:

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Miika Tommila managed the review and drafted the report, with the exception of Chapter 8 on Renewable Energy, which was prepared by Elena Merle-Beral, Chapter 10 on Nuclear Energy, which was prepared by Evelyne Bertel and Chapter 9 on Electricity, which benefited from François Nguyen's contribution. Many other IEA colleagues have provided important contributions, including Barbara Buchner, Anne-Sophie Corbeau, Tom Kerr, Sara Piskor, Carrie Pottinger and Brian Ricketts. Monica Petit and Bertrand Sadin prepared the figures. Karen Treanton and Erdinç Pinar provided support on statistics. Viviane Consoli provided editorial assistance.

#### ORGANISATIONS VISITED

- ACOGEN, co-generation association
- AEGE, large energy consumers' association
- AOP, oil industry association
- APPA, renewable energy industry association
- APRIE, independent power producers' association
- ASPAPEL, pulp and paper manufacturers' association
- CEOE, Spanish Confederation of Business Organisations
- CENER, National Renewable Energy Centre
- CIEMAT, Centre for Energy, Environment and Technological Research, attached to the Ministry of Science and Innovation
- CIUDEN, Spanish Energy Research Foundation
- CLH, hydrocarbon logistics company
- CNC, Competition Authority
- CNE, National Energy Commission
- Coal Institute
- CORES, stockholding agency
- CSN, the Nuclear Safety Council
- Enagás, natural gas TSO
- ENRESA, National Radioactive Waste Corporation
- IDAE, the Institute for Energy Diversification and Saving

- Ministry of Economy
- Ministry of the Environment and Marine and Rural Affairs
- Ministry of Industry, Tourism and Trade
- Ministry of Transport
- OMEL, electricity market operator
- Red Eléctrica de España (REE), electricity TSO
- SEDIGAS, gas industry association
- UNESA, electricity industry association
- WWF Spain

#### ANNEX

#### ENERGY BALANCES AND KEY STATISTICAL DATA

							U	nit: Mtoe
SUPPLY								
		1973	1990	2000	2005	2006	2007	2016
TOTAL PRO	DUCTION	<b>11.3</b> 6.5	<b>34.6</b> 11.7	<b>31.7</b> 8.0	<b>30.1</b> 6.3	<b>31.3</b> 6.1	<b>30.3</b> 5.5	
Peat Oil Gas Comb. Renewables & Waste <sup>1</sup> Nuclear Hydro Wind Geothermal Solar		0.7 0.0 0.0 1.7 2.5	1.2 1.3 4.1 14.1 2.2 0.0 - 0.0	0.2 0.1 4.1 16.2 2.5 0.4 0.0 0.0	0.2 0.1 5.1 15.0 1.5 1.8 0.0 0.1	0.1 0.1 5.1 15.7 2.2 2.0 0.0 0.1	0.1 0.1 5.4 14.4 2.4 2.4 0.0 0.1	
TOTAL NET	r imports	41.7	55.6	91.5	113.6	113.1	112.0	
Coal Oil	Exports Imports Net Imports Exports Imports Int'l Marine and Aviation Bunkers Net Imports	0.0 2.2 4.3 45.3 5 2.2 38.8	0.0 7.1 7.1 12.1 61.7 4.7 44.9	0.5 13.4 12.8 7.5 79.0 8.7 62.8	0.4 14.8 14.4 8.4 88.3 10.9 69.0	0.8 14.3 13.5 9.9 89.6 11.4 68.3	1.3 14.7 13.3 10.7 90.1 11.8 67.7	    
Gas Electricity	Exports Imports Net Imports Exports Imports Net Imports	0.9 0.9 0.2 0.0 -0.2	3.7 3.7 0.3 0.3 -0.0	- 15.5 15.5 0.7 1.1 0.4	30.2 30.2 1.0 0.9 -0.1	31.6 31.6 1.1 0.8 -0.3	31.5 31.5 1.2 0.8 -0.5	  
TOTAL STOCK CHANGES		-1.4	-0.1	-1.2	-1.9	-3.0	1.6	
TOTAL SUPPLY (TPES) <sup>2</sup> Coal Peat Oil Gas Comb. Renewables & Waste <sup>1</sup> Nuclear Hydro Wind Geothermal Solar Electricity Trade <sup>3</sup>		<b>51.6</b> 9.0	<b>90.1</b> 19.3	<b>121.9</b> 20.9	<b>141.8</b> 20.5	<b>141.5</b> 17.9	<b>144.0</b> 20.0	<b>161.7</b> 13.2
		37.6 0.9 0.0 1.7 2.5 - - -0.2	45.5 5.0 4.1 14.1 2.2 0.0 - 0.0 -0.0	62.1 15.2 4.1 16.2 2.5 0.4 0.0 0.0 0.0 0.4	68.1 29.8 5.1 15.0 1.5 1.8 0.0 0.1 -0.1	67.6 31.2 5.1 15.7 2.2 2.0 0.0 0.1 -0.3	67.9 31.8 5.4 14.4 2.4 2.4 0.0 0.1 -0.5	66.1 41.3 15.6 15.4 2.9 5.5 - 2.5 -0.8
Shares (%) Coal Peat Oil Gas Comb. Renewables & Waste Nuclear Hydro Wind		17.5	21.4	17.2	14.4	12.6	13.9	8.2
		72.9 1.8 3.3 4.8	50.5 5.5 4.5 15.7 2.4	50.9 12.5 3.4 13.3 2.1 0.3	48.0 21.0 3.6 10.6 1.1 1.3	47.8 22.1 3.6 11.1 1.6 1.4	47.2 22.1 3.7 10.0 1.7 1.6	40.9 25.6 9.6 9.5 1.8 3.4
Solar Electricity Trade		- -0.3		 0.3	- <u>-</u> -0.1	0.1 -0.2	0.1 -0.3	1.5 -0.5

0 is negligible, - is nil, .. is not available

Only partial information is available for 2016. Forecasts for 2010. 2020 and 2030 are not available.

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#### DEMAND

FINAL CONSUMPTION BY SECTOR							
	1973	1990	2000	2005	2006	2007	2016
TFC Coal Poat	<b>38.6</b> 4.0	<b>60.7</b> 3.2	<b>85.5</b> 1.3	<b>102.1</b> 1.5	<b>100.2</b> 1.4	<b>102.6</b> 1.5	1 <b>20.0</b> 2.0
Oil Gas Comb. Renewables & Waste <sup>1</sup> Geothermal Solar	28.9 0.7 - -	38.2 4.6 3.9	52.2 12.4 3.4 0.0 0.0	57.8 18.2 3.7 0.0 0.1	57.1 15.6 3.9 0.0 0.1	58.2 16.3 4.1 0.0 0.1	59.3 22.4 8.5 - 0.5
Heat	5.I -	10.8	10.2	20.8	22.1	22.3	27.3
Shares (%) Coal Peat	10.3	5.3	1.5	1.4	1.4	1.5	1.6
Oil Gas Comb. Renewables & Waste Comb. Renewables & Waste	74.8 1.8 6.5	62.8 7.6 4.0	61.0 14.5 3.7	56.7 17.8 3.9	57.0 15.6 4.0	56.7 15.9 7.1	49.4 18.6
Solar Electricity Heat	- 13.2 -	- 17.8 -	19.0 _	0.1 20.4	0.1 22.0	0.1 21.8 -	0.4 22.8 -
TOTAL INDUSTRY <sup>4</sup> Coal Peat	<b>20.6</b> 3.6	<b>25.2</b> 2.9	<b>34.1</b> 1.2	<b>38.8</b> 1.3	<b>33.2</b> 1.2	<b>34.0</b> 1.3	<b>39.0</b> 1.9
Oil Gas Comb. Renewables & Waste <sup>1</sup> Geothermal	13.3 0.4 -	11.2 3.8 1.8	14.6 9.6 1.3	13.4 13.8 1.4	12.8 9.2 1.6	13.0 9.6 1.6	10.5 15.3 2.7
Solar Electricity Heat	3.3	5.4	7.4	0.0 9.0	0.0 8.4 -	0.0 8.5 -	- 8.5 -
Shares (%) Coal Peat	17.6	11.7	3.5	3.3	3.5	3.8	4.9
Oil Gas Comb. Renewables & Waste Geothermal	64.6 2.0 -	44.5 15.0 7.3	42.9 28.2 3.8	34.5 35.4 3.5 -	38.6 27.8 4.8	38.2 28.3 4.7	27.0 39.3 6.8
Solar Electricity Heat	15.8 -	21.6	21.6	23.3	25.3	25.0	21.9
TRANSPORT <sup>2</sup>	10.9	21.3	30.2	36.5	37.5	38.7	45.7
TOTAL OTHER SECTORS <sup>5</sup> Coal Peat	<b>7.1</b> 0.3	1 <b>4.2</b> 0.3	<b>21.2</b> 0.1	<b>26.8</b> 0.2	<b>29.5</b> 0.2	<b>29.9</b> 0.2	<b>35.3</b> 0.1
Oil Gas Comb. Renewables & Waste <sup>1</sup> Geothermal Solar	4.8 0.3 - -	6.0 0.8 2.1	7.8 2.7 2.1 0.0 0.0	8.6 4.4 2.1 0.0 0.1	7.3 6.4 2.2 0.0 0.1	7.3 6.6 2.2 0.0 0.1	7.5 7.1 2.4 - 0.5
Electricity Heat	1.7	5.1	8.5	11.3	13.3	13.5	17.8
Shares (%) Coal	4.4	2.1	0.3	0.7	0.8	0.7	0.1
l'eur Oil Gas Comb. Renewables & Waste	67.8 4.2	41.9 5.8 14.6	36.7 13.0 9.7	32.3 16.5 7.9	24.9 21.5 7.3	24.3 22.2 7.3	- 21.2 19.9 6.8
Solar Electricity Heat	- - 23.7 -	35.6	0.1 40.1	0.2 42.4	0.2 45.1	0.3 45.1 -	1.5 50.4 -

#### DEMAND

ENERGY TRANSFORMATION AND LOSSES							
	1973	1990	2000	2005	2006	2007	2016
ELECTRICITY GENERATION <sup>6</sup> INPUT (Mtoe) OUTPUT (Mtoe) (TWh gross)	<b>12.6</b> <b>6.5</b> 75.7	<b>33.1</b> <b>13.0</b> 151.2	<b>45.7</b> 19.1 222.2	<b>53.8</b> <b>24.8</b> 288.9	<b>54.7</b> <b>25.4</b> 295.5	<b>56.0</b> <b>25.8</b> 300.2	<b>64.0</b> <b>32.8</b> 381.9
Output Shares (%)	18 9	401	36.4	28.0	23.0	24.8	12.8
Peat Oil Gas Comh Renewahles & Waste	33.2 1.0	5.7 1.0 0.4	10.2 9.1	8.5 27.3	8.1 30.6 1.1	6.2 30.8 1.2	1.8 36.5 5 5
Nuclear Hydro Wind Conthermal	8.7 38.2 -	35.9 16.8 -	28.0 13.3 2.1	19.9 6.2 7.3	20.3 8.8 7.9	18.4 9.2 9.2	15.4 8.9 16.9
Solar	-	-	-	1.7	0.2	0.3	2.2
TOTAL LOSSES of which:	13.9	29.3	36.9	40.0	41.2	42.2	41.7
Electricity and Heat Generation <sup>7</sup> Other Transformation Own Use and Losses <sup>8</sup>	6.1 4.1 3.7	20.1 3.0 6.2	26.6 2.2 8.1	28.9 2.1 9.0	29.3 2.0 10.0	30.2 2.0 10.0	31.1 
Statistical Differences	-0.9	0.1	-0.4	-0.3	0.0	-0.8	-
INDICATORS							
GDP (billion 2000 USD) Population (millions) TPES/GDP <sup>9</sup> Energy Production/TPES Per Capita TPES <sup>10</sup> Oil Supply/GDP <sup>9</sup> TFC/GDP <sup>9</sup> Per Capita TFC <sup>10</sup> Energy-related CO <sub>2</sub> Emissions (Mt CO <sub>2</sub> ) <sup>11</sup> CO <sub>2</sub> Emissions from Bunkers (Mt CO <sub>2</sub> )	281.94 34.96 0.18 0.22 1.48 0.13 0.14 1.10 140.6 6.9	440.64 39.01 0.20 0.38 2.31 0.10 0.14 1.56 205.9 14.8	580.67 40.26 0.21 0.26 3.03 0.11 0.15 2.12 283.9 27.0	681.88 43.40 0.21 3.27 0.10 0.15 2.35 339.7 34.2	708.39 44.07 0.20 0.22 3.21 0.10 0.14 2.27 332.3 35.7	734.34 44.87 0.20 0.21 3.21 0.09 0.14 2.29 344.7 36.8	958.15 50.23 0.17  3.22 0.07 0.13 2.39  37.2
GROWTH RATES (% per year)							
	73-79	79-90	90-00	00-05	05-06	06-07	07-16
TPES Coal	4.1 3.0	2.9 5.4	3.1 0.8	3.1 -0.4	-0.2 -12.8	1.7 11.9	1.3 -4.5
Oil Gas Comb. Renewables & Waste Nuclear Hydro Wind Geothermal	4.1 6.7 24.8 0.4 8.2 -	-0.5 12.3 49.4 20.9 -5.3	3.2 11.8 0.2 1.4 1.5 82.4	1.9 14.4 4.4 -1.5 -9.6 34.9	-0.7 4.7 -1.3 4.5 44.9 10.1	0.5 2.0 6.5 -8.4 7.2 18.1	-0.3 2.9 12.5 0.8 2.2 9.9 -100.0
Solar	-	-	41.9	14.5	27.7	65.1	38.0
TFC	4.1	1.9	3.5	3.6	-1.8	2.3	1.8
Electricity Consumption Energy Production Net Oil Imports GDP Growth in the TPES/GDP Ratio Growth in the TEC/GDP Ratio	6.4 5.5 3.2 2.3 1.8 1.9	3.6 7.5 -0.4 2.9 -0.9	4.1 -0.9 3.4 2.8 0.3 0.6	5.1 -1.0 1.9 3.3 -0.2 0.4	5.9 3.9 -1.1 3.9 -3.8 -6.0	1.2 -3.1 -0.9 3.7 -2.0 -0.7	2.3  3.0 -1.6 -1.3

Please note: Rounding may cause totals to differ from the sum of the elements.

#### FOOTNOTES TO ENERGY BALANCES AND KEY STATISTICAL DATA

- 1. Combustible renewables and waste comprises solid biomass, liquid biomass, biogas, industrial waste and municipal waste. Data are often based on partial surveys and may not be comparable between countries.
- 2. Excludes international marine bunkers and international aviation bunkers.
- 3. Total supply of electricity represents net trade. A negative number in the share of TPES indicates that exports are greater than imports.
- 4. Industry includes non-energy use.
- 5. Other Sectors includes residential, commercial, public services, agriculture, forestry, fishing and other non-specified sectors.
- 6. Inputs to electricity generation include inputs to electricity and CHP plants. Output refers only to electricity generation.
- 7. Losses arising in the production of electricity and heat at main activity producer utilities and autoproducers. For non-fossil-fuel electricity generation, theoretical losses are shown based on plant efficiencies of approximately 33% for nuclear and 100% for hydro, wind and photovoltaic.
- 8. Data on "losses" for forecast years often include large statistical differences covering differences between expected supply and demand and mostly do not reflect real expectations on transformation gains and losses.
- 9. Toe per thousand US dollars at 2000 prices and exchange rates.
- 10. Toe per person.
- 11. "Energy-related CO<sub>2</sub> emissions" have been estimated using the IPCC Tier I Sectoral Approach from the *Revised 1996 IPCC Guidelines*. In accordance with the IPCC methodology, emissions from international marine and aviation bunkers are not included in national totals. Projected emissions for oil and gas are derived by calculating the ratio of emissions to energy use for 2007 and applying this factor to forecast energy supply. Future coal emissions are based on product-specific supply projections and are calculated using the IPCC/OECD emission factors and methodology.

2

#### INTERNATIONAL ENERGY AGENCY "SHARED GOALS"

The 28 member countries\* of the International Energy Agency (IEA) seek to create conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and to the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants. In order to secure their objectives, member countries therefore aim to create a policy framework consistent with the following goals:

1. Diversity, efficiency and flexibility within the energy sector are basic conditions for longer-term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2. Energy systems should have the ability to respond promptly and flexibly to energy emergencies. In some cases this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3. The environmentally sustainable provision and use of energy are central to the achievement of these Decision-makers shared goals. should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should respect the Polluter Pays Principle where practicable.

4. More environmentally acceptable energy sources need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA member countries wish to retain

<sup>\*</sup> Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States.

and improve the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5. **Improved energy efficiency** can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6. Continued research. development and market deployment of new and improved energy technologies make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, includina industry participation and with co-operation non-member countries, should be encouraged.

7. **Undistorted energy prices** enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8. **Free and open trade** and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9. Co-operation among all energy market participants helps to improve information and understanding, and encourages the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA Ministers at their 4 June 1993 meeting in Paris.)

#### ANNEX

## D

#### **GLOSSARY AND LIST OF ABBREVIATIONS**

In this report, abbreviations are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention and abbreviated subsequently, this glossary provides a quick and central reference for many of the abbreviations used.

b/d bcm	barrels per day billion cubic metres
CCGT CCS CDM CHP CNC CNE $CO_2$ $CO_2$ -eq CSN CSP	combined-cycle gas turbine carbon capture and storage clean development mechanism (under the Kyoto Protocol) combined production of heat and power; sometimes, when referring to industrial CHP, the term «co-generation» is used. Competition Authority National Energy Commission carbon dioxide carbon dioxide equivalent Nuclear Safety Council concentrated solar power
E4 EU ETS	Energy Saving and Efficiency Strategy 2004-2012 European Union Emissions Trading Scheme
F-gases	HFCs (hydrofluorocarbons); PFCs (perfluorocarbons); $SF_6$ (sulphur hexafluoride)
G8 GDP GHGs GW	Group of Eight (Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States) gross domestic product greenhouse gases ( $CO_2$ , carbon dioxide; $CH_4$ , methane; $N_2O$ , nitrous oxide; see F-gases) gigawatt, or 1 watt × 109
IDAE	Institute for Energy Diversification and Saving
١١	joint implementation (under the Kyoto Protocol)

kb∕d kV kWh	thousand barrels/day kilovolt, or 1 volt $\times$ 10 <sup>3</sup> kilowatt-hour = 1 kilowatt $\times$ 1 hour, or 1 watt $\times$ 1 hour $\times$ 10 <sup>3</sup>
L LNG	litre liquefied natural gas
mb⁄d mcm Mt Mtoe MW MWh	million barrels/day million cubic metres million tonnes million tonnes of oil equivalent; see toe megawatt of electricity, or 1 Watt x 10 <sup>6</sup> megawatt-hour = 1 megawatt × 1 hour, or 1 watt × 1 hour × 10 <sup>6</sup>
NAP NESO NPP	National Allocation Plan National Emergency Sharing Organisation nuclear power plant
OMEL	Compañia Operadora del Mercado Español de Electricidad, S.A.;
OPEC	Organization of the Petroleum Exporting Countries
PPP	purchasing power parity: the rate of currency conversion that equalises the purchasing power of different currencies, <i>i.e.</i> estimates the differences in price levels between different countries
REE	Red Eléctrica de España, electricity TSO
t TFC toe TPA TPES TSO TW	tonne total final consumption of energy; the difference between TPES and TFC consists of net energy losses in the production of electricity and synthetic gas, refinery use and other energy sector uses and losses tonne of oil equivalent, defined as 107 kcal third-party access total primary energy supply transmission system operator terawatt or 1 watt $\times 10^{12}$
TWh	terawatt-hour = 1 terawatt × 1 hour, or 1 watt × 1 hour × $10^{12}$
UNFCCC	United Nations Framework Convention on Climate Change
VAT	value-added tax

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