INTERNATIONAL ENERGY AGENCY

Energy Policies of IEA Countries

THE UNITED STATES

2007 Review

OECD

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-seven of the OECD thirty 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 the international oil market.
- 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.

The IEA member countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. Poland is expected to become a member in 2008. The European Commission also participates in the work of the IEA.

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.

The OECD member countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.
The European Commission takes part in the work of the OECD.

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Disclaimer

The report is based on a visit to the United States which took place in late June 2007, and was drafted between July and early November 2007. It has therefore not been possible to take into account in the analysis the latest developments in the energy policy of the United States, most importantly the passage of the energy bill in December 2007.

Figure 1
Map of the United States

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the IEA.
Source: *IEA.*

EXECUTIVE SUMMARY AND KEY RECOMMENDATIONS

EXECUTIVE SUMMARY

During the past five years, important developments have taken place that have affected the United States' energy policy. The new Energy Policy Act, EPAct 2005, is the first comprehensive energy policy act since 1992 and has set important new directions in the area of clean energy use. There is increasing public concern about global warming caused by anthropogenic CO_2 emissions. New and expanded RD&D programmes have been implemented to support the development and deployment of clean energy technologies such as coal-fired power stations with carbon capture and storage (CCS), solar photovoltaics, and next-generation nuclear plants. Nevertheless, important challenges remain for energy policy makers to address.

There are two key issues now affecting all debates on the future energy supply of the United States. One is how to increase energy security by reducing the currently growing dependence on imported supplies. The other is how to address growing emissions of greenhouse gases (GHGs), notably whether and how to introduce a consistent value on CO_2 emissions. These two challenges are closely connected. The United States is the only major IEA member country where the share of fossil fuel consumption in total energy supply is expected to increase and one of the few without a policy designed to internalise the external cost of CO_2 emissions.

At present, the United States is moving to address these two challenges, in large part through the development and deployment of cleaner energy technologies. In the area of energy R&D, the United States is a world leader in many technologies, and has contributed greatly to the development of new and advanced energy technology. It is today the largest provider of funds for research into new technologies in the world, and is driving the development of technologies relating to CCS, second-generation (such as cellulose-derived) biofuels, and fourth-generation nuclear power stations. It also has substantial R&D efforts under way to improve the fuel efficiency of vehicles and lower the costs of renewable electricity sources such as wind and photovoltaics. Substantial financial support is available at the federal and/or state level for the deployment of some of these technologies. The potential medium-term global impact of programmes, such as FutureGen or the Hydrogen Initiative, is very high, and the United States government has done well in taking a lead in these and other technology projects. Of particular interest is the well-funded Climate Change Technology Program, authorised by EPAct and guided by a recently released visionary strategic plan. The multi-agency nature of this programme, by its design, should help to integrate research on technology across organisational boundaries.

But thus far, no comprehensive federal government action is planned to place a value on CO_2 emissions, leaving industry facing uncertainty about project development decisions that may be affected by the introduction of such a policy. Individual states, such as Colorado, have already moved ahead, applying a shadow price for CO_2 in project appraisals, while others are considering developing different regulatory mechanisms to value CO_2 emissions. The view expressed now by a number of stakeholders in the US energy sector is that an explicit pricing mechanism for CO_2 is a question of "when, not if", and that it will be required to bring forward clean technology investment. The uncertainty generated by this expectation is holding back investments in new technologies and projects that are urgently required by the United States' economy, such as refineries and power stations. While the established policy of decreasing GHG emissions intensity in relation to gross domestic product (GDP) has been successful, the time may now have come for the government to pursue more aggressive policies regarding GHG emissions reductions.

A further source of uncertainty is the lack of close co-operation on this question between the government institutions in Washington, most importantly the Administration and the Congress, and between the federal government and the states. In Washington, the different policy agendas and the approval procedures for energy R&D funding are hampering the smooth long-term development of solutions to the energy challenges in the United States. For example, the periodic lapse of the tax credit for wind power production has caused sharp fluctuations in investment. In some regions, difficulties in co-ordinating federal and state roles have caused delays in developing important infrastructure, such as LNG terminals, in opening up new areas of the outer continental shelf (OCS) for exploration and production, and in developing new unconventional resources of oil and gas in the Rocky Mountain states. It will be of high importance for the development of these technologies, projects and resources that closer co-ordination between the federal and state governments will develop to help ensure that regulatory oversight is streamlined, while still recognising the state concerns that only sound, cost-effective projects should go forward in an environmentally sustainable manner.

One such area where the country could benefit from federal guidance is in renewables, where 25 states and the District of Columbia have now established renewable portfolio standards (RPS), using differing design principles and goals. These policies, together with the federal tax credit for wind power production, have helped the United States renewables industry to grow considerably, in particular in the area of wind power generation, but the different standards are also imposing a cost on the economy through their lack of consistency. The federal government has stated that it has no intention to introduce an RPS for electricity, and has only outlined relatively modest goals for the contribution of renewables to future electricity supply, a policy different from that in vehicle fuels, where a federal standard has been established with EPAct 2005. The federal government's concern is that establishing a uniform federal power standard may not be appropriate because of the significant geographical variations in renewable resource endowments. On the other hand, trading green certificates across state borders, to the extent that transmission capacity permits, would help to overcome this perceived barrier, as has been seen in other IEA member countries. The federal government should, therefore, consider the establishment of a federal electricity RPS covering the whole of the United States, to mirror the policy in the transport fuels sector, taking into account cross-border trade of electricity. As a minimum, it would be useful to establish at least a common basis for the design of RPS across the country, to ensure their compatibility, and to establish a federal registry for RPS credits, so that they can be traded nationally.

There is a major policy gap with respect to the promotion of energy efficiency, even though there are strong federal programmes to boost the energy efficiency of buildings and appliances as well as industry, which have had some effect. More could, however, be done to encourage greater efficiency in electricity generation, and very significant room remains for speeding the introduction of efficiency improvements in transport, which would immediately contribute to energy and environmental security. Addressing the gaps on the demand side is one of the most important challenges faced by United States energy policy overall, not just efficiency policy.

In the transport sector, reducing fuel demand through more efficiency will increase security of supply by reducing import dependence, and lower CO_2 and other emissions. Bringing fuel efficiency standards to levels more in line with other countries would significantly reduce growth in oil demand and thereby help energy security, and relieve the tightness in international oil markets. The current proposals for an increase in the vehicle fuel standards will eventually boost fuel efficiency substantially. However, they will take effect gradually, leaving United States consumers with vehicles that are far below the fuel efficiency standards in other IEA member countries and even in important non-member countries such as China and India. At the same time the current proposals, compared to the impact of bolder action, will increase the cost of achieving the ambitious goal of switching the consumption of a significant amount of traditional gasoline to biomass-derived gasoline.

EPAct 2005 contains a commendable range of supply measures to stimulate the exploration for, and production of, oil and gas, both from conventional resources offshore and unconventional resources, as well as to encourage investment in refining. Because of difficulties in aligning federal interests and a diversity of state interests, little progress has been made in opening further areas of the OCS, which are expected to contain significant amounts of recoverable resources. It will be an important contribution to the future security of supply in the United States to find the compromises required to open these areas to environmentally sustainable exploration and production.

The introduction by the Environmental Protection Agency (EPA) of the Clean Air Interstate Rule and the Clean Air Mercury Rule are commendable moves in the absence of legislative action. Nevertheless, creating a firm legislative basis for the introduction of a more stringent air pollution framework is an important task for the Administration and Congress.

Natural gas use is rapidly growing in the United States, in particular in power generation, where it has now overtaken nuclear to become the second most important generation source. The growing use of gas, however, has placed increasing demands on constrained domestic supply, driving natural gas prices to historically high levels, to an extent that market pressures are now driving down demand for this clean fossil fuel. The growing demand has also started to change the dynamics of the United States' gas market, exposing it to international competition and pricing. Increasing imports from diverse sources may nevertheless be an option to bring down prices in the longer term, and a number of new liquefied natural gas (LNG) terminals, both in the United States and close to its borders, have been opened or licensed, but further diversification of import routes for gas is desired. The 2002 Hackberry LNG terminal decision by the Federal Energy Regulatory Commission (FERC) was a most important and commendable decision in enabling this investment to go ahead. Investment in LNG terminals should also be geographically diversified, by trying to locate as many terminals as possible outside the Gulf of Mexico region. Such diversification is a development which can only happen when regional or local interests are balanced with national interests. Strong local opposition in many regions hampers diversification, and needs to be addressed in a constructive manner.

Coal is an important fuel in the United States, representing half of the nation's electricity generation, and contributing in particular to the economies of the western states. In order to ensure a continued role for coal, even in a time of more stringent environmental requirements, it will become necessary to move towards cleaner and advanced technology for coal combustion. While gasification is one possibility, important efficiency increases can be realised by more widespread use of ultra-supercritical pulverised coal technology, which is well proven in other IEA member countries. This would reduce emissions from coal generators by up to 20%, compared to pulverised coal technology, without requiring the introduction of unproven technology. Coal in the past has also benefited from up to USD 2 billion per year government subsidy through the synfuel tax credit, which is now commendably being abolished. The government should consider using this money to support low- and zero-emission coal technologies to allow coal to compete in its own right against alternative fuels such as natural gas, renewables, and nuclear.

With the increasing use of electricity in all sectors of the economy, it is vital to take steps to improve generating efficiency and reduce power-sector CO_2 emissions. In recent years, despite a doubling of highly efficient gas-fired generating capacity, there has been more intensive use of coal-fired capacity, due largely to fuel cost differentials as gas prices have increased sharply and a carbon value on fossil fuels has not been imposed. More aggressive steps need to be taken to encourage more efficient use of fossil plants in the generating mix and the use of best available technology for new coal plants going forward. The lack of a meaningful increase in the efficiency of power generation is contributing to a continued high ratio of emissions to GDP in the United States, and is in the medium to long term threatening the goal of the government to reduce emissions intensity.

The United States has traditionally played an important leadership role in the world in the area of competition. Nevertheless, its electricity markets have experienced a retreat from market reform in recent years. In order to ensure that consumers are paying competitive rates for electricity in the future, FERC and the federal government should continue to push state regulators to further open up markets. In the area of transmission investment, the 2003 blackout clearly showed the weaknesses of the transmission systems. The establishment of a reliability organisation and mandatory reliability standards in response to this event is very commendable. Encouraging adequate transmission investment in competitive markets is an important and continuing challenge for the industry and the regulator, not just to increase system reliability, but also to enable these markets to work effectively and to allow the most cost-effective investments in electricity generation to go ahead.

A nuclear renaissance in the United States is now not only possible, but likely. This is very welcome. Nevertheless, the first new plants will not enter service until at least 2015, and then only in small numbers. There is competition by a number of consortia to gain from the provisions of EPAct 2005 supporting new nuclear construction. It will be important for the United States energy supply to follow through on this significant interest, by developing a framework that will allow the market-driven construction of new nuclear plants beyond the first few units of capacity for which generous support mechanisms were included in EPAct 2005.

KEY RECOMMENDATIONS

The government of the United States should:

- *Reduce fossil fuel dependence and GHG emissions by pursuing more aggressive demand-side and clean energy policies. In particular, introduce policies that go beyond those currently proposed to increase the efficiency of the power, transport and building sectors.*
- *Consider the introduction of a consistent value for CO_2 and other GHG emissions to speed the more rapid introduction of clean energy technology projects and reduce investor risks.*
- *Pursue closer co-ordination between Congress, Administration, and state governments, as well as between executive and legislative branches of the federal government, in order to ensure that energy policy challenges facing the country are addressed in a consistent manner.*

GENERAL ENERGY POLICY

COUNTRY OVERVIEW

The United States is the largest economy in the world. It covers an area of 9 826 million square kilometres, with a population of 298 million in 2006. The major population areas are New York City and northern New Jersey with 18.7 million inhabitants on the east coast; Los Angeles, Long Beach and Santa Ana with 12.9 million on the west coast; and the Chicago area with 9.4 million in the eastern centre of the country. The civilian labour force stood at 151 million in 2006, 7 million (4.6%) of which were unemployed. The United States is a net immigration country, with an average net immigration of 1.2 million from 2001 to 2005. The population density of the United States is relatively low, with 30.4 inhabitants per square kilometre.

The country is a union of 50 states and the District of Columbia. Government is based on a strong division of power, with three main branches. The executive branch is headed by a strong, indirectly elected president, assisted by Cabinet secretaries, departments and agencies. Congress, the legislative branch, consists of two directly elected chambers, the Senate representing the states, each of which elects two senators regardless of its population, and the House representing electoral districts based on population. The judicial branch, notably the Supreme Court and federal appellate courts, also plays important roles in energy policy decisions.

The United States has experienced strong economic performance in recent years, compared to other OECD countries. Since the mid-1990s, GDP growth in the United States has been considerably faster than in the other OECD countries as a whole, averaging 3.2% in real terms from 1996 to 2006. GDP per capita has also grown, although the rate of growth is smaller given stronger population growth. As a consequence of the strong GDP growth, energy supply and demand have also increased, albeit not at the same rate.

ENERGY SUPPLY AND DEMAND

SUPPLY

The United States is dependent on fossil fuels for almost all its energy supply. It is fully self-sufficient in coal and largely self-sufficient in natural gas, with about a fifth of gas supplied by imports from North American neighbours. Because of the high demand for oil, however, the United States is heavily dependent on oil imports, and the import dependence has increased since 1990 to reach over 50% in 2005.

The United States produced 70% of its energy needs domestically in 2005 (see Table 1). Import dependence in 2005 had nearly doubled from 16% to 30% since 1990, and the baseline projections published in the Energy Information Administration's (EIA) *Annual Energy Outlook* (AEO) 2007 indicate a further increase to 32% by 2030.

Renewables play a relatively small role in United States' energy supply, accounting for only 3.2% of total primary energy supply (TPES), unchanged from 1990, and 8.9% of electricity supply, a decline of 25% from 11.8% in 1990. EIA forecasts that the share of renewables is likely to increase back to 1990 levels by 2010, before declining again.

Table 1

Share of TPES Provided by Indigenous Production by Fuel, 1990 to 2030

	Share (%)					*Change (%)*	
Fuel	*1990*	*2005*	*2010*	*2020*	*2030*	*2005/1990*	*2020/2005*
Coal	118	102	101	97	96	–14	-5
Oil	56	34	40	37	32	–40	10
Gas	95	83	81	80	79	–13	–4
Import dependence	16	30	28	30	32	86	–1

Sources: *Energy Balances of OECD Countries,* IEA/OECD Paris, 2007 and country submission.

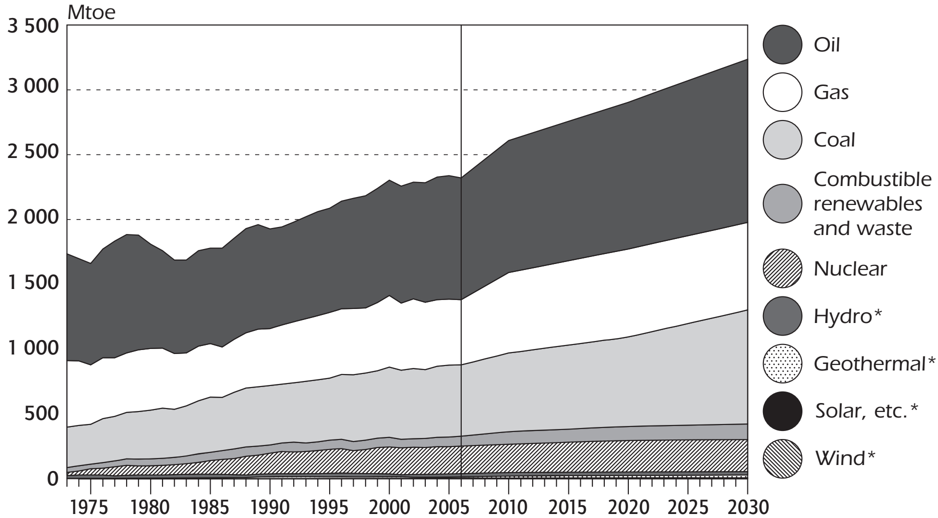
DEMAND

Energy demand has increased by 22% between 1990 and 2005, and is predicted to increase at about the same rate, by another 24%, between 2005 and 2020. Demand is increasing in all sectors of the economy, but is primarily driven by increases in the transport and residential sectors. Electricity demand in particular is increasing rapidly in the residential and commercial sectors, and can therefore be expected to become more variable.

While energy efficiency has improved in the United States, the improvements have only been able to slow demand growth to some extent, but not to halt it, owing to rapid economic and population growth.

Figure 2

Total Primary Energy Supply, 1973 to 2030

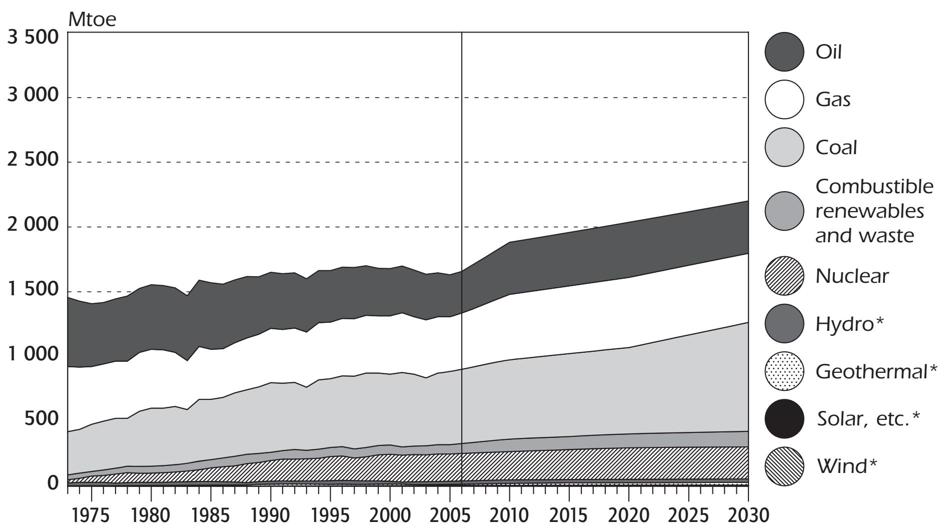


* negligible.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2007 and country submission.

Figure 3

Energy Production by Sector, 1973 to 2030

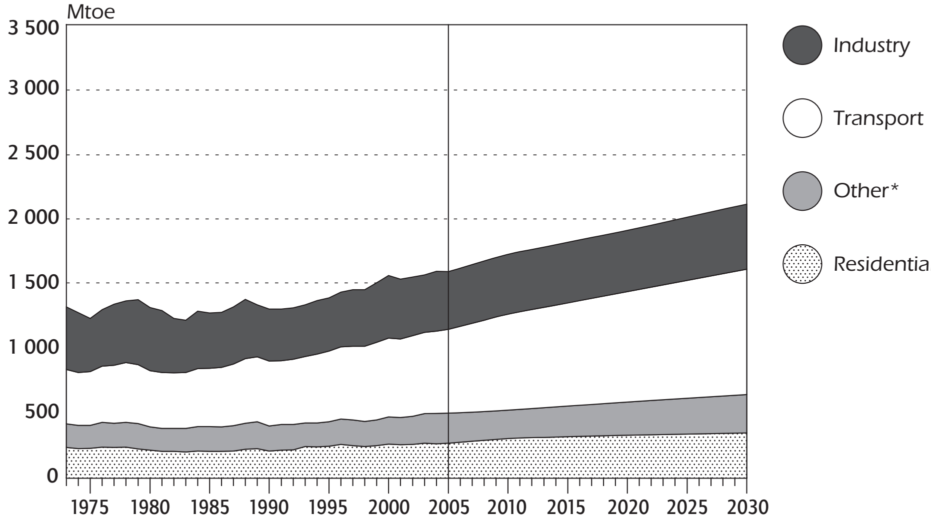


* negligible.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2007 and country submission.

Figure 4

Total Final Consumption by Sector, 1973 to 2030



* includes commercial, public service, agricultural, fishing and other non-specified sectors.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2007 and country submission.

ENERGY POLICY

The federal government has a strong preference for market-based regulations in the energy and environment policy area, extensively using trading mechanisms to reduce air pollution, and supplier obligations to increase the amount of biofuels for vehicles.

Since the last in-depth review, there have been broad advances in federal energy policy through the Energy Policy Act of 2005, Advanced Energy Initiative, and the *Twenty in Ten* initiative, which aims to reduce gasoline consumption by 20% over the next ten years. In addition, a large amount of new energy policy is being conducted by the states themselves. Together, these can be seen as components of a comprehensive energy strategy with five key goals:

- Diversify energy supply by promoting alternative and renewable sources of energy, encouraging the expansion of nuclear energy in a safe and secure manner, increasing domestic production of conventional fuels, and investing in science and technology.
- Increase energy efficiency and conservation in homes and businesses.
- Improve the energy efficiency of cars and trucks.
- Modernise electric power infrastructure.
- Expand the Strategic Petroleum Reserve.

The *Twenty in Ten* initiative was announced in the 2007 State of the Union speech by the President of the United States, consisting of two major elements. The first element focuses on the supply side, and sets a mandatory fuels standard to require 35 billion gallons[1] of renewable and alternative vehicle fuels to be supplied in 2017, nearly five times the current 2012 target which was set in EPAct 2005. In 2017, it is expected that this will displace 15% of projected annual gasoline use compared to the business-as-usual prediction. In the energy bill passed in December 2007, a target of 36 billion gallons of these fuels was adopted for 2022. The second element of the initiative is focusing on the demand side, with the reform and modernisation of the Corporate Average Fuel Economy (CAFE) standards for cars and the extension of the existing *Light Truck Rule*. It is expected that by 2017, this will reduce projected annual gasoline use by up to 8.5 billion gallons, a further 5% reduction compared to business as usual. Together, these measures will bring the total reduction in projected annual gasoline use to 20%. In the energy bill of 2007, the requirement was toughened, to a 40% improvement by 2020, raising CAFE standards to an average of 35 miles per gallon (mpg).

Box 1

The 2005 Energy Policy Act

The Energy Policy Act (EPAct) of 2005 was signed into law after several years of debate. In the view of the United States Administration, the act "[...] promotes dependable, affordable, and environmentally sound production and distribution of energy for America's future." To achieve this, the act takes major steps to strengthen energy infrastructure, promote energy efficiency, expand the use of renewable energy, and boost the domestic production of conventional fuels.

At the federal level, major steps have already been taken to implement the provisions of EPAct 2005. These include areas such as electricity reliability and transmission, developing unconventional hydrocarbon resources in the Rocky Mountains, giving siting authority for LNG terminals to the Federal Energy Regulatory Commission (FERC), and increasing investment in energy R&D. Many of the measures remain dependent on funding being authorised by Congress.

Some of the more notable measures in the act are described below, though there are many others.

Measures to Increase Energy Efficiency in Homes and Businesses

- Energy efficiency standards for a wide variety of appliances and equipment.

1. A US gallon equals 3.785 litres. Gasoline sales are handled on a gallon basis in the United States, unlike most other IEA countries where they are handled on a litre basis.

- Tax incentives for the purchase of efficient appliances and equipment.
- Tax incentives for the purchase of fuel-efficient hybrid and diesel vehicles.

Measures to Improve the Energy Efficiency of Cars and Trucks

- Authorisation of funding to accelerate R&D in batteries, power electronics, systems integration and other technologies for use in hybrid vehicles.
- New, multi-year rule-making by the Department of Transportation to raise fuel economy standards for passenger cars, light trucks, and sport utility vehicles.
- The National Highway Traffic Safety Administration, which administers Corporate Average Fuel Economy standards, is to report on the feasibility of reducing automobile fuel consumption by a significant percentage by 2014.
- The Environmental Protection Agency is to update procedures for rating automobile fuel efficiency, so that fuel economy labels more accurately reflect fuel efficiency with today's higher speed limits, different driving patterns, and faster acceleration rates.

Measures to Encourage Expansion of Nuclear Energy

- Production tax credits of USD 0.018/kWh for 6 000 MW of new nuclear capacity for the first eight years of operation. These will be allocated pro-rata to plants for which a licence application is lodged before the end of 2008, which will begin construction before the end of 2013, and which will enter operation before the end of 2020.
- Loan guarantees for clean energy projects using innovative or improved technologies, including nuclear plants. These can cover up to 80% of the total cost of a project, but will be subject to overall limits set by Congress.
- Risk insurance for utility companies building the first six new nuclear power plants, to cover the costs of regulatory and litigation delays that are not the fault of the company.
- Support for the continuation of the *Nuclear Power 2010* programme to demonstrate regulatory processes for siting new plants.

Measures to Promote the Use of Renewable Energy

- Renewable Fuel Standard that requires the yearly use of 7.5 billion gallons of ethanol and biodiesel by 2012 (a level which is in fact expected to be achieved in 2007), representing roughly 3% of total gasoline use, and equivalent to roughly 180 million barrels of oil.
- Extension of existing tax credit for production of electricity from wind, biomass and landfill gas, with a new credit for residential solar systems, to the end of December 2007.

- Full funding authorised for the Hydrogen Fuel Initiative, which aims to develop fuel cell technology and ways of producing and distributing hydrogen fuel.

Measures to Boost Production of Conventional Fuels

- Reforms to clarify the process for obtaining onshore oil and gas production permits.
- Full funding authorised for the Clean Coal Power Initiative (CCPI), which includes the FutureGen plant to demonstrate separation of CO_2 streams for sequestration.
- A grant programme to support carbon dioxide injection for enhanced oil and gas recovery and for increased carbon dioxide sequestration.
- Elimination of a 2% oxygenate requirement for reformulated gasoline, reducing the number of "boutique fuels"[2] and making fuel supply more flexible.
- Royalty relief for marginal oil wells, as well as renewal of royalty relief in risky frontier areas such as offshore Alaska and ultra-deep waters in the Gulf of Mexico.
- An R&D programme for methane hydrates, a potentially large new source of natural gas.
- A task force to co-ordinate and accelerate the commercial development of oil shale and oil sands, with leasing of federal lands for R&D activities related to such development.

Measures to Strengthen Energy Infrastructure

- Requirement for mandatory reliability standards to better protect power grids against outages in a competitive market-place for electricity generation.
- Establishment of a last resort federal government siting authority over state authority for transmission lines that are found to be of national interest, to ensure a better functioning power grid.
- Repeal of the Public Utility Holding Company Act (PUHCA) of 1935 and its replacement with a revised PUHCA placing fewer restrictions on investment in electric generation and transmission facilities by existing electric utilities. Clarification of FERC's jurisdiction as lead agency in the regulatory approval of onshore LNG facilities, which should facilitate the siting of such facilities where needed and thereby allow increased imports of LNG.

2. This term refers to gasoline variants produced according to non-standard specifications in some regions or states of the United States.

MARKET REFORM

The United States oil markets are fully open to competition, and the country's natural gas market is a regulatory model within the IEA for what liberalisation can achieve. Since 2001, however, energy market reform in the United States has slowed in the electricity sector, where the potential for reform still exists. While the federal government and FERC remain committed to reform, the attitude in many states has changed, owing to negative experiences with reform, particularly in California, together with concerns about rates and reliability. The EPAct 2005 reaffirmed a commitment to competition in wholesale power markets as national policy, while nothing was mentioned on retail power markets which are largely the province of states and municipalities. FERC has since then continued to foster competition, which it sees as the best protection of consumers against suppliers' market power.

The major direct influence by FERC can be exerted in the power transmission sector, where the Commission issued Order No. 890 in February 2007 to reform transmission access and ensure that transmission service is provided on a non-discriminatory basis.

ENERGY INSTITUTIONS

Primary responsibility for federal energy policies and programmes is vested in the **United States Department of Energy.** The department's work is carried out by several distinct offices described in detail below. Data are collected and analysed by the Energy Information Administration, which is part of the DOE but is headed by a functionally independent administrator.

- The **Office of Electricity Delivery and Energy Reliability** (OE) supports reliable electricity supply through programmes which are described in more detail in Chapter 8.
- The **Office of Energy Efficiency and Renewable Energy** (EERE) develops cost-effective energy efficiency and renewable energy technologies that provide a diverse supply of reliable, affordable, and environmentally sound energy for the nation. Its programmes are described in more detail in the energy efficiency, renewable energy and R&D chapters.
- The **Office of Fossil Energy** (FE) manages a range of programmes in fossil fuel R&D, described in Chapter 3. It is also responsible for overseeing the *Strategic Petroleum Reserve,* the country's emergency crude oil stockpile and an integral part of the IEA emergency system. Further, the office has regulatory responsibilities in the area of international natural gas sales and in the construction of transboundary electricity lines.
- The **Office of Nuclear Energy (NE)** provides technical leadership to address critical domestic and international nuclear issues. It has several

programmes dealing with national and international safety of waste treatment, and it operates five research reactors. More detail on the programmes can be found in Chapter 9.

- The **Office of Civilian Radioactive Waste Management** develops and manages the federal system for disposing of all spent nuclear fuel from commercial reactors and high-level radioactive waste resulting from nuclear defence activities. The Nuclear Waste Policy Amendments Act of 1987 directed DOE to characterise only Yucca Mountain, Nevada, to determine its suitability as a repository site for the disposal of spent nuclear fuel and high-level radioactive waste.
- The **Office of Environment, Safety and Health** is responsible for protecting the environment, workers and public from hazards posed by DOE facilities and operations.
- The **Office of Science** works to produce science and technical knowledge that is needed to develop energy technology options; to understand the health and environmental implications of energy production and use; to improve knowledge of the fundamental nature of energy and matter; to operate the large-scale facilities required in natural sciences to ensure a competitive position for the United States; and to help ensure the availability of scientific talent. It has a number of sub-offices, including the Offices of High Energy and Nuclear Physics; Basic Energy Sciences; Biological and Environmental Research; Advanced Scientific Computing Research; and Fusion Energy Science.
- The **Office of Policy and International Affairs (PI)** helps to establish and improve DOE policies and programmes for energy security, environmental security, science and technology. Its main goals are to ensure attention to the energy dimensions of policy decisions by other parts of the government, develop energy policies and priorities, ensure their effective and consistent implementation, and advance them through international agreements.

The **Energy Information Administration (EIA)** is an independent statistical and analytical agency within DOE. EIA maintains a comprehensive data and information programme relevant to energy supplies and reserves, energy production, energy demand, energy technologies, and related financial and statistical information. The EIA's mission is to provide high-quality, policy-independent energy information to meet the requirements of government, industry and the public in a manner that promotes sound policy making, efficient markets, and public understanding.

The **Federal Energy Regulatory Commission (FERC)** is an independent commission which has regulatory powers in electricity, hydropower, natural gas and oil markets. It regulates interstate gas and electricity markets (*i.e.* pipelines and transmission services) and is nominally part of DOE but operates independently, with appointed commissioners and professional staff. Retail rates charged by local gas and electric distribution companies, as well as the rate of return on electricity-generating facilities that are operated by utilities in franchised service territories, are regulated by the states in which they are located.

- **Electric Power:** The commission oversees wholesale electricity rates and service standards, as well as the transmission of electricity in interstate commerce. Sales of electricity for resale (sales between investor-owned utilities or by an investor-owned utility to another publicly- or co-operatively-owned), and transmission and interchanges comprise a little over a quarter of total United States investor-owned electric utility sales. Retail electricity sales, siting of generation and transmission facilities are generally regulated by state public utility commissions. Under EPAct 2005, new authorities on transmission reliability were given to FERC.
- **Hydropower:** Hydroelectric power regulation was the first work undertaken by the Federal Power Commission, the commission's predecessor, after Congress passed the federal Water Power Act of 1920. This work includes project licensing and exemptions, dam safety, project compliance activities, investigation and assessment of headwater benefits, review of project proposals by other federal agencies, and inter-agency co-ordination.
- **Natural Gas:** The commission regulates both the construction of pipeline facilities and the transportation of natural gas in interstate commerce. Companies providing services and constructing and operating interstate pipelines must first obtain Commission certificates of public convenience and necessity. In addition, approval by the commission is required to abandon facility use and services, as well as to set rates for these services. The commission also regulates the international transportation of natural gas and oversees construction and operation of facilities needed by pipelines at the point of entry or exit.
- **Oil:** The commission regulates the rates and practices of oil pipeline companies engaged in interstate transportation. The objective is to establish just and reasonable rates to encourage maximum use of oil pipelines as a relatively inexpensive means of bringing oil to market, while protecting shippers and consumers from unjustified costs. The commission does not oversee the construction of oil pipelines or regulate the supply and price of oil or oil products. Rather, it helps to assure shippers equal access to pipeline transportation, equal service conditions on a pipeline, and reasonable rates for moving petroleum and petroleum products by pipeline.

The **North American Electric Reliability Corporation** (NERC) is the body responsible for the reliability of the electricity transmission network in the United States. On 20 July 2006, it was certified as the "Electric Reliability Organisation" by the Federal Energy Regulatory Commission. On 1 January 2007, the North American Electric Reliability Council, a long-standing voluntary reliability body, was merged with it. NERC develops and enforces reliability standards; monitors the bulk power system; assesses future adequacy; audits owners, operators and users for preparedness; and educates and trains industry personnel. NERC is a self-regulatory organisation that relies on the diverse and collective expertise of industry participants. As the Electric Reliability Organisation, NERC is subject to audit by the United States Federal Energy Regulatory Commission and governmental authorities in Canada.

The **United States Department of Transportation** (DOT) is responsible for transportation policy, including planning. The DOT **National Highway Traffic Safety Administration (NHTSA)** is currently responsible for regulation of vehicle safety and the setting of Corporate Average Fuel Economy (CAFE) standards. The 2007 Supreme Court ruling that CO_2 is a pollutant may lead to the latter role being taken over by the EPA and/or some individual states. Also under the DOT is the **Federal Aviation Administration (FAA)**, an independent agency which is responsible for air traffic regulation and security. It participates in projects to increase the energy efficiency of air traffic.

The **United States Department of Interior** (DOI) is responsible for the management of royalties from oil and gas, and the environmental impact assessment of the development of new resources, such as oil shale.

The **Environmental Protection Agency (EPA)** is an independent agency and is responsible for the development and enforcement of environmental regulations based on laws enacted by Congress. It carries out research, offers financial assistance, and publishes information for the public.

The fifty **federal states, the District of Columbia, and United States Territories** are responsible for many environmental and energy-related issues within their borders. They have regulatory commissions which are either elected or appointed by the governor or the state legislature, and which have the responsibility to regulate energy undertakings within the state. States regulate all retail electricity rates and services, as well as decisions on siting and construction of electricity generation and transmission.

The **White House Council of Environmental Quality (CEQ)** co-ordinates federal environmental efforts and works closely with agencies and other White House offices in the development of environmental policies and initiatives. Congress established CEQ as part of the National Environmental Policy Act of 1969 (NEPA). Additional responsibilities were provided by the Environmental Quality Improvement Act of 1970. NEPA assigns CEQ the task of ensuring that federal agencies meet their obligations under the act.

The **Office of Science and Technology Policy (OSTP)** was established in 1976 with a broad mandate to advise the President on the effects of science and technology on domestic and international affairs. The 1976 act also authorises OSTP to lead an inter-agency effort to develop and implement science and technology policies and budgets. The director of the office serves as scientific advisor to the United States President.

ENERGY PRICING AND TAXATION

Energy prices are set by the market or by regulation where specific conditions apply, *e.g.* in natural monopolies, or certain privately-owned energy suppliers. Electricity prices can be regulated either by FERC (wholesale) or by state regulatory commissions (retail).

Compared to other IEA member countries, energy is taxed at a relatively low rate in the United States. Taxes can be raised independently by states, and/or the federal government, and they are cumulative. The most pervasive energy tax is the federal gasoline tax, which currently stands at USD 0.184 per gallon of gasoline, equivalent to USD 0.049 per litre of gasoline.[3] Because of additional taxes being imposed in each of the states, the average gasoline tax stands at USD 0.459 per gallon (USD 0.121 per litre). The highest combined federal and state tax is applied in the state of New York with USD 0.629 per gallon, while the lowest combined tax applies in Alaska with USD 0.264 per gallon. This level of tax is among the lowest in the IEA, and gasoline is considerably cheaper in the United States than in any other member countries.

Income is also raised from mineral rights for the production of coal, oil or natural gas on federal lands. This is described in detail in Chapter 7.

The tax system is, however, also used to subsidise some forms of energy, and energy efficiency, through the provision of tax breaks for a variety of energy-related goods, or the production of clean energy products. Tax breaks apply, for example, to wind power, ethanol produced from biomass, the purchase of energy-efficient cars or investment in insulation. They also apply to some forms of offshore oil and gas production, and to coal mining under specific conditions (synfuel tax credit).

PUBLIC AWARENESS AND FORECASTING

The Energy Information Administration (EIA) produces projections of energy supply and demand each year in the *Annual Energy Outlook (AEO)*. The projections in the *AEO* are not statements of what will happen but of what might happen, given the assumptions and methodologies used. The projections are business-as-usual trend projections, given known policy, technology, and demographic trends. While the analyses in the *AEO* focus primarily on a reference case, lower and higher economic growth cases, and lower and higher energy price cases, more than 30 alternative cases are generally included. EIA also publishes a short-term

3. On average in 2006, USD 1 = EUR 1.2554

energy outlook that is updated each month. Monthly forecasts for up to 18 months are provided.

As in previous editions of the *AEO*, the reference case assumes that current laws and regulations affecting the energy sector generally remain unchanged throughout the projection period. Some possible policy changes – notably the adoption of policies to limit or reduce greenhouse gas (GHG) emissions – could change the reference case projections significantly. The degree of uncertainty increases in the out years of the projections because of a variety of factors.

CRITIQUE

Since the last review, major developments have taken place in the United States energy policy. The most important of these is the Energy Policy Act 2005 (EPAct 2005), which is a comprehensive approach to address energy challenges faced by the United States. Congress and the Administration are working on implementing the policies, mandated and authorised in EPAct 2005. The energy strategy which is based on the act, focusing on sustainability and security through efficiency and diversification, is fully in line with the decisions of the G8 Heiligendamm Summit in 2007. The strong push for a nuclear renaissance coming out of the act is particularly noteworthy. But there are concerns, described in more detail below, about its implementation in some areas, and significant challenges in the energy sector remain to be addressed before the vision of a secure, diverse and sustainable energy supply can become a reality. Split responsibilities between the federal and state levels, as well as significant differences in energy policy between the Administration and Congress, and the sheer complexity of the delivery mechanisms, increase the challenge of realising a coherent and comprehensive energy strategy for the United States.

A fundamental problem is the absence of a clear link at the federal policy level between energy, environmental and security policies. While individual policies and measures address aspects of each of these three fundamental requirements, they are not consistent, and United States energy policy as a whole is not doing well at balancing the three Es of economic development, energy supply security, and environmental protection. This lack of a balanced policy is contributing to the continued high and growing dependence on fossil fuels, a situation that is almost unique among IEA member countries, which in turn contributes to increasing import dependence, and worsening the environmental impacts of energy use. These two issues are interdependent, and addressing the environmental impact of energy use, in particular reducing the emissions of CO_2, will automatically help lower the growing import dependence of the United States.

Although United States energy policy identifies as important both supply- and demand-side mechanisms, the focus has been more strongly on the supply side in the past. This is visible, for example, in the strong push to open currently exempt regions to oil and gas exploration and production, while the plans for vehicle efficiency standard improvements are significantly behind the technological potential of car manufacturers. More recently, however, the EPAct 2005 contains a commendable range of demand-side measures, indicating that this focus may now be shifting. To build on this, the Administration should consider reinforcing existing demand-side programmes in all sectors of the energy markets, such as vehicles, buildings and appliances, and to prolong successful EPAct 2005 demand-side measures.

Concerns about the lack of coherence in policy development between the federal and the state levels relate in particular to a very strong but inconsistent policy push, and policies which appear disjointed in terms of pace, consistency, continuity, and approach. For example, while a supply requirement of renewables for the transport sector has been established at federal level, no equivalent federal requirement is foreseen for the electricity sector. In this sector, demand is also growing rapidly, while efficiency improvements in electricity generation are not in evidence, a situation very similar to that in the transport sector. Other examples relate to specific technology areas, the development of unconventional resources, CO_2 pricing, and the development of support schemes for electricity produced from renewables. Strong and forward-looking leadership at the federal level would ideally be the way of addressing these inconsistencies. Developing a piecemeal, state-by-state approach to environmental and renewables policy has serious negative consequences on costs and effectiveness of implementing it. Collaboration and co-ordination with the states in advance can help lower the overall costs to the economy of implementing a balanced environmental policy that, at the same time, lowers the country's reliance on foreign imports.

Energy security is becoming an increasing challenge for United States energy policy, due to the very high and growing dependence on imported fossil fuels, in particular oil, but also gas. While the link between GDP growth and increases in energy consumption has been decoupled, growth in energy demand is still considerable, and import dependence is increasing rapidly. This reinforces concerns about the geopolitical stability of energy supply. While new suppliers have helped to diversify the supply base for the United States, these are not without risk, as can be seen by recent destabilising developments in Nigeria, now the fourth-largest oil supplier of the United States. At the same time, developing domestic resources appears to be very difficult, because of continued reluctance at the state and local levels to accept the environmental risks they associate with such developments. This is making it harder to diversify supply and limit import dependence. Developing secure supplies and delivery corridors, *e.g.* from Canada and Mexico, as well as diversified sources, such as renewables and alternative fuels, while at the same time harnessing technological developments to reduce energy demand in transport and electricity, is therefore a key challenge to United States energy policy.

EPAct 2005, the *Twenty in Ten* initiative, the policy actions of individual states, and the scientific and investor communities are all driving a cleaner and more sustainable energy policy, consistent with security. To deliver this policy, it will need to be vigorously pursued jointly by the Administration and Congress. This will demand more regulatory action, more energy R&D, and more support for bringing clean and secure technologies from the laboratory to the market. Owing to relatively slow progress since the passage of the act, a great deal remains to be tackled in this area. To ensure the challenges are addressed, the federal government will need to provide strong leadership, in co-operation with the states, to articulate and implement a coherent strategy for a secure and sustainable energy supply over the longer term.

Such a strategy for a secure and sustainable energy supply should take into account the need for diversity and balance, and consider life-cycle impacts of different energy sources. More emphasis needs to be put on market-pull as opposed to technology-push measures. This could be achieved by expanding existing measures such as performance standards, codes and labelling schemes into new sectors where they currently do not apply, while increasing the requirements for existing sectors. It could also include the consideration of a federal renewable portfolio standard, and direct support for currently uncompetitive clean technologies.

A fundamental element in the delivery of a secure and sustainable energy supply will, however, be the introduction of a consistent explicit value for reduced CO_2 emissions. Various incentive programmes for lower-carbon energy sources create implicit values for carbon in the market-place, but they are not consistent or comprehensive. Efforts by individual groups and states to deliver a CO_2 price are going in the right direction, but will be less effective, and more distorting to the economy than a federal scheme would be. They will also not be able to deliver the scale of incentives which is required to bring forward fully sustainable technologies across the whole of the United States. Introducing such a system would bring the United States energy policy closer in line with policies pursued at the international level, increase investor security, and allow the country's energy markets to link more securely to international trends. Designing and implementing a pricing mechanism for CO_2 is probably the most important challenge currently facing United States energy policy. The government should, therefore, urgently move to address this challenge.

On the international level, the United States is consistently and rightly emphasising the importance of open, liberal and competitive markets for the security of energy supplies. In many regions in the United States, competitive wholesale markets for electricity already deliver the right results for consumers and industry. Nevertheless, at the retail level, liberalisation of markets appears to have stalled, and it may be rolled back in some states. To enable all customers to benefit from the potential advantages that competition may bring, such as reduced prices and more reliable supplies, the federal government should push strongly for further liberalisation of energy markets throughout the country, through the development of coherent regulatory frameworks.

RECOMMENDATIONS

The government of the United States should:

- *Exert strong leadership to develop and articulate a balanced and sustainable energy policy, focusing in particular on a decrease of fossil fuel dependence by pushing for strong energy efficiency and clean energy supply policies.*
- *Evaluate the costs and benefits of establishing a consistent CO_2 price, for example by setting up a federal emissions trading scheme or by introducing a CO_2 tax, taking account of international experience in order to support market-pull measures for the accelerated introduction of clean energy technologies.*
- *Reinforce the development of open and competitive energy markets through consistent regulatory frameworks.*

ENERGY RESEARCH AND DEVELOPMENT

OVERVIEW

The United States government is the largest funding entity for energy R&D in the world, and energy R&D has historically played a critical role in achieving advances in all fields of energy, including nuclear, fossil fuels, renewables, and end-use technologies. A vibrant and entrepreneurial network of educational and research institutions, private entities, and wide-ranging international collaboration is supporting energy R&D in the United States.

STRATEGY

Several general energy policy objectives provide direction and goals for the United States effort on energy technology R&D, including[4]:

- Changing the way vehicles, homes and businesses are powered (Advanced Energy Initiative).
- Increasing domestic energy production (DOE Strategic Plan).
- Developing technologies and conservation measures that lower greenhouse gas emissions (Climate Change Technology Program *Strategic Plan*, National Energy Policy).
- Increasing the use of nuclear energy and renewables in the energy profile (National Energy Policy).

Presidential announcements and initiatives also drive energy technology R&D programmes. Some examples of recent initiatives include:

- *Twenty in Ten* initiative.
- Global Nuclear Energy Partnership.
- International Partnership for the Hydrogen Economy.

Other presidential initiatives are more cross-cutting in nature. For instance, the American Competitiveness Initiative focuses on the development of the next generation of scientists, engineers and educators through investment in research and development, strengthening science and maths education, and encouraging entrepreneurship and technology discovery.

4. Source: United States presentation to the IEA Committee on Energy Research and Technology.

Investments in energy R&D are an important policy instrument to meet national energy policy objectives. There is not a single US energy technology R&D strategy, but several cross-cutting initiatives advance, co-ordinate and guide technology R&D investments. Two of the currently most important are the Climate Change Technology Program and the Advanced Energy Initiative.

CLIMATE CHANGE TECHNOLOGY PROGRAM

The Climate Change Technology Program (CCTP) is the most comprehensive effort to support development of long-term climate change R&D portfolios in the United States or elsewhere. It is a multi-agency programme, led by the Department of Energy (DOE), charged with co-ordinating and prioritising the federal government's climate change-related RD&D portfolio – nearly USD 4 billion annual investments in climate-related technology research, development, demonstration and deployment.

In September 2006, the CCTP issued its Strategic Plan, which provides a comprehensive, long-term look at the nature of the climate change challenge and potential technology solutions over near-, mid- and long-term deployment. It also examines the current climate change technology portfolio and possible areas of future research, and provides strategic direction to ten federal R&D agencies, including DOE.

ADVANCED ENERGY INITIATIVE

The Advanced Energy Initiative (AEI) aims to accelerate the development of advanced technologies that could change the way American homes, businesses and automobiles are powered. AEI is designed to take advantage of technologies that, with some encouragement, could play a significant role in helping to reduce both the US use of foreign sources of energy and its pollution and GHG emissions. AEI includes increased investments in coal plants with carbon capture and sequestration, solar and wind power, nuclear energy, improved battery and fuel cell technologies for pollution-free cars, and cellulosic biorefining technologies for biofuels production. The following programmes are examples of research and development efforts linked to AEI:

- **The Solar America Initiative** is designed to accelerate the development of advanced solar power technologies, including photovoltaics and concentrating solar power systems, with the goal of making them cost-competitive with other forms of electricity by 2015.
- **The Biofuels Initiative** will reduce the costs of producing advanced biofuels and ready technologies for commercialisation. The goal is to make cellulosic ethanol cost-competitive with corn-based ethanol by 2012.

- **Wind Energy Research** is designed to improve the efficiency and lower the costs of conventional wind turbine technologies and to develop new small-scale wind technologies for use in low-speed wind environments.
- **The Hydrogen Fuel Initiative** is exploring production options, as well as the infrastructure needed to store and deliver hydrogen economically and safely. Current research is expected to make possible an industry decision to commercialise hydrogen fuel-cell vehicles in 2015, and possibly bring them to market by 2020.
- **The Building Technologies Program** works to improve the efficiency of buildings and the equipment, components and systems within them. The programme demonstrates the bottom-line benefits of new technologies and building practices, and promotes their widespread use.
- **The Coal Research Initiative**, along with its Fuel Cell Program, is developing technologies that capture CO_2 from large point sources and store the emissions in geological formations capable of holding vast amounts of CO_2. In 2003, DOE launched a nationwide network of seven Regional Carbon Sequestration Partnerships that include 40 states, four Canadian provinces, three Indian nations, and over 300 organisations. The partnerships' main focus is on determining the best approaches for geological storage in their regions. They are also examining regulatory and infrastructure needs. Small-scale validation testing of 25 sites involving geological sequestration technologies began in 2005.
- **FutureGen** is a ten-year government–industry collaboration to build the world's first coal-fired power and hydrogen production plant with near-zero atmospheric emissions. This project, which includes India and the Republic of Korea, will incorporate the latest technologies in coal gasification, oxygen and hydrogen separation membranes, turbines, fuel cells, and carbon sequestration (see Box 10 in Chapter 7).
- **Generation IV** Nuclear Energy Systems Initiative is an international co-operative effort to develop fourth-generation advanced, economical, safe, and proliferation-resistant nuclear systems that can be adopted commercially by 2030.
- **The Global Nuclear Energy Partnership** seeks to enable the expanded use of nuclear energy worldwide in co-operation with other governments, while avoiding proliferation of sensitive technologies and materials. GNEP aims to develop new technologies that effectively and safely recycle spent nuclear fuel (see Box 12 in Chapter 9).
- **ITER** is a multilateral collaborative project among the United States, China, the European Union, Japan, Russia, India and the Republic of Korea to build an experimental fusion facility at Cadarache in France. This is a step towards the long-term goal of designing and demonstrating a fusion energy production system for commercialisation by 2050.

THE UNITED STATES ENERGY INNOVATION INFRASTRUCTURE

The United States has a vast and resource-deep infrastructure for innovation, consisting of public and private actors, government policies, incentives, and large human and non-human resources. In the United States, no explicit overarching innovation policy exists and no single institution is managing the innovation system. Instead, various federal and state agencies are involved, each with separate jurisdictions and agendas and thus sponsoring their own innovation programmes (see Figure 5). The DOE is the key federal agency involved in energy technology innovation.

FEDERAL GOVERNMENT POLICIES TO SUPPORT ENERGY TECHNOLOGY INNOVATION

The federal government enables energy technology innovation in a variety of ways, including research funding, partnerships with industry, small business grants, the national laboratory system, and tax and regulatory policies.

Technology Push

On the energy technology "push side" the United States federal government is the largest source of funding for fundamental research in the world. In science and basic research, several federal agencies support the physical sciences including the National Science Foundation, the National Institute for Science and Technology, NASA, the Department of Defense and DOE, which together provide about USD 13 billion each year for research related to the physical sciences.

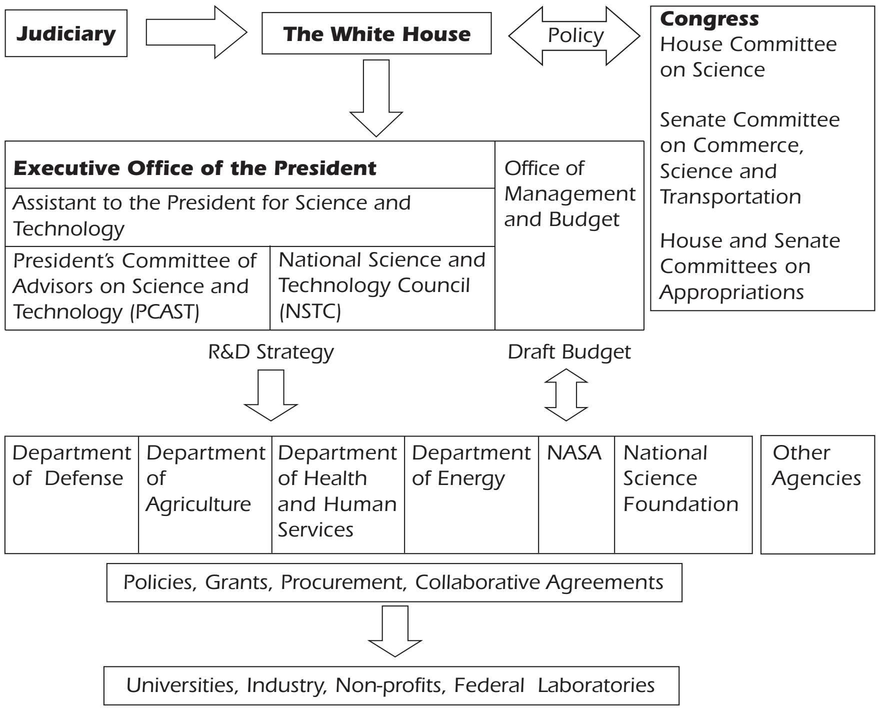
In addition to basic research, DOE and a number of other agencies fund applied R&D and efforts to commercialise advanced energy technologies. They also provide significant funding for energy technology development.

Market Pull

On the energy technology "pull side" of the innovation infrastructure, the federal government establishes tax and regulatory policies that encourage consumer and private-sector purchases and the use of alternative energy technologies that are not cost-competitive without subsidies. Many such policies were implemented or extended in the EPAct (*e.g.* on federal energy use, renewable energy, biofuels, hybrid and alternative fuel vehicles, hydrogen and fuel cells, nuclear energy, energy efficiency and buildings technologies; electricity grid; and clean coal). In addition to the EPAct and related legislation

Figure 5

Innovation Systems Components



Source: *DOE.*

that preceded it, Congress has instituted several regulatory programmes that encourage the use of energy-efficient or alternative energy technologies. These include regulations on vehicle efficiency, biofuels production, and flex-fuel vehicles, *e.g.* the Corporate Average Fuel Economy (CAFE). States are also working towards enacting a market pull tax and other policies and regulations, including 26 states that have adopted renewable portfolio standards for electricity.

Furthermore, federal agencies have established voluntary government-industry partnerships that strengthen information-sharing and collaboration among stakeholders. For example, in the FreedomCAR and Fuel Partnership, DOE and other agencies work with manufacturers and suppliers to co-ordinate pre-competitive, cost-shared research. To encourage small businesses to engage in research that supports national goals and has potential economic value, a portion of the federal budget for research and development is set aside each year for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (SBTR) programmes.

Box 2

Examples of Market-Pull Programmes

The **Green Power Partnership** facilitates purchases of environment-friendly electricity products generated from renewable energy sources by addressing the market barriers that may be stifling demand. It publishes information about low-cost purchasing strategies, educates partners about features of different green power products, and reduces the transaction costs for organisations interested in purchasing green power. States are also providing market-pull support, described below.

The **Combined Heat and Power Partnership** provides technical assistance designed to meet CHP project needs along each step of the project development cycle in order to make investments in CHP more attractive. EPA educates industry about the benefits of CHP and project development strategies, and provides networking opportunities. EPA also works with state governments to design air emissions standards and interconnection requirements that recognise the benefits of clean CHP.

The **Renewable Energy Systems and Energy Efficiency Improvements Program** supports biomass/renewable energy-related ventures.

The **Renewable Energy and Energy Efficiency Partnership** seeks to accelerate and expand the global market for renewable energy and energy-efficient technologies.

The **National Action Plan for Energy Efficiency,** facilitated by DOE and EPA, is an effort by leaders of the electric and gas utility industry, state energy regulators and allied groups to greatly expand the delivery of energy-efficiency by utilities to their ratepayers.

STATE SUPPORT TO SPUR TECHNOLOGY INNOVATION

States have become major contributors to the development and deployment of renewable energy technologies. States use several policy measures for this purpose, including regulatory measures (*e.g.* renewable portfolio standards), clean energy funds (tax credits and production incentives), support for R&D, and indirect tax incentives. Virtually every state uses at least one of these mechanisms to encourage greater use of renewable resources for electricity generation or vehicle fuels. An important mechanism in many states is a clean energy fund, which can include production incentives, grants and buy-down programmes, long-term contracts, debt financing, and risk insurance. Many states also contribute to energy research and development conducted at state universities and in the private-sector. For example, the New York State Energy Research and Development Authority administers 2 700 clean energy and energy-efficiency projects. Some states offer indirect tax incentives for clean energy installations, such as property tax reductions for homes with solar PV panels, corporate tax reductions for capital investment in renewable energy systems, and recruitment incentives to attract renewable energy equipment manufacturers. Sixteen states provide excise tax exemptions or producer credits for ethanol fuel. In all of these ways, states are a key factor in pulling new renewable energy technologies to the market.

THE ROLE OF UNIVERSITIES

US universities form an essential link between government and private industry in the development and commercialisation of new energy technologies. Universities foster innovation in numerous ways. These include support for fundamental research, high-level initiatives, and regional partnerships. Many universities have established high-level, multidisciplinary initiatives that aim to co-ordinate diverse research efforts and cross-cutting competences to address national and global energy and environmental challenges.

In many regions of the United States, a local or regional clustering of strong R&D centres, high-technology manufacturing, appropriately educated and skilled workers, and supportive government policies, has created an ideal environment for innovation. Many universities also partner with state and local governments, national laboratories, and the private-sector to accelerate development of innovative technologies, including energy. These collaborations help to bridge the gap between basic research and market commercialisation. One example is the Renewable and Sustainable Energy Initiative, led by the University of Colorado at Boulder. It builds collaboration among the National Renewable Energy Laboratory, Colorado School of Mines, Colorado State University, and the University of Colorado at Denver. The initiative has organised a symposium and "seed grant" competition to inspire innovative research in sustainable energy technology, as well as research on related policy and legislative issues; social, cultural and philosophical dimensions; and economic aspects of energy.

Many universities operate or work closely with entrepreneurial incubators and research parks to help promising research developments make the often difficult transition to market. These organisations provide start-up companies with the resources to commercialise research breakthroughs by supplying financial assistance, business connections, mentorship, and facilities. They also provide assistance with technical assessment, product development, intellectual property protection, and marketing. Novel models for commercialisation continue to be developed, with many universities now supporting joint ventures, licences, and spin-off company development.

DEPARTMENT OF ENERGY: LEADERSHIP IN PUBLIC ENERGY RD&D

Since its inception in 1977, DOE has had leadership responsibility for energy research, development and demonstration (RD&D) with the aim to enable the United States to develop and deploy advanced energy technologies for meeting future demands and diversify its energy portfolio. Its mission is "Discovering the solutions to power and secure America's future" which underlines the role of energy technology development in reaching energy policy goals. As such, the DOE Strategic Plan is founded on innovation through science-driven development of new technologies.

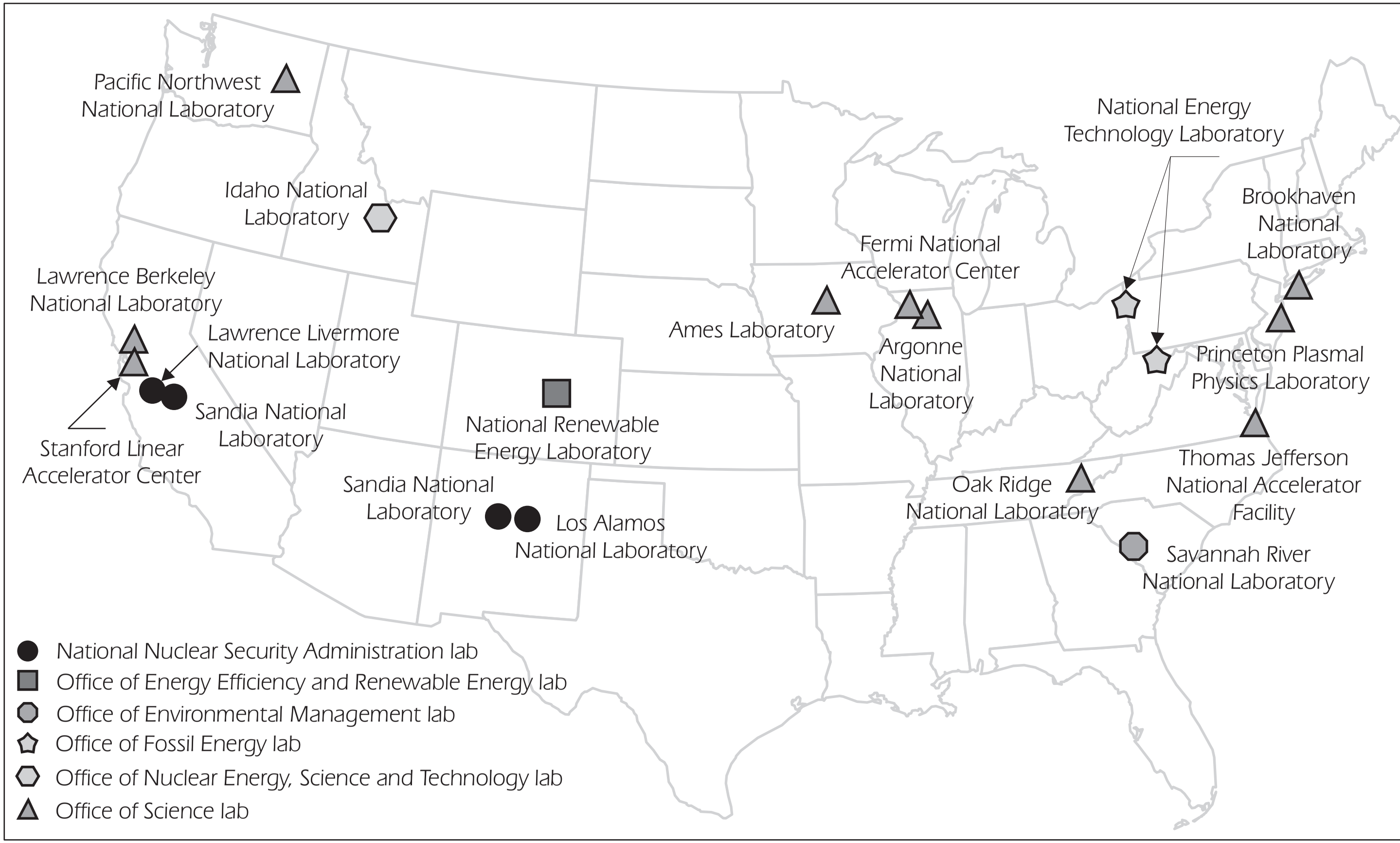
DOE NATIONAL LABORATORIES

The DOE supports a number of laboratories, research centres and test facilities throughout the country. Many of these laboratories host world-class facilities where thousands of scientists and engineers perform cutting-edge research. The DOE system of 14 laboratories, which conduct a broad range of energy-related research, is probably the best known. Besides contributing directly to the national research and development effort, the national laboratories play an important role in technology diffusion from government-funded research. The most commonly used mechanisms for technology transfer include sharing intellectual property rights, co-operative research and development agreements, licensing, user facilities, technical consulting, and personnel exchanges. The Departments of Agriculture and Transportation and the Environmental Protection Agency also support laboratories that conduct energy-related research relevant to their agency missions.

The DOE national laboratories (NL) are government-owned, federally-staffed or contractor-operated organisations that serve as centres of high scientific and technology expertise to support national goals. The DOE provides oversight of national labs of this type, including (among others) Argonne NL; Idaho NL; Lawrence Berkeley NL; Lawrence Livermore NL; Los Alamos NL; Oak Ridge NL; Pacific Northwest NL; Sandia NL; and the National Renewable Energy Laboratory; in addition to several labs operated directly by DOE, such as the National Energy Technology Laboratory. The national labs address a wide range of issues that require collaboration among diverse scientific disciplines. For example, basic research on nanoscale materials could involve experts in many disciplines, including chemistry, materials science, computational mathematics, biology and physics. Subsequently, this interdisciplinary collaboration might yield nanomaterial breakthroughs that lead to innovative technologies in energy storage, fuel cells, solid-state lighting, solar photovoltaics, biofuels, and other applications. The national

Figure 6

Major DOE Laboratories and Field Facilities



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the IEA.
Source: United States DOE.

labs often work closely with universities and industry to share results and to collaborate on research activities that will yield new technologies with energy, economic, environmental, and national security benefits.

RD&D FUNDING TRENDS

FUNDING SOURCES AND MECHANISMS

Energy research awards are made to a variety of entities, depending on the agency and the nature of the research being conducted. Most of the government's energy-related R&D is funded through the Department of Energy. Research universities and institutions, private companies and consortia are all eligible to receive DOE funding. The share of funds going to each type of entity is difficult to determine though funds for basic research projects are usually awarded to research universities and national laboratories, which in turn may subcontract further to universities or private laboratories. As the nature of the research becomes more applied and the technologies move closer to commercialisation, a higher portion of funding is awarded to private-sector companies. Other agencies may operate under different policies and procedures.

Awards for RD&D are usually made through a competitive, merit-based process. At the Department of Energy, research needs are identified in consultation with academia, national laboratories, research institutions, and the private-sector. A solicitation is issued that describes these needs and available funding. Proposals received through the solicitation are reviewed and evaluated by experts and "scored" or rated on the basis of technical, cost and other factors (*e.g.* the amount of private-sector cost share), and awards are made to the most highly rated proposals. The awards themselves can take many forms, including direct grants and co-operative agreements, some of which involve cost-sharing (*e.g.* for large energy demonstration projects).

The Energy Policy Act requires cost-sharing for certain mandated programmes. In addition, cost-sharing requirements also apply to joint projects the primary purpose of which is the commercial use of the technology by the private-sector, and when it is expected that the partner will receive significant economic benefit as a result of the project. The amount of cost-share required varies by the type of project. An applied R&D project, for example, may have a minimum private-sector cost-share requirement of 20%, while a large demonstration project, such as a clean coal facility, may have a minimum private-sector cost-share requirement of 50%. Cost-share can also be a consideration for deployment activities, such as those in support of the Asia-Pacific Partnership. Generally, there is no cost-share requirement for basic research projects.

TRENDS IN FEDERAL INVESTMENTS

The DOE budget for energy R&D, when adjusted for inflation, fell by 60% from its peak in fiscal year 1978 to fiscal year 2005 (see Figure 7), although it has been fairly stable since 2001. Energy R&D funding in the late 1970s was robust in response to rapidly rising oil prices and an ensuing energy crisis, but R&D funding plunged when oil prices returned to their historic levels in the mid-1980s. The decline in investment in energy R&D has occurred while overall United States R&D grew by 6% per year, and federal R&D investments in health and defence grew by 10% and 15% per year, respectively. As a result, the percentage of all United States R&D invested in the energy sector declined from 10% in the 1980s to 2% today. This fall masks important sectoral differences, however. While research funding for nuclear fission experienced a dramatic decline since 1978, expenditure for energy efficiency technology research remained stable, and expenditure for basic energy sciences increased significantly.

The public R&D investment has increased slightly in recent years reflecting United States technology initiatives (see Table 2). The main trends are:

- Increases in budgets for key renewable energy technologies – in particular solar and biofuels.
- Increases in clean coal – in particular carbon capture and storage.
- A surge in the nuclear energy budget.

TRENDS IN PRIVATE-SECTOR R&D INVESTMENTS

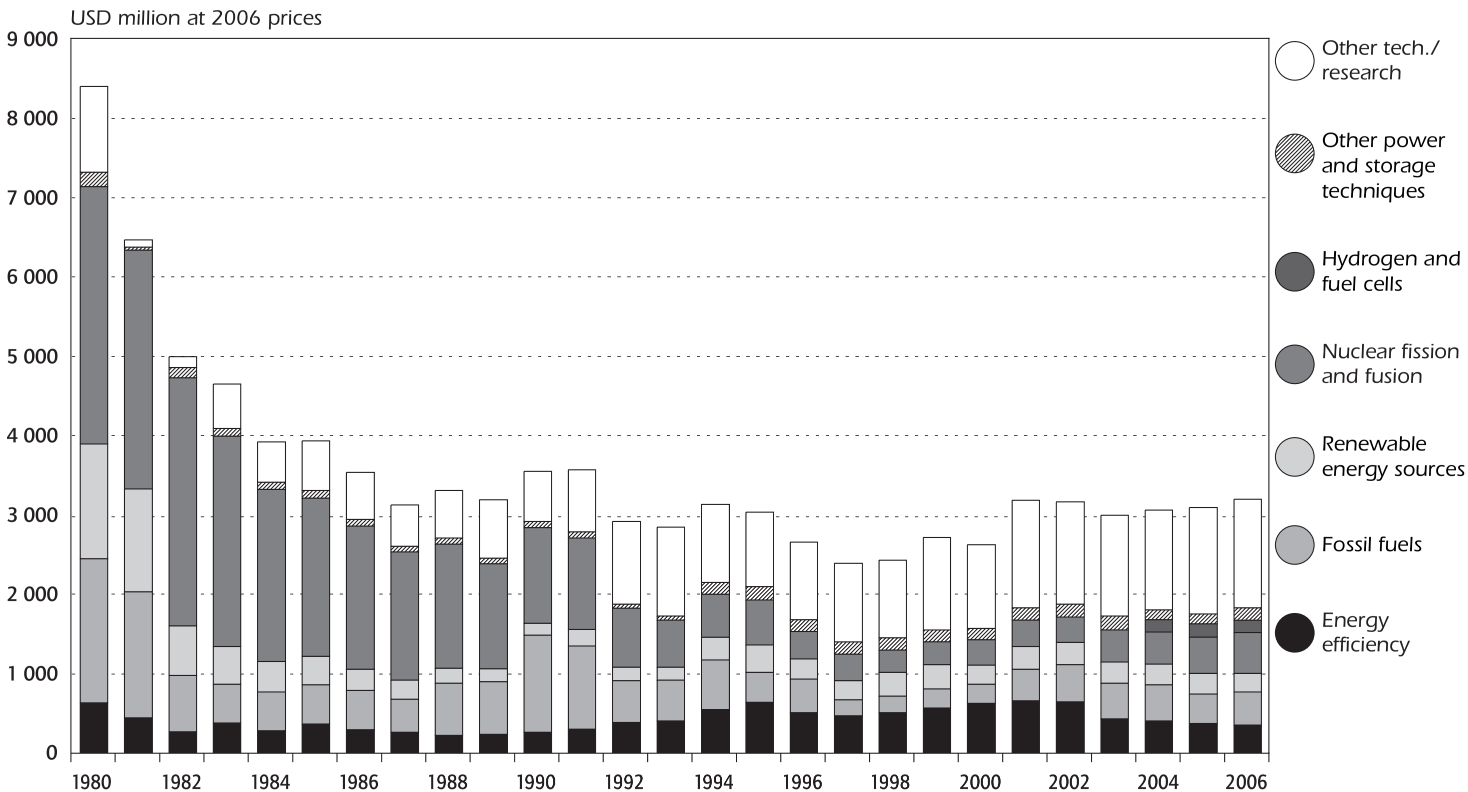
Declining private-sector investment in energy R&D is a key area for concern. In the 1980s and 1990s the private and public sectors each accounted for approximately half of the nation's investment in energy R&D. Today the private-sector makes up only 24%. Analysing the drivers behind investment trends in three segments of the energy economy – fossil, nuclear and renewable – indicates that a variety of mechanisms are at work.

The market for fossil fuel electricity generation has been growing by 2–3% per year, yet R&D has declined by half in the past ten years, from USD 1.5 to USD 0.7 billion. In this case, the shift to a deregulated market has been an influential factor reducing incentives for collaboration, and generating persistent regulatory uncertainty. The electric utility industry research consortium, the Electric Power Research Institute (EPRI), has seen its budget decline by a factor of three. Rather than shifting their EPRI contributions to their own proprietary research programmes, electric utilities and equipment makers have reduced both their EPRI dues and their own research programmes.

Private-sector nuclear R&D has continued to decline despite recently rising expectations about the future construction of new plants. Over 90% of nuclear energy R&D is now federally funded.

Figure 7

Government Energy R&D Spending, 1980 to 2006



Source: Country submission.

Table 2

Energy R&D Funding by Sector, 2003 to 2007
(in million USD)

Year	*2003*	*2004*	*2005*	*2006*	*2007*
Energy efficiency	**795 227**	**819 065**	**690 180**	**643 767**	**675 502**
Industry	148 766	133 349	109 187	90 230	85 816
Residential and commercial	136 168	130 081	121 247	128 417	159 962
Transportation	510 294	555 634	459 747	425 120	429 725
Oil, gas and coal	**429 288**	**450 834**	**346 096**	**380 931**	**397 415**
Oil and gas	117 400	104 843	103 961	62 606	14 700
Coal	275 100	308 960	201 323	235 512	243 076
CCS	36 788	37 031	40 812	82 813	139 639
Renewable energy	**424 651**	**384 426**	**344 113**	**334 111**	**504 776**
Solar energy	111 159	105 445	95 747	94 482	171 605
Wind energy	70 469	64 517	52 047	51 034	61 552
Ocean energy	–	–	–	–	–
Bioenergy	179 162	161 232	146 190	149 958	257 320
Geothermal energy	28 390	24 625	25 300	23 257	5 000
Hydropower	5 016	4 673	4 900	–	–
Other renewables[1]	30 456	23 933	19 930	15 380	9 300
Fission and fusion	**386 759**	**400 278**	**470 859**	**521 579**	**618 858**
Nuclear Fission	146 064	144 419	204 159	240 979	299 908
Nuclear Fusion	240 695	255 859	266 700	280 600	318 950
H_2 and fuel cells	**163 646**	**217 478**	**296 880**	**282 926**	**310 167**
Electricity delivery and energy reliability	**148 319**	**152 062**	**167 918**	**158 165**	**123 714**
Cross-cutting	**1 124 862**	**1 275 009**	**1 320 380**	**1 375 710**	**1 500 533**
Total	**3 472 751**	**3 699 152**	**3 636 426**	**3 697 189**	**4 130 965**

1. "Other renewables" includes programmes that cover multiple renewable energy technologies.

Source: United States Government R&D budgets and country submission.

Policy intermittency and regulatory uncertainty play a role in discouraging R&D investments in the solar and wind energy sectors. Improvements in technology have made wind power more competitive and have helped the global photovoltaic industry to expand. Yet, investment by large United States companies into R&D supporting these rapidly expanding technologies has actually declined.

VENTURE CAPITAL

Venture capital investment in energy provides a potentially promising exception to the trends in private and public R&D. Energy investments funded by venture capital firms exceeded USD 1 billion in 2000, and despite their subsequent cyclical decline to USD 520 million in 2004, are still of the same scale as private R&D by large companies. Recent announcements, such as California's plan to devote up to USD 450 million of its public pension fund investments to environmental technology companies, and Pacific Gas and Electric's USD 30 million California Clean Energy Fund for financing new ventures, suggest that a new investment cycle may be starting. While venture capital does not offset the declining investment by the federal government and large companies, the venture capital sector is now a significant component of the United States energy innovation system, raising the importance of monitoring its activity level, composition of portfolio firms, and effectiveness in bringing promising technologies to the commercial market.

DOE RESEARCH PROGRAMMES AND PRIORITIES

The United States maintains a diverse R&D portfolio with significant R&D investments on both supply-side and demand-side technologies. On the demand side, technology RD&D efforts span transport, buildings, industry, and electricity use. On the supply side, RD&D efforts cover clean fossil fuel use and CCS, renewable energy, and nuclear energy. This section will give an overview of areas given higher funding priority in recent years – biofuels, CCS and solar.

BIOFUELS INITIATIVE

The United States President, the Congress and the DOE have set out ambitious goals for biofuels which require substantive investments in biofuels RD&D:

- Cost-competitive cellulosic ethanol by 2012.
- Developing cellulosic ethanol biorefineries.

- **The Twenty in Ten** announcement which aims to reduce United States gasoline use by light-duty vehicles by 20% by 2017 through a 15% reduction from new Alternative Fuels Standard at 35 billion gallons/year and a 5% reduction from enhanced efficiency standards (CAFE).
- **Thirty in Thirty** serves as a longer-term DOE biofuels goal with the aim to ramp up the production of biofuels to 60 billion gallons and displace 30% of United States gasoline consumption by light-duty vehicles by 2030.

Figure 8 illustrates the comparative technological maturity of first- and second-generation biofuels. First-generation biofuels are commercially developed technologies, but have high costs and limited scalability, whereas second-generation technologies aim to resolve these limitations. The DOE Bioenergy Research Portfolio focuses on second-generation biofuels. Research on first-generation biofuels – mainly corn ethanol – is warranted when it has a cellulosic element or is related to develop and commercialise systems to extract and convert fibres out of corn.

The current focus on-second generation biofuels in the DOE Biomass Program Portfolio aims to remove barriers to large-scale production of cellulosic biofuels.

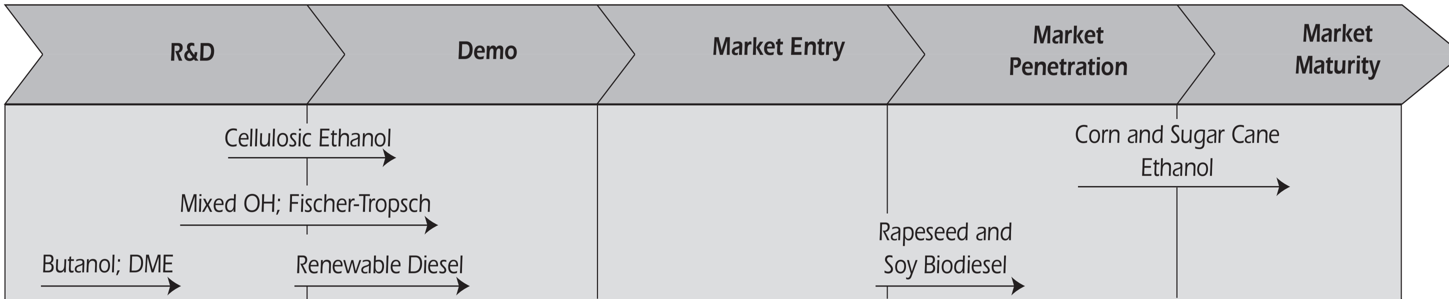
- **Collaborative R&D**
    - **Feedstocks:** integration of feedstock with conversion processes.
    - **Conversion technologies:** biochemical and thermo-chemical.
- **Integrated Biorefineries**
    - **Systems integration:** feedstocks, conversion, biopower, and infrastructure.
    - **Demonstrations:** pilot scale and commercial scale for diverse feedstocks.
- **Infrastructure (new).**

An indicative timeline for the cellulosic ethanol is shown in Figure 9. DOE strategy is to absorb some of the risk for the private-sector through investments in a focused RD&D programme. DOE awarded six new biorefinery projects totalling up to USD 385 million over the next four years which will lead to the use of non-food-based biomass from agricultural waste, such as trees and perennial grasses to produce transportation fuels, electricity and other products. Government funding will be matched roughly two-for-one by private funding, so that total funding for these projects will be around USD 1.2 billion. The DOE will also provide USD 375 million for three innovative bioenergy research centres to achieve significant breakthroughs in systems biology for the cost-effective production of renewable energy.

The public investment in biofuel RD&D is informed and co-ordinated through a multi-agency co-ordination effort: the Biomass Research and Development

Figure 8

First and Second Generation Biofuels Development



2nd Generation Biofuels

- **R&D efforts are focused on:**
  – Increasing the range of feedstock from which to produce biofuels
  – Reducing biomass-to-liquid conversion costs
- **Two main technology platforms in development:**
  – Biochemical pathway: conversion of the cellulose to sugars and fermentation to alcohol fuels
  – Thermochemical pathway: gasification of biomass to syngas and synthesis to fuels
- **Commercial renewable diesel plants are under construction (*e.g.* Neste oil "NexBTL")**

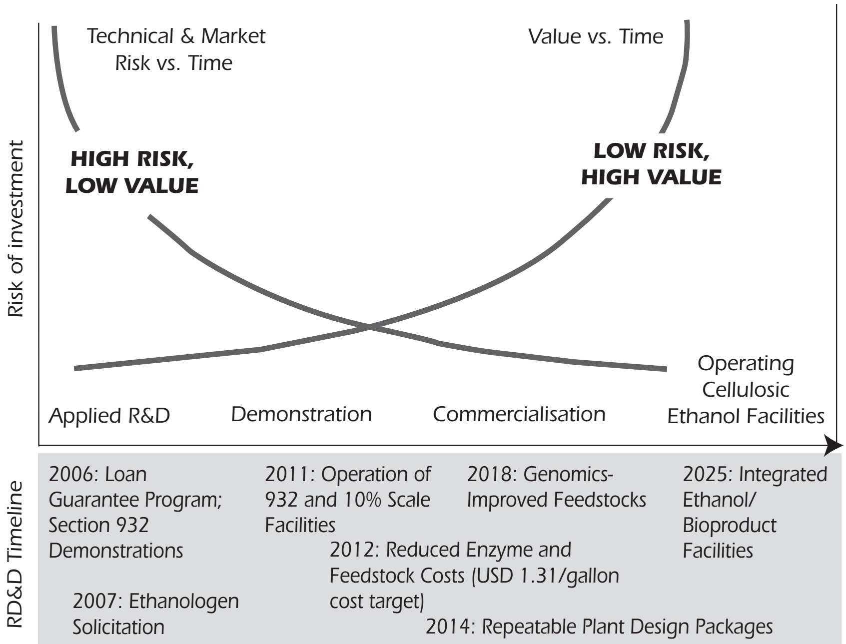
1st Generation Biofuels

- **Ethanol** is a clean burning, high-octane alcohol fuel used as a replacement and extender for gasoline
  – Has been commercially produced since the 1970s in the US and Brazil, still the market leaders
  – Corn ethanol is cost-competitive (without subsidies) with gasoline when crude oil is above USD 50/barrel (USD 30/barrel from sugar cane)
- **Biodiesel** is a high-cetane, sulphur-free alternative to (or extender of) diesel fuel and heating oil
  – Commercialised in Europe in the 1990s
  – Worst economics (and smaller market) than ethanol

Source: Navigant and United States DOE, Office of Biomass Programs.

Figure 9

Expected Timeline for DOE RD&D Investments in Cellulosic Ethanol



Source: United States DOE, Office of Biomass Programs.

Initiative (BRDI). The BRDI is a multi-agency effort to co-ordinate and accelerate all federal bio-based products and bioenergy research and development. The BRDI announced its intention to deliver a National Biofuels Action Plan in the fall of 2007, and has two co-ordinating bodies:

- Biomass Research and Development Board, a cabinet-level council co-chaired by DOE and USDA (also includes the Department of Interior, the Department of Transportation, the Environmental Protection Agency, and the Department of Commerce).
- Biomass Research and Development Technical Advisory Committee: 30 senior representatives from industry, academia and state government.

CARBON CAPTURE AND SEQUESTRATION

The development of advanced technologies that can significantly reduce emissions of carbon dioxide (CO_2) from energy production is a central component of the United States technology strategy. The main objective of the current fossil research portfolio is a near-zero atmospheric emission, coal-based electricity generation plant that can coproduce low-cost hydrogen. The

United States lead effort on carbon capture and sequestration involves four key elements:

- **Carbon Sequestration Core Program.** DOE Fossil Energy programme is developing a portfolio of technologies that can capture and permanently store greenhouse gases (GHGs).
- **The Carbon Sequestration Leadership Forum.** DOE is working with the Department of State to organise an international ministerial-level panel that will meet regularly to discuss the growing body of scientific research and emerging technologies and plan joint projects for carbon sequestration.
- **Regional Sequestration Partnerships.** DOE is creating a nationwide network of federal, state and private-sector partnerships to determine the most suitable technologies, regulations and infrastructure for future carbon capture, storage and sequestration in different areas of the country.
- **The FutureGen Initiative.** The USD 1 billion FutureGen project, announced by President Bush on 27 February 2003, will capture and store carbon emissions, making it the world's first coal-fuelled prototype power plant to incorporate carbon sequestration technologies.

The carbon sequestration R&D programme is pursuing evolutionary improvements in existing CO_2 capture systems and also exploring revolutionary new capture and sequestration concepts. The most likely options currently identifiable for CO_2 separation and capture include:

- Absorption (chemical and physical).
- Adsorption (physical and chemical).
- Low-temperature distillation.
- Gas separation membranes.
- Mineralisation and biomineralisation.

The FutureGen project aims to integrate several components of the CCS R&D programme and is discussed in detail in Chapter 7 – Coal Section.

SOLAR PHOTOVOLTAIC POWER

Generating electricity from solar energy focuses on using semiconductor devices to convert sunlight directly to electricity. A variety of semiconductor materials can be used, varying in conversion efficiency and cost. Today's commercial modules are 11% to 13% efficient, and grid-tied photovoltaic (PV) systems generate electricity for about USD 0.18 to 0.23/kWh under ideal siting and financing conditions for commercial (low end of range) and residential (high end of range) systems. Actual levelised cost of energy may be significantly greater in parts of the United States where the solar resource potential is less than ideal. Research activities, conducted with partnerships between the federal laboratories and the private-sector, include the fundamental understanding and optimisation of photovoltaic materials, process, and devices; module validation and testing; process research to lower costs and scale up production; and technical issues with inverters and batteries.

Research programme goals in this area focus primarily on a new initiative – the *Solar America Initiative* (SAI) – which will accelerate R&D efforts designed to achieve market competitiveness for PV solar electricity by 2015 (*i.e.* 5 to 10 cents/kWh under ideal siting and financing conditions). The SAI is offering a new approach to the solar R&D programme as illustrated in Table 3. The accelerated R&D effort will focus on PV technology pathways that have the greatest potential to lower costs and improve performance. New industry-led R&D partnerships, known as *Technology Pathway Partnerships*, will be funded to address the issues of cost, performance and reliability associated with each technology pathway. Potential partners within the *Technology Pathway Partnerships* include industry, universities, laboratories, states, and other governmental entities. If the research is successful, and if other policies remain

Table 3

Changes in Solar R&D Programme Approach within the Solar America Initiative

	Pre-SAI	*SAI*
Research focus	Technical improvements to individual components	Technical improvements to integrated PV systems
Performers, R&D agenda	• National labs drive R&D to enabling efficiency/cost requirements • Companies and universities are helped in maturing technology	• Companies develop products for priority market applications • Industry influences lab/university research agenda
Programme goal date	2020	2015
Pace of progress	Incremental progress through state laboratory funding	Substantial progress driven by large competitive solicitation and aggressive downselect process
R&D funding approach	Individual projects at national labs, universities and companies	System projects with multiple value-chain partners, individual projects for earlier stage technologies
Technology acceptance	Large number of small-scale projects that generate local interest	Small number of large-scale, high-visibility projects that will help lower PV market barriers

Source: DOE.

in place to promote deployment (production tax credits, state renewable portfolio standards), then by 2015, 5 to 10 GW of new solar power capacity could be deployed, equivalent to the amount of electricity needed to power 1 to 2 million homes. This deployment level would result in 10 million metric tonnes of avoided carbon dioxide emissions in the United States. The interim cost goal is to reduce the 30-year user cost for PV electrical energy to a range of USD 0.11 to 0.18/kWh under ideal conditions by 2010.

PROGRAMME EVALUATION AND MANAGEMENT

DOE uses a variety of methods and tools to assess its programmes. Internally, programmes are required to report quarterly on their progress in meeting annual performance metrics. The data are then consolidated for senior management review.

Since 2002, the DOE has been working in conjunction with the Office of Management and Budget to assess its programmes using the Program Assessment Rating Tool (PART). Through a series of targeted questions with requirements for specific evidential documentation, PART assesses each programme's purpose, and links to the Strategic Plan, management decision-making, and performance results. Essential for assessing programme results is the use of meaningful performance measures that clearly tie to DOE's mission. It is committed to increasing the use of key PART measures and associated quantitative targets as annual performance goals in the cascade described above. As of 2006, DOE has assessed over 94% of its programmes using PART and is committed to continuing to use PART as a programme assessment tool.

Each of the individual programmes within DOE and its national laboratories undergoes reviews for performance and accountability on an annual basis. The results of these evaluations are then published in the Performance and Accountability Report which details goals and progress towards meeting those goals.

On an annual basis, the Office of Inspector-General (OIG) provides the DOE with an objective assessment of programme performance. The OIG conducts specific reviews of programmes, grants and contracts at the request of the DOE and provides management with recommendations for improvement.

INTERNATIONAL COLLABORATION

The United States government is a leader in international technology collaboration (see Table 4 and Box 3). It works through:

- bilateral technology co-operation (180 SST agreements and 14 bilateral agreements)[5];
- international institutions (IEA, OECD, Asia-Pacific Partnership, APEC, UN, G8, EU);
- multi-lateral co-operation on specific technology challenges (Carbon Sequestration Leaderrship Forum, International Partnership for the Hydrogen Economy, GEN IV, Methane to Markets, ITER); and
- the IEA Implementing Agreements where it participates in 35 agreements in end-use, fossil fuel, renewable and fusion technologies.

Table 4

International Energy R&D Initiatives with United States Participation and/or Leadership

Name	*Area of activity*	*Number of partners*
Carbon Sequestration Leadership Forum (CSLF)	Focused on CO_2 capture and storage	22
International Partnership for the Hydrogen Economy (IPHE)	Organises, co-ordinates and leverages hydrogen RD&D programmes	17
Generation IV International Forum (GEN IV)	Devoted to R&D on next generation nuclear systems	10
ITER	Project to develop fusion as a commercial energy source	7
Methane to Markets (M2M)	Recovery and use of methane from landfill, mines, oil & gas systems, and agriculture	17
Asia-Pacific Partnership on Clean Development & Climate	Focuses on accelerating deployment of technologies to address energy security, air pollution, and climate change	6
Global Bioenergy Partnership	An Italian G8 initiative to support wider, cost-effective biomass and biofuels development, particularly in developing countries	n/a
Global Nuclear Energy Partnership (GNEP)	A US initiative that seeks to develop worldwide consensus on enabling expanded use of economical, carbon-free nuclear energy to meet growing electricity demand, using a nuclear fuel cycle that enhances energy security and promotes non-proliferation	n/a

Source: DOE.

5. Recent examples of bilateral technology R&D agreements include Canada (Weyburn); Norway (fossil fuels); and China (FutureGen).

Box 3

The International Partnership for the Hydrogen Economy

The International Partnership for the Hydrogen Economy (IPHE) was formed in November 2003 among 16 countries (Australia, India, Brazil, Italy, Canada, Japan, China, the Republic of Korea, Norway, France, Russia, Germany, the United Kingdom, the United States, Iceland, and New Zealand) and the European Commission (EC). The IPHE provides a mechanism to organise, evaluate and co-ordinate multinational research, development and deployment programmes that advance the transition to a global hydrogen economy. The partnership leverages national resources, brings together the international skills and talents and develops inter-operable technology standards.

The IPHE has reviewed actions being pursued jointly by participating countries and is identifying additional actions to advance research, development and deployment of hydrogen production, storage, transport, and distribution technologies; fuel cell technologies; common codes and standards for hydrogen fuel utilisation; and co-ordination of international efforts to develop a global hydrogen economy.

By creating the IPHE, the partners have committed to accelerate the development of hydrogen and fuel cell technologies to improve their energy, environmental and economic security.

CRITIQUE

Energy technology research and development plays a major role in achieving national energy goals. The innovation infrastructure is well developed and the United States is considered a world leader in many research areas. DOE has a commendable firm commitment to its mission of science-driven energy technology innovation and is the single most significant global funding source for energy RD&D.

The federal government primarily supports energy technology innovation by investing in basic science, applied research, development and demonstration via the national laboratory system. Innovation is also supported through partnerships with industry, small business grants, fuel, vehicle and appliance standards, loan guarantees for clean energy, and tax and regulatory policies. The close integration of private partners into public research ensures that the output of R&D programmes has practical applicability, and this approach is highly commendable. Nevertheless, the United States government should put a particular focus on establishing clear paths for new technologies coming out of basic research successes to enter into the market.

States and local governments currently play a critical role in creating market pull incentives to new technologies such as wind, solar PV and efficient lighting, through regulatory measures, renewable portfolio standards, clean energy funds, tax credits and production incentives. By allowing individual states, many of which are larger than most IEA member countries, to pursue market pull approaches that are in line with their needs, the United States is benefiting from the possibilities offered by experimentation with different approaches, and ensures that solutions are appropriate to local needs. This is highly laudable.

A broad-based decline in public funding has taken place since the early 1980s with a stabilisation and slightly upward trend in recent years. Federal funding has increased slightly since the last review in 2002, but it is still not clear if the increase in funding is in line with the ambitious goals that are being pursued. The United States government should continue to closely evaluate the impact of recent developments in funding levels on its programmes, and consider applying to Congress for additional funding in programmes where the funding is deemed insufficient.

Large reductions in investment by the private-sector can be observed. While the recent trend in venture capital investment in clean energy is a promising case that seems to run counter to the overall trends for industry involvement in the sector, it does not alter the fact that the recent decline in private-sector funding for energy R&D is raising questions. Private funding has historically exhibited less volatility than public funding; it rose only moderately in the 1970s and was stable in the 1980s, periods during which federal funding increased by a factor of three and then dropped by half, and this stability provided a measure of security to the research institutions. The current lack of industry R&D investment strongly suggests that the public sector needs to play a role in not only increasing investment directly, but also correcting the market and regulatory obstacles that discourage investment in new technology. For example, the data on private-sector fossil R&D validate warnings in the mid-1990s about the effect of electricity sector deregulation on technology investment. Raising the energy R&D contribution by the private-sector should become a key goal for the United States government, since this is the most certain way to enable new technologies to come to the market and contribute to a cleaner and more secure energy future.

Since 2001, DOE investment in basic energy sciences has been stable; investment in fission, hydrogen and fuel cells research has increased slightly; and investment in renewables research has declined. From FY 2006 to 2007, DOE requested increased funding for research in renewables (Advanced Solar Initiative and biofuels), hydrogen, fuel cells and fission, whereas requests for efficiency, fossil fuels and electricity transmission and distribution research decreased. Geothermal, hydropower, petroleum and natural gas RD&D were not part of the fiscal year 2007 request. Attempts to focus the public research effort on areas which are in line with the targets and goals that have been set are highly commendable, but care should be taken not to reduce or completely eliminate efforts in promising areas just because new initiatives are being developed. Overall, it is not quite clear how much interaction takes place between the R&D community, DOE and other parts of the Administration, when new programmes are being developed. Increasing transparency and feedback mechanisms may help United States energy R&D in the longer term by making it easier to convince Congress of the funding needs for the programmes.

The request process is to a large extent dependent on Congressional approval and goals, which may be different from those of the Administration. This can lead to outright rejection of requests, or to increases or decreases of the funding made available compared to the funding requested, with a potentially negative impact on programme stability. The government should consider developing approaches with Congress to ensure a stable, long-term funding environment, which will benefit the goals of energy R&D in the United States overall. Stop-start funding situations should be avoided wherever possible.

A particular problem in this regard are Congressional earmarks[6], which have the potential to ring-fence significant amounts of the funding made available and reduce the freedom of programme managers to spend the money where they think most appropriate.

Most programmes have very ambitious targets for the development of new technologies (*e.g.* cellulosic ethanol to be competitive by 2012, solar PV to be cost-competitive by 2015, FutureGen to be demonstrated in 2012, advanced reactor and recycling plants to be developed in a 20 to 30-year time frame). These goals seem extremely ambitious within the current investment level in public and private research, development and demonstration.

Other agencies like the Departments of Transportation and Agriculture and EPA fund energy-related R&D which calls for strong co-ordination work to avoid duplication of efforts and to increase synergies among programmes. Recent co-ordination with the Department of Agriculture on biofuels research and co-ordination under the Climate Change Technology Program (CCTP) are commendable examples. They should be continued and extended where appropriate.

The CCTP is a co-ordination programme that was created to steer and prioritise the federal government's existing and very substantial (nearly USD 3 billion) annual investment in climate-related technology research,

6. An earmark is a special provision in a bill inserted by a member of Congress, often directing funding towards a very specific purpose or entity, thereby reducing the freedom of funding allocation of the Administration.

development, demonstration and deployment. This robust effort is expected to lead to advanced technologies being available sooner than would otherwise be the case. However, many of these technologies are likely to remain more expensive than those available now. This raises some doubt about the extent to which those technologies will be deployed in the absence of some form of market signal.

The United States government is a leader in international technology collaboration. Engaging international partners through a wide range of approaches offers the ability to tailor new initiatives closely to the needs of the country. Nevertheless, there is a risk in creating new initiatives outside the established framework, related to the capacity of potential partners to participate in them. Consideration should be given to use established frameworks of co-operation before creating new initiatives, to harness the existing structures for international research collaboration.

RECOMMENDATIONS

The government of the United States should:

- *Strengthen its commitment to invest in energy technology RD&D and, taking into account the significant challenges in energy technology, increase the public funding levels in line with the objectives and ambitions articulated in EPAct 2005.*
- *Set transparent priorities within a coherent long-term strategy for public investments in RD&D based on a process involving academia, national labs and industry.*
- *Avoid stop-go funding packages for long-term RD&D which requires sustained and steady support.*
- *Work with Congress to reduce earmarking of energy RD&D appropriations.*
- *Continue the support for basic energy science research and strengthen current efforts to improve the linkages between the basic science and the applied energy technology communities.*
- *Put a particular focus on ensuring that R&D in the laboratory results in advancements that can cost-effectively be deployed in the market-place by involving industry more closely.*
- *Continue and expand its leadership in international energy technology collaboration, focusing on co-operation through existing arrangements and institutions.*

OVERVIEW

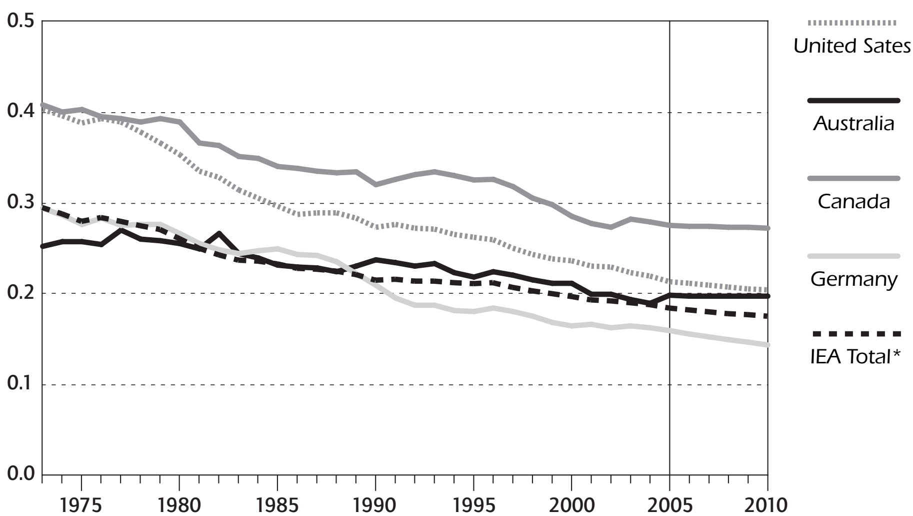
Energy intensity in the United States has fallen in line with the government's policy of pursuing intensity reductions, and reducing energy-related GHG emissions in relation to GDP. Overall, energy intensity improved by 20% between 1995 and 2005. This rate of improvement is ahead of that of many other major economies in the world (see Figure 10 and Table 5).

In international comparison, however, the United States is still less efficient than other major energy users, such as Japan, which in 2005 was 28% more efficient, or Germany, which was 23% more efficient, on a purchasing power parity (PPP) basis.

Figure 10

Energy Intensity in the United States and in Other Selected IEA Countries, 1973 to 2010

(toe per thousand USD at 2000 prices and purchasing power parities)

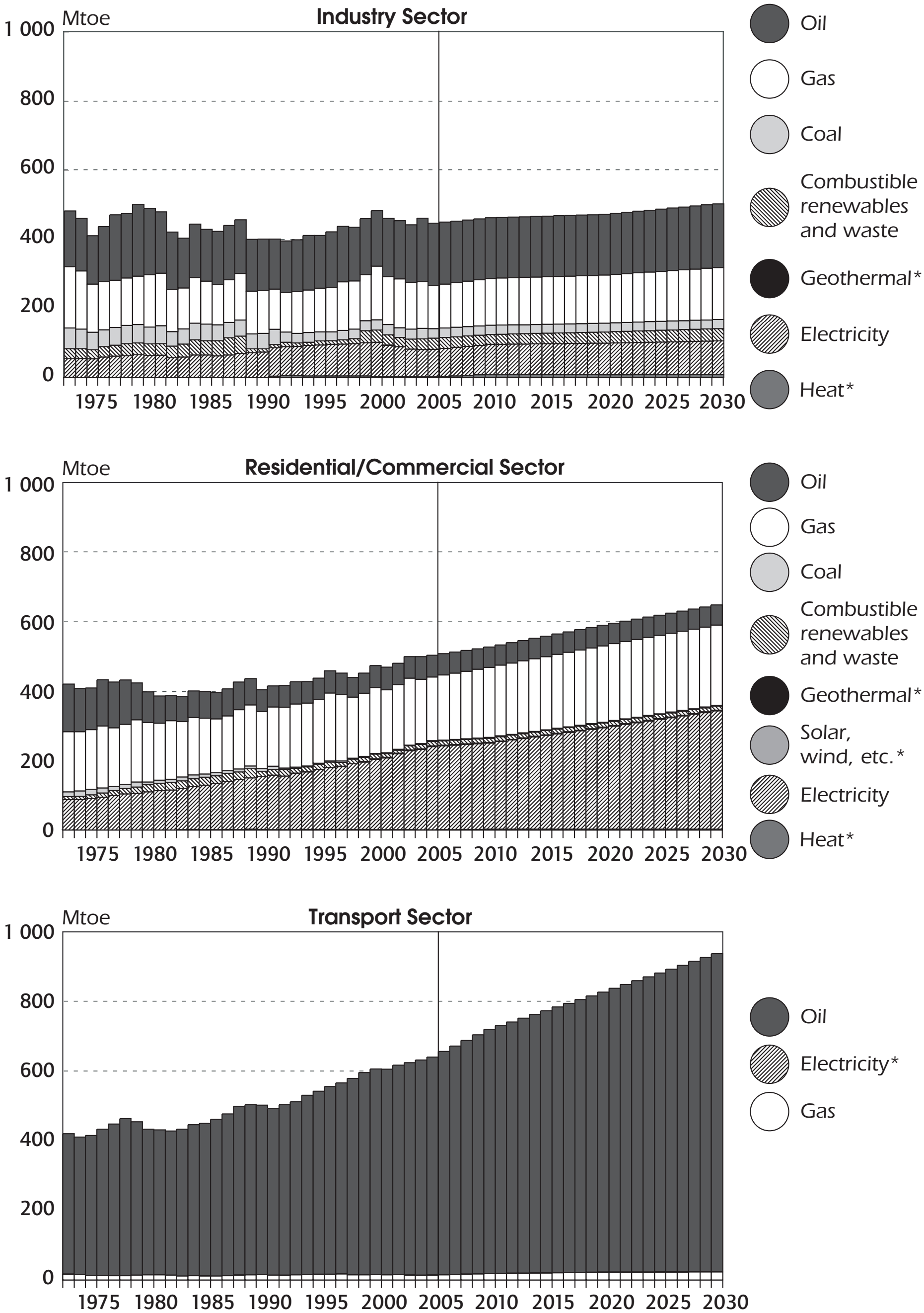


* excluding Luxembourg and Norway throughout the series, as forecast data are not available for these countries.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2007; *National Accounts of OECD Countries*, OECD Paris, 2007 and country submissions.

Figure 11

Total Final Consumption by Sector and by Source, 1973 to 2030



* negligible.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2007 and country submission.

Table 5

Energy Intensity Developments in Selected IEA Member and Non-Member Countries in 1995 and 2005

(in BTU per year-2000 dollars using PPP)

			Change	*Difference to best*	
Country	*1995*	*2005*	*2005/1995*	*1995*	*2005*
Russia	20 339	14 935	-27%	204%	189%
Korea, South	13 210	12 471	-6%	97%	141%
United States	11 352	9 113	-20%	70%	76%
Australia	9 553	9 045	-5%	43%	75%
China	9 763	7 906	-19%	46%	53%
France	7 816	7 243	-7%	17%	40%
Germany	7 891	7 021	-11%	18%	36%
Japan	6 744	6 539	-3%	1%	26%
United Kingdom	7 540	6 048	-20%	13%	17%
Denmark	6 694	5 173	-23%	0%	0%

Source: EIA website *International Total Primary Energy Consumption and Energy Intensity.*

SECTORAL DEVELOPMENTS

The overall improvement in intensity does mask important differences between sectors and, therefore, hides the potential for significant efficiency increases in sub-sectors of the economy. Energy demand increases since 1990 and projected increases to 2030 are particularly high in the transport sector and in the use of electricity in the residential/commercial sector. Industrial energy use, however, and gas use in the residential/commercial sector are predicted to stay relatively stable. The situation in the individual sectors is discussed in detail below, using a common matrix of indicators, shown in Table 6.

It is important to note that in end-use sectors, with the exception of transport, the key measure is for delivered energy, ignoring conversion losses. These are most important in the area of electricity use, where the delivered energy can be as little as 30% of the original energy input, because of losses in production, transmission and distribution. Electricity use has been growing significantly in the residential and commercial sectors, with a negative impact on energy system efficiency, due to the lack of parallel improvements in power generation efficiency (see below).

Table 6

Sectoral Development of Energy Efficiency, 1985 to 2004

Sector	*Activity change*	*Energy use change*	*Intensity change*[1]
Energy supply			
Power generation[2]	+18%[3]	+18%	–0%
End-use[4]			
Residential buildings[5]	+28%	+18%	–18%
Commercial buildings	+35%	+36%	–0%
Industry[6]	+64%	+8%	–20%
Transport	+55%	+42%	–14%
Passenger transport[7]	+59%	+38%	–14%
Freight transport[8]	+43%	+53%	–14%

1. This is an aggregate which takes into account changes in activity and energy use, and all structural changes which have affected the sector in the period.
2. For power generation, net electricity generation is used as activity, and CO_2 emissions are used as a proxy intensity indicator. Calculating on the basis of fuel input/electricity output shows a 1.4% improvement in fossil fuel plant fleet efficiency, driven solely by the introduction of combined-cycle gas turbine (CCGT) plant into the generation fleet since 2000. Coal-fired plant fleet efficiency has decreased by 3% since 1995, reflecting the additional running hours of older, and less efficient plant, and the continued investment in low-efficiency generation technology for new plant.
3. 1995.
4. This considers delivered energy only, thereby masking important changes such as the rapid rise of electricity consumption in the buildings sector, which degrades overall energy system efficiency.
5. Intensity change is measured as decline in energy use per square foot of floor area. This is greater than the decline in energy use per unit of activity, since activity is measured in terms of the number of households, and average floor space per household increased. Of the 18% decline in intensity, 7% was due to changes in household size, location and weather, while the rest was due to efficiency improvement.
6. Intensity change is measured as decline in overall energy use per dollar of industrial sector GDP. This is less than the decline in energy end-use per unit of activity, since the energy use figures ignore electricity losses. Of the 20% decline in intensity, 17% was due to structural shifts in the mix of manufacturing and in manufacturing as a fraction of industrial output, while the remainder was due to efficiency improvement.
7. Intensity change is measured as decline in energy use per passenger mile. This has taken place despite a 2% rise in consumption due to a shift from cars to light trucks, so efficiency improvement is somewhat greater.
8. Intensity change is measured as decline in energy use per tonne-mile, weighted by mode of transport. This has occurred even though energy use for freight transport went up since the 53% increase is adjusted for a 23% increase in energy use due to shifts from more efficient modes (water and rail) to less efficient modes (truck and air).

Source: Government Submission, EIA *Electric Power Annual 2007.*

Table 7

CO_2 Emissions Intensity in Power Generation, 1995 and 2004

Emission	*1995*	*2004*	*Changes 2004/1995*
Carbon dioxide (CO_2) (thousand metric tonnes)	2 079 761	2 456 934	18.1%
Net generation (thousand MWh)	3 353 487	3 970 555	18.4%
CO_2 emissions kg/MWh	620	619	–0.2%

Sources: EIA *Electric Power Annual 2007;* IEA calculations.

TRANSFORMATION SECTOR

Overall efficiency in electricity generation, using net generation and CO_2 emissions as proxy indicators, has shown almost no improvement between 1995 and 2004 (see Tables 7 and 8). As a consequence, power-sector emissions have continued to increase at an annual rate of 1.85% during the period, in line with net power generation. The lack of improvement in this indicator explains why the power sector's overall share of CO_2 emissions has grown in the United States since 1990, and is expected to continue to do so.

Table 8

Capacity and Output Changes in Power Generation, 1995 to 2006

	Coal	*Gas*	*Nuclear*	*Renewables*	*Total*
Capacity increase	1%	123%	1%	58%	28%
Share of total gross capacity increase	1%	95%	0%	4%	n/a
Output increase	16%	64%	17%	30%	21%
Share of total output increase	40%	45%	16%	3%	n/a

Sources: EIA *Electric Power Annual 2007;* IEA calculations.

Overall efficiency in the power sector is dependent on technology choice, and technology-specific load factors, which depend on operator decisions made on the basis of fuel prices. While the average potential efficiency of the United States power sector has greatly improved since 2000 with the commissioning of a significant number of high-efficiency CCGT units (included under "gas" in Table 8), the efficiency of generated electricity has not reflected this potential, owing to relatively low load factors at the CCGT plants, compared to coal plants (see Table 8). The use of high-efficiency combined heat and power (CHP) technology is confined primarily to the industrial sector, and it accounts for only small amounts of the country's power generation.

Table 9 shows announced, currently ongoing, and recently completed new coal power station projects in the United States. Coal accounts for almost half of the country's power generation, and is the most economical fuel in the absence of a policy placing a value on CO_2. It indicates that the technology of choice is low-cost, low-efficiency sub-critical pulverised coal (PC), which makes up over half of the projects that can be expected to be completed in the near- to mid-term future. Once a power station technology choice has been made, only marginal efficiency improvements are generally possible, and the station can be expected to have a lifetime of at least 30 to 50 years. Given that, realistically, only those plants in the "progressing" column will come on line before 2012, it can be seen that the current technology choices in the coal-fired power sector in the United States are locking in low efficiencies for the future.

Table 9

Choice of Coal Power Plant Technology

Technology	*Operational (since 2000)*	*Progressing (permitted to construction)*	*Announced but not permitted*	*Total*	*Indicative typical efficiencies (HHV[1])*
Pulverised coal subcritical	10	25	26	61	37%
Pulverised coal supercritical	1	4	9	14	42%
Pulverised coal Ultra supercritical	0	0	0	0	45%
Circulating fluidised bed	8	12	12	32	41%
Integrated gasification combined cycle	1	4	29	34	41%
Total	**20**	**45**	**76**	**141**	**n/a**
Share of PC subcritical in projects	50%	56%	34%	43%	n/a

1. HHV = higher heating value.

Source: North American Electric Reliability Corporation, IEA.

Table 10

Growth in Electricity Demand by Sector, 1995 to 2006

	1995 TWh	*2006 TWh*	*Share 1995 %*	*Share 2006 %*	*Change in % 2006/1995*
Industry[1]	1 163	1 158	38	30	0
Commercial	863	1 300	28	34	51
Residential	1 043	1 352	34	35	30
Total	**3 069**	**3 809**	**100**	**100**	**24**

1. Includes on-site generation.

Sources: EIA *Electric Power Annual 2007;* IEA calculations.

RESIDENTIAL/COMMERCIAL SECTOR

Buildings account for over two-thirds of electricity consumption in the United States. Most importantly, the residential and commercial sectors have experienced a rapid growth of electricity demand, which is expected to continue, and is the main driver for increasing energy demand in the sector as a whole (see Table 10). The most important increase has been in the commercial sector, which has grown at over twice the annual growth rate of electricity demand as a whole. Continued growth of electricity use is expected from increasing use of air-conditioning, as a result of higher demands for comfort, and a continuing shift of the population towards the south of the United States. At the same time, utility efforts in demand-side management (DSM) have decreased in their relative effectiveness since 1995 (see Chapter 8), though a strong recent resurgence in interest is showing a corresponding increase in utility DSM efforts.

Residential Buildings

The residential energy intensity index is based upon a ratio of energy use per square foot of floor area. Energy use per household declined substantially over the period 1978-1987, but changed little in the succeeding ten years. While total energy use, measured as delivered energy (*i.e.* excluding electricity losses), remained static between 1987 and 1997, heating and cooling energy use declined over this period. Energy use in appliances however increased enough to offset the declines in other end-uses, so that total energy use remained about the same[7]. Consumption declined in 1990, 1997, 1998 and 2001, years of mild winter weather, indicating the strong correlation of weather and energy consumption in the sector. The intensity index has generally trended downward since 1985, with the greatest declines observed

7. These estimates were based upon the Residential Energy Consumption Survey (RECS), a household survey conducted periodically by the Energy Information Administration.

since the early part of the 1990s. Since 1993, several structural effects have moderated energy consumption in the residential sector. In 2004 these factors combined to reduce energy use by about 7% as compared to 1985. Long-term shifts in the geographic distribution of households (*e.g.* north to south) and the types of housing units (*e.g.* single-family vs. multi-family) were responsible for nearly a 3% reduction in delivered energy in 2004 compared to 1985. Weather factors were responsible for the balance of the change.

Commercial Buildings

The energy efficiency trend in this sector, to the extent that there is one, is upward for some building types (Education, Health Care and Assembly buildings) and downward for others (Offices and Retail/Service buildings).[8] Understanding explanatory factors, such as building type, is a work in progress. It is currently not possible to quantify these factors in any comprehensive fashion for the system of indicators. Commercial energy consumption, measured as delivered consumption, has increased every year since 1985 with the exceptions of 1990, 1998, 2001 and 2004. The declines observed in 1991 and since 2001 are primarily the result of reduced economic activity. In these periods, vacancy rates of commercial office and retail space increased and the utilisation of occupied space fell. Energy use in commercial buildings is sensitive to weather, although not to the same degree as in residential buildings.

INDUSTRIAL SECTOR

The industrial sector comprises manufacturing and other non-manufacturing not included in transportation or services. These non-manufacturing sectors are agriculture, forestry and fisheries, mining, and construction. Only the manufacturing sector routinely collects data on energy use, although information on energy costs for the other sectors are available through census data every five years.

Industrial energy use has declined since 1997. Structural change away from energy-intensive industry has contributed significantly to the decline from 1998, and by 2004 had contributed to about a 17% reduction in energy use relative to 1985. The change resulting from structural shifts is a composite of two effects: the change in manufacturing as a fraction of total industrial output over time, and the changes (mostly shifts among industries) that have occurred over time within manufacturing. Manufacturing, which is more energy-intensive than non-manufacturing, has grown slightly compared to total industrial GDP, with most of that change occurring since 1995. This

8. These estimates were based upon the Commercial Building Energy Consumption Survey (CBECS), a survey of commercial buildings conducted periodically by the Energy Information Administration.

influence has led to a 7.5% increase in energy use, most of it since the recession of the early 1990s. Manufacturing industries that are less energy-intensive have grown more strongly, relative to those industries that are highly energy-intensive, thus reducing the energy intensity of manufacturing as a whole. These shifts have been most dramatic since 1992, when the energy intensity of manufacturing was at about the same level as in 1985. Since then, these shifts have reduced energy use in the industrial sector by about 23%.

TRANSPORT SECTOR[9]

For the transport sector, there is virtually no difference between delivered energy and total energy because the use of electricity is so minor. The two major sub-sectors that make up the transport sector are passenger movement and freight transport. Within each of these sub-sectors there have been shifts between highway transport and other modes (air, rail, and water). In the passenger transportation sub-sector, there has been a dramatic change in the mix of vehicles, with light-duty trucks such as sport utility vehicles (SUVs) increasing their market share over more conventional automobiles. The net impact of these shifts in the mix of transportation modes (called "modal shifts") has contributed to higher energy consumption, estimated to have increased transportation energy use by about 7% over the period.

Passenger Transport

Modal shifts at the aggregate passenger transportation level have contributed to about a 0.5% reduction in energy use between 1985 and 2004 as a result of a changing distribution of passenger-miles between highway, air and rail transportation. Much of that intensity decline occurred before 1992. The cumulative effect of modal shifts *within* the highway, airline and rail categories (primarily attributed to changes in the mix of vehicles), however, increased energy use by 2.2%. When these indexes are combined, the result is a structural change net effect of +1.7%).

From 1990 to 2005, the National Highway Traffic Safety Agency (NHTSA) was forbidden to improve CAFE vehicle efficiency standards. United States passenger transport has the highest fuel use per mile travelled among IEA member countries, together with Canada. Modal shifts in passenger transport, primarily between highway and air transportation, have reduced energy use slightly (on an energy per passenger-mile basis, air travel is less energy-intensive than highway travel). The most significant development has been the changing mix between light trucks and passenger cars. This trend has contributed to the 2.2% increase in overall passenger energy consumption since 1985.

9. Results presented are based on total energy consumption for the period between 1985 and 2004.

Freight Transport

Most of the change in intensity occurred between 1985 and 1998. Since 1999, intensity has fallen by less than 2%. Both modal shifts at the aggregate level (*e.g.* shifts between air freight and truck freight) and activity increases have contributed to higher energy consumption, while intensity changes have slightly reduced energy use. Modal shifts account for a nearly 23% increase in energy consumption over this period. Much of this shift is due to a greater fraction of freight tonne-miles being carried via truck and air, as compared to water, rail and pipelines. Road freight transport overall is comparatively efficient in the United States, because of the longer distances, and heavier weight of trucks, compared to most IEA member countries. Other forms of freight transport in the United States are also of comparatively high efficiency.

POLICIES AND MEASURES

POLICIES

The United States commitment to increasing energy efficiency and the pursuit of conservation policy was emphasised in the *National Energy Policy* (NEP) published in May 2001. The NEP states: "Conservation and energy efficiency are important elements of a sound energy policy." The document then outlines a range of measures by which the federal government can influence and promote energy efficiency, including information dissemination, standard-setting, encouraging R&D into efficient products, as well as programmes such as the Energy Star programme. The goal derived from this is to improve the energy intensity of the United States economy by 20% between 2002 and 2012.

The most important legal development since the last review was the Energy Policy Act of 2005 (EPAct 2005; see Annex B). This act was the first omnibus energy legislation enacted in more than a decade and has a strong focus on improving energy efficiency and increasing the use of renewable energy sources. Improved energy efficiency is encouraged through new statutory standards, requirements for federal action, and incentives for voluntary improvement, which are outlined in Annex B.

PROGRAMMES AND MEASURES

The *Corporate Average Fuel Economy (CAFE)* programme has been in place since 1978. Each firm manufacturing or importing cars for sale into the United States must meet the fuel economy standard independently for each of three categories of vehicle: domestic passenger cars, imported passenger cars, and light trucks. Table 11 shows that there has been relatively little improvement in fuel economy since 1996.

Table 11

Passenger Car Fuel Economy Performance by Manufacturer in mpg

	Year				*Change in %*	
	1996	*2007*	*1996*	*2007*	*2007/1996*	
Domestic	**Passenger cars**	**Passenger cars**	**Light trucks**	**Light trucks**	**Passenger cars**	**Light trucks**
Chrysler/DaimlerChrysler	27.6	28.6	20.3	22.8	4%	12%
Ford	26.8	28.8	20.6	22.2	7%	8%
General Motors	28.3	29.6	20.7	22.5	5%	9%
Honda	33.2	33.7	n/a	24.8	2%	n/a
Mazda	29.8	n/a	n/a	n/a	n/a	n/a
Nissan	n/a	33.4	n/a	n/a	n/a	n/a
Toyota	28.3	31.7	n/a	23.1	12%	n/a
Import						
BMW	27.3	27.5	n/a	23.4	1%	n/a
Chrysler/DaimlerChrysler Imports	28.2	27.5	n/a	n/a	–2%	n/a
Fiat	13.8	n/a	n/a	n/a	n/a	n/a
Ford Imports	31.5	27.5	n/a	n/a	–13%	n/a
GM Imports	35.8	32.0	n/a	n/a	–11%	n/a
Honda	27.8	39.9	n/a	n/a	44%	n/a
Hyundai	32.9	31.8	n/a	25.2	–3%	n/a
Isuzu	n/a	n/a	19.5	n/a	n/a	n/a
Kia	29.0	31.9	23.4	23.8	10%	2%
Land Rover	n/a	n/a	17.2	n/a	n/a	n/a
Mazda	32.7	n/a	21.2	n/a	n/a	n/a
Mercedes-Benz (2007 w/ DaimlerChrysler)	25.1					
Mitsubishi	29.9	28.1	19.1	24.9	–6%	30%
Nissan	30.4	25.9	23.0	22.7	–15%	–1%
Porsche	21.5	27.5	n/a	n/a	28%	n/a
Subaru	27.7	28.6	n/a	27.2	3%	n/a
Suzuki	34.0	30.5	27.5	23.9	–10%	–13%
Toyota	29.8	38.5	n/a	n/a	29%	n/a
Volvo	26.1	n/a	23.2	n/a	n/a	n/a
Volkswagen	28.2	28.6	n/a	19.8	1%	n/a
Sales weighted average (Domestic)	**28.3**	**n/a**	**20.5**	**n/a**	**n/a**	**n/a**
Sales weighted average (Import)	**29.7**	**n/a**	**22.1**	**n/a**	**n/a**	**n/a**
Total fleet average	**28.7**	**30.6**	**20.7**	**23.6**	**7%**	**14%**
Fuel economy standards	**27.5**	**27.5**	**20.7**	**22.2**	**0%**	**7%**

Source: National Highway Traffic Safety Agency.

From 1990 through 2002, the Department of Transportation (DOT), which sets vehicle efficiency standards through the National Highway Traffic Safety Administration (NHTSA), was prohibited by law from adjusting CAFE standards. In 2003, this prohibition was lifted, and NHTSA raised the light truck fuel economy standard from 20.7 miles per gallon (mpg) by stages to 22.7 mpg for the 2007 model year. In 2006, NHTSA proposed a new approach for light trucks in which fuel economy is based upon vehicle size. Under this approach, the impacts of the regulations are spread across more vehicles, so fuel savings are expected to be greater for a given economic cost, and the light truck fuel economy standard will rise to 24.1 mpg by model year 2011. In April 2006, the Administration requested authority from Congress to reform passenger car CAFE standards along similar lines, so that greater savings can be obtained at lower cost. Congress is currently considering legislation along these lines.

In August 2007, a Government Accounting Office (GAO) report recommended that Congress should consider giving NHTSA the authority to reform the car CAFE programme as it did the light truck programme, and the resources to update information on new fuel-efficient technologies, and to adjust the programme in the future. GAO also recommended that the NHTSA analyse the need for enhancements to the CAFE programme, and, in conjunction with the appropriate agencies, evaluate policies meant to reduce fuel consumption to ensure they are achieving stated goals. The DOT agreed to consider the recommendations, and the EPA agreed with them.

The *Energy Star* labelling programme, which has expanded internationally, informs consumers and businesses about the efficiency of buildings, home appliances and office equipment. DOE manages the labelling for appliances, while EPA manages the programme for equipment. Since the last in-depth review, the programme has been substantially expanded in the commercial market.

The NEP of 2001 recommended that *Energy Star* be expanded from office buildings to include schools, stores, homes and health care facilities. The programme has since been broadened to include several new categories of commercial buildings such as hospitals, supermarkets, hotels, financial centres, bank branches, courthouses, warehouses and residence halls. A national energy performance rating system, introduced in 1999 and further developed in 2002, lets interested parties rate a building's efficiency on a scale of zero to 100. Top performing buildings receive the *Energy Star.* This system has been valuable in assessing building energy efficiency and identifying cost-effective opportunities for improvements for a wide range of building types, including hospitals, schools, grocery stores, office buildings, warehouses and hotels.

The NEP also recommended that *Energy Star* labels be extended to additional products, appliances and services. The programme has since been extended to include home ventilation fans, small commercial heating, ventilation and air-conditioning units, ceiling fans, commercial refrigerators, portable phones, home insulation and air leak sealing, commercial cooking equipment, and vending machines. *Energy Star* specifications have also been upgraded for residential windows, compact fluorescent bulbs, residential light fixtures, central air-conditioners, televisions, and video-cassette recorders.

The DOE *Appliance Standards Program* develops, promulgates, and enforces test procedures and energy conservation standards for residential appliances and certain commercial equipment. DOE has energy efficiency standards in place for most major types of energy-using appliances, including air-conditioners, clothes washers and dryers, space and water heaters, kitchen cookers and ovens, refrigerators and freezers, and lighting. Some of the impetus for national efficiency standards came from manufacturers who wished to avoid the costly confusion of multiple state standards.

In 2004, DOE established a minimum-efficiency standard for residential central air-conditioners of SEER (Seasonal Energy Efficiency Ratio) 13. The new standard took effect in January 2006, reducing energy use by new air-conditioners by 23% relative to the prior standard. Also in 2004, DOE published *Advance Notices of Proposed Rulemakings* regarding energy efficiency standards for three products: distribution transformers, commercial air-conditioners and heat pumps, and residential furnaces and boilers.

POWER SECTOR

The DOE Office of Energy Efficiency and Renewable Energy (EERE) is working with equipment manufacturers to improve the cost and performance of renewable energy technologies, including photovoltaic, solar thermal power, wind power, hydroelectric power, and geothermal energy. The DOE Office of Electricity Delivery and Energy Reliability encourages utility energy efficiency by managing research in advanced transmission and distribution technologies, high-temperature superconductivity, smart grid infrastructure and energy storage, and by providing to states and regions best practice-based assistance on state electricity policies, in particular on energy efficiency, renewable energy, demand response, regional planning, and transmission siting.

INDUSTRIAL SECTOR

Energy Star for Industry works with manufacturing industries to enhance corporate energy management systems. EPA works with specific industries to identify barriers to energy performance, define strategies for minimising these barriers, and to design management tools that assist the industries with improvements. These efforts include the development of plant energy performance indicators that enable the industries to assess the efficiency of particular manufacturing plants, building upon the successful energy performance and benchmarking work in the commercial sector.

The *Industrial Technologies Program* aims to reduce the energy intensity of the United States industrial sector through a co-ordinated programme of research, development and deployment activities. The programme collaborates with industry (*e.g.* energy-intensive industries such as forest and paper products, steel, aluminium, metal casting, and chemicals) on R&D to improve the energy efficiency and productivity of industrial processes. *Technology Delivery* employs a variety of outreach and technology transfer activities to reach end-users in this large and diverse sector.

The *Industries of the Future* programme seeks to reduce projected annual industrial energy consumption by over 250 million tonnes of oil equivalent (Mtoe) by 2020, a 50% reduction compared to the IEA forecast, which would achieve an estimated USD 26 billion in production cost savings. The focus is on nine materials and process industries which account for the majority of energy use in the industrial sector and present the greatest opportunity for limiting energy use. The programme expects to help the partner industries to reduce energy consumption per unit of output by 25% from 1990 levels.

Under the programme, each of the participating industries defines a vision of its marketing, business and technology goals through 2020, identifies its most critical needs for the future, and enters into public-private partnerships to share the costs and risks of the R&D and technology deployment required. On the basis of its vision, each industry develops one or more technology road-maps, which articulate specific technology strategies and create a comprehensive R&D agenda. DOE assists industries during this process and acts as a neutral party to help competitors, suppliers, customers and other key stakeholders reach consensus. The published road-maps align public and private research investments with industry and public needs. The underlying idea is that industry will take ownership of the planning process and require industry support for R&D activities, to ensure that the developed technologies are quickly moved into commercial use.

Climate Vision is a public-private partnership initiative for the industrial sector to provide a short-term contribution to the goal of reducing GHG emissions intensity by 18% between 2002 and 2012. Business associations representing energy-intensive industry sectors and *The Business Roundtable* have become programme partners with the federal government and have issued letters of intent to meet specific targets for reducing GHG emissions. Partners represent a broad range of industry sectors, and the programme works with its partners to standardise measuring and monitoring; find cost-effective solutions to reduce energy use and GHG emissions; accelerate R&D; and explore cross-sector efficiency gains to reduce emissions.

In 2006, DOE introduced a new campaign called *Save Energy Now* to address high natural gas prices. Through the campaign, DOE is offering energy savings assessments to 200 energy-intensive facilities. Plants receive a no-cost, targeted, three-day steam or process heating assessment by DOE energy efficiency experts using the department's software analysis tools. DOE also distributes *Save Energy Now* CD-ROMs containing a compendium of tip sheets, case studies, technical manuals and software tools to help plants assess energy-saving opportunities.

TRANSPORT SECTOR

The *Vehicle Technologies Program* develops energy-efficient and environment-friendly highway transportation technologies for both cars and trucks. The long-term aim is to develop "leapfrog" vehicle technologies (through significant improvements in vehicle energy efficiency) that will preserve mobility while using less oil and reducing costs and environmental impacts. The programme focuses its research and development investments specifically on potential technology improvements that have uncertain or long-term outcomes, yet have the potential for significant public benefit. It supports R&D in vehicle systems, hybrid electric systems, hybrid and electric propulsion, advanced combustion engines, advanced materials technologies, and fuels technology. The programme's technology deployment activities include support for legislative and rule-making aimed at alternative fuels and fleets, and education, training and technical assistance related to different technology focus areas. These focus areas for technology deployment include: alternative fuel vehicles, alternative fuel infrastructure development, reduced engine idling for commercial trucks and buses, expanded use of non-petroleum and renewable fuel blends, hybrid vehicles, driving practices for improved efficiency, and engine/vehicle technologies that maximise fuel economy.

The *Clean Cities Program* supports efforts to deploy alternative fuels and vehicles and develop the necessary supporting infrastructure. It works through a network of more than 80 volunteer, community-based coalitions, which develop public-private partnerships to promote the use of alternative fuels and vehicles, expand the use of fuel blends, encourage the use of fuel economy practices, increase the acquisition of hybrid vehicles by fleets and consumers, and advance the use of engine idling reduction technologies in heavy-duty vehicles.

On 14 July 2005, the DOE and the United States Council for Automotive Research (USCAR) announced an agreement to develop advanced high-performance batteries for electric, hybrid and fuel cell vehicles. The DOE *FreedomCAR Program* and *USCAR United States Advanced Battery Consortium* would spend up to USD 125 million over five years for R&D on new battery materials and technologies to increase energy storage capacity (extending vehicle range), improve charge/discharge performance, reduce costs, and make batteries more durable and reliable. These battery improvements should make highly fuel-efficient electric and hybrid vehicles more marketable to consumers.

In May 2005, DOE and USCAR agreed to provide USD 70 million to develop light-weight, high-strength materials that can boost fuel efficiency by reducing vehicle weight. In February 2005, DOE and industry agreed to spend USD 175 million on seven projects for research in advanced combustion technology and five projects for technology to convert waste heat from engines to electrical or mechanical energy, all of which should boost vehicle efficiency.

EPA, DOT and DOE are working together on truck stop electrification (TSE), a programme that will permit idling trucks to shut down their engines and run lights, heating and air-conditioning from on-site electricity. This programme promises reductions in truck fuel consumption and emissions. Through a series of workshops and conferences aimed at anti-idling and truck stop electrification, DOT, EPA and DOE are developing TSE codes and standards that will pave the way for new technologies to reduce truck idling.

RESIDENTIAL /COMMERCIAL SECTOR

The *Building Technologies Program* develops technologies, techniques and tools for making residential and commercial buildings more energy-efficient, productive and affordable. The portfolio of activities includes efforts to improve the energy efficiency of building components and equipment and their effective integration using whole-building-system-design techniques, the development of building codes and equipment standards, the integration of renewable energy systems into building design and operation, and the accelerated adoption of these technologies and practices. The programme's focus is on residential buildings integration R&D, commercial buildings integration R&D, emerging technologies R&D, technology validation and market introduction, and equipment efficiency standards and analysis.

The *Energy Efficient Mortgages Program* (EEM) helps home-buyers or home-owners to save money on energy bills by enabling them to finance the cost of adding energy-efficiency features to new or existing housing as part of their home purchase or refinancing mortgage. Cost-effective energy-saving measures may be financed as part of the mortgage. A buyer's debt-to-income ratio on the loan for an energy-efficient home could be stretched so that a larger part of the borrower's monthly income can be applied to the monthly mortgage payment. All homes built to the Council of American Building Officials Model Energy Code (MEC) can qualify for an EEM. Since an *Energy Star* home is 30% more energy-efficient than a home built to the MEC, it exceeds the minimum requirements for EEMs and automatically qualifies for the stretch. Federal Housing Administration-approved lending institutions, which include many banks, savings and loan associations, and mortgage companies, can make loans covered by EEM insurance.

Federal agencies are encouraged to use *Energy Savings Performance Contracts* (ESPCs) to finance investments in energy-saving improvements. An ESPC is a contracting vehicle where energy cost savings fund the capital improvements undertaken by a third party, thereby allowing agencies to accomplish energy projects for their facilities without up-front capital costs and without special Congressional appropriations to pay for the improvements. An ESPC project is a partnership between the customer and an energy services company (ESCO). The ESCO conducts a comprehensive energy audit and identifies improvements that will save energy at the facility. In consultation with the agency customer, the ESCO designs and constructs a project that meets the agency's needs and arranges financing to pay for it. The ESCO guarantees that the improvements will generate savings sufficient to pay for the project over the term of the contract. After the contract ends, all additional cost savings accrue to the agency. Contract terms up to 25 years are allowed.

The *Commercial Building Integration Program* works to realise energy-saving opportunities provided by advancing a whole-building approach for commercial construction and major renovation. The programme is working through industry partnerships in design, construction, operation and maintenance, indoor environment, and control and diagnostics of heating, ventilation, air-conditioning, lighting, and other building systems. The programme helps to transfer the most energy-efficient building techniques and practices into commercial buildings through regulatory activities, such as supporting the upgrade of voluntary (model) building energy codes and promulgating upgraded federal commercial building energy codes.

Building America is a private-public partnership that develops energy solutions for new and existing homes by using a systems engineering approach to home building and combines the knowledge and resources of industry leaders with DOE's technical capabilities. This includes uniting segments of the building industry that traditionally work independently from one another, such as teams of architects, engineers, builders, equipment manufacturers, material suppliers, community planners, mortgage lenders, and contractor trades.

The *Weatherisation Assistance Program* provides cost-effective energy efficiency improvements to low-income households through the weatherisation of homes. The programme helps low-income families to permanently reduce their energy bills by making their homes more energy-efficient. The programme performs energy audits to identify the most cost-effective measures for each home, which typically includes adding insulation, reducing air infiltration, servicing heating and cooling systems, and providing health and safety diagnostic services. Priority is given to the elderly, persons with disabilities, families with children, and households that spend a disproportionate amount of their income on energy bills. Utility bills make up 15% to 20% of household expenses for low-income households, compared to 5% or less for other households.

GOVERNMENT BUILDINGS

The *Federal Energy Management Program* (FEMP) works with federal agencies and United States private-sector partners to assist agencies in realising energy, environmental and cost-savings potential, including federal energy intensity goals, as set by Presidential Executive Orders or Congressional legislation, in the areas of energy efficiency, renewable energy, GHG emissions, and water management. FEMP employs a variety of approaches such as direct technical assistance and assistance in accessing alternative private-sector funding, to achieve its programme goals.

INFORMATION AND PUBLIC OUTREACH CAMPAIGNS

The *Database of State Incentives for Renewables and Efficiency* (DSIRE) is a DOE-funded comprehensive source of information on state, local, utility, and federal incentives that promote renewable energy and energy efficiency. The DSIRE website provides federal, state, local governments and the public with a method for accessing information about renewable energy and energy efficiency incentives and regulatory policies administered by federal and state agencies, electric power companies and local organisations across the country.

DOE and EPA are jointly facilitating an aggressive voluntary effort called the *National Action Plan for Energy Efficiency,* launched in July 2006, in which the leaders of the electric and gas utility industries, their state regulatory commissions, and allied organisations have called for major expansion of energy efficiency delivered to electricity and gas customers. As of November 2007, nearly 120 organisations have already taken action and over 30 new commitments have been made in the past year. These commitments to energy efficiency from 42 utility commissions and other state and local agencies, 34 utilities, seven large end-users, and over 37 other organisations, have helped remove barriers to energy efficiency by establishing and supporting state-level collaborative processes, starting new energy efficiency programmes, exploring policies and efforts to align utility incentives with cost-effective energy efficiency, educating stakeholders and meeting aggressive energy saving goals.

DOE and EPA release an annual *Fuel Economy Guide*, which provides listings of model year vehicles that are fuel economy leaders, both overall and by vehicle class. Manufacturers and EPA both test vehicles on the basis of EPA specifications to determine fuel economy estimates before sale. The guide is also available on-line for consumers to easily access information, and allows comparisons back to model year 1990, using the current mileage standard.

In October 2005, DOE and EPA launched the *Change a Light, Change the World Campaign for Light Bulb Replacement* to encourage residents to replace a conventional bulb or fixture in their home or workplace with one that has earned the government's *Energy Star* label for energy efficiency.

In May 2004, DOE and the Alliance to Save Energy launched the *Powerful Savings Campaign* to help consumers reduce their energy bills and the nation reduce its energy use through "smart" energy practices and energy efficiency. The campaign focuses on increasing public awareness on the importance of energy efficiency, and improving energy practices both at home and on the road through an extensive media outreach campaign. In December 2004, DOE launched a new website, as a consumer-friendly portal to detail energy saving information from various federal agencies.

The *Easy Ways to Save Energy* campaign promotes energy savings through an "Energy Savers Guide". The guide is being distributed to consumers across the country. Aggressive radio and print advertisements to promote more efficient energy use are also employed.

EVALUATION AND MONITORING

The DOE Office of Energy Efficiency and Renewable Energy (EERE) has launched an *Energy Intensity Website* that provides detailed information and data on changes in energy intensity in the United States since 1985 to help raise public awareness about how and why energy intensity in the country has changed over the years. The website discusses trends and also provides data on economy-wide energy intensity trends, as well as intensity changes in the four end-uses sectors and their sub-sectors: commercial and residential buildings, transportation, and industrial. The detailed energy intensity indicators on the website control for structural changes in the economy that are not directly associated with energy efficiency improvement (*e.g.* driving more trucks than cars, population shifts, etc.) which is key to having a meaningful measure of intensity associated with energy efficiency improvement.

CRITIQUE

The United States has traditionally enjoyed abundant energy resources, produced or imported at relatively low cost and with low levels of taxation, compared to other IEA member countries. Together with structural factors, such as the wider distances travelled, high mobility of the population, and continuing rapid population and economic growth, this has led to a situation where there is substantial room for the United States to improve the efficiency of buildings, appliances and transport. Energy cost increases in recent years, together with concerns about energy supply security, have led to a stronger focus by the government on addressing energy efficiency policy. The most notable development here has been the EPAct 2005, which contains a wide range of new measures to support energy efficiency in the United States, even though not all provisions of the act have been implemented. Tax credits offered by the act are estimated to be worth USD 2 billion over two years, and additional R&D expenditure in energy efficiency and renewables is estimated at USD 1 billion. These increases in incentives and funding are highly commendable. They add to an already existing impressive range of incentive schemes for energy efficiency, ranging from tax credits and grants, to product standards, and information and education campaigns. The instruments to pursue a successful energy efficiency policy through incentives and standards are present in the United States and well developed and this, together with structural changes, has contributed to the significant improvements in the country's energy intensity since 1995.

Nevertheless, despite the impressive range of instruments and rate of improvement, energy intensity is still significantly higher in the United States than that in other IEA member countries, and 76% above that of the best performer, Denmark. Of greater concern, the improvement rate of energy intensity over the ten years from 1995 to 2005 is also not matching that of Denmark. This indicates that significant economically attainable potential for efficiency improvements exists throughout the United States economy. There are clear structural explanations for at least part of the efficiency differences, such as the longer distances over which goods and people travel in the United States, combined with higher economic integration of the United States compared to Europe, for example. It is questionable, however, whether these factors alone can explain the continued discrepancy, since it is likely that the comparatively low energy prices also play a major role. It is also questionable if structural factors alone can explain the relative worsening of the United States position compared to the top performer Denmark in intensity improvements over the period 1995 to 2005, given that structural factors should have remained relatively unchanged over this period. To improve the United States performance in energy efficiency, we urge the government to make its policies fully consistent with the 16 energy efficiency policy recommendations the IEA presented to the Group of Eight (G8). These policy measures were endorsed by both G8 leaders and IEA members in 2007 (see Box 4).

The key problem in creating the right incentives for more energy-efficient behaviour and decision-making in the United States is related to the price of energy. Through low taxation, lack of internalisation of the CO_2 emission costs, continued significant subsidies for the use of fossil fuels (*e.g.* the synfuel tax credit), and failure to expose energy consumers to cost-reflective prices (for example through rate-freezes in retail electricity rates), prices have been distorted.

Box 4

The G8 Energy Efficiency Recommendations

At the Group of Eight (G8) Summit in 2005 in Gleneagles, Scotland, the G8 countries[10] asked the IEA to assist in developing and implementing energy efficiency policies. Responding to this request, the IEA prepared 16 recommendations for IEA countries to pursue, covering appliances, lighting, buildings, transport, industry and cross-sectoral policies. The suite of recommendations was subsequently endorsed by all 26 IEA countries in 2007, and we urge the United States to work to implement them.

Appliances

- Limit stand-by power use to 1 watt.
- Establish minimum energy efficiency standards for television set-top boxes and digital television adapters.
- Establish mandatory energy performance standards and, where appropriate, energy labelling across the full range of mass-produced equipment.
- Require individual and networked devices to enter low-power modes automatically.

Lighting

- Adopt best practice in lighting energy efficiency.
- Phase out the most inefficient incandescent bulbs as soon as commercially and economically viable.

Buildings

- Strengthen the energy efficiency requirements of building codes.
- Promote low-energy houses.
- Monitor energy efficiency improvements in existing buildings.

Transport

- Implement a fuel-efficient tyre programme.
- Introduce mandatory fuel efficiency standards for cars and small trucks.
- Adopt international test procedures for measuring tyre rolling resistance.

Industry

- Improve the coverage, reliability and timeliness of industries' energy-use data.

Cross-sectoral

- Provide adequate resources for their energy efficiency policy agencies and publish energy efficiency action plans.
- Encourage investment in energy efficiency.
- Report progress in the implementation of the proposed energy efficiency actions to the IEA.

10. The G8 countries are: Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States.

Environmental and energy security externalities of energy consumption have also not been internalised in the end-use prices. This has encouraged consumers to use more energy than they would have done if faced with fully cost-reflective prices. Failing to give the right incentives for conservation has removed the strongest reason for energy users to demand more efficient products. While gasoline use is taxed, and internalisation of some environmental aspects of energy use exists (*e.g.* the SO_2 market or congestion charges in some regions), the low impact on price of these measures have contributed to the continued high energy consumption levels. To address the multiple challenges that United States energy policy is facing, the price mechanism is the most important tool to address them. The government should use it, by abolishing fossil fuel subsidies and creating taxation or other pricing regimes that internalise environmental costs. The continuing policy providing for low energy prices is leading to forecasts of demand that are unsustainable, and creates significant security and environmental risks not just for the United States, but also for the rest of the world.

Because of its size, the United States transport sector has a global impact on oil markets, and energy security worldwide, as was demonstrated following the supply disruptions after the 2005 hurricanes. The system as a whole is also less efficient than that of most other industrialised countries owing to less developed public transportation systems, higher annual mileage per capita in both passenger and freight transport, and a fleet of cars and trucks with inferior mileage performance. The transport sector is the key sector to achieve energy security and sustainability, and transport efficiency policy, therefore, holds significant potential to improve both of these. Moving towards a more sustainable transport sector would herald a fundamental change to the way in which the United States is using energy. Progress has already started, for example in the new powers given to the EPA to regulate CO_2 emissions, the lifting of the injunction on raising vehicle efficiency standards in 2003, the emergence of the use of the price mechanism in the form of congestion charges and tolling, and the strong emphasis on the use of technology to provide different forms of fuel and different sources of conversion. The government will have to draw all transport policy measures together to deliver a consistent whole, and ensure sustained and stable funding levels, if it wants to successfully address the sustainability and security challenge in the transport sector.

To achieve the required improvements, addressing the demand side of transport will be critical. Existing transport management programmes are a good basis for a more aggressive approach to improving energy efficiency. The approach to counteract congestion with economic instruments can also be expected to be highly cost-effective. To be economically and socially acceptable this type of congestion management will have to be supplemented with the further development of the public transportation system, to lead to sustainable modal shifts. The United States government should therefore consider providing the funds required to develop and extend, where practicable, public transportation systems capable of competing with individual car transportation, to relieve congestion and reduce fuel demand.

On the supply side, little progress has been made since 1990 in improving individual vehicle performance. In 2003, the restriction on raising vehicle efficiency standards, which had prevented these from being improved since 1990, was lifted. This is highly commendable, and the government should ensure that no such restriction is placed on the NHTSA again. Commendably, the NHTSA started work to raise standards very quickly after the lifting of the restriction, and this work is continuing. It will be most important to address the efficiency of the light truck class of vehicles, which comprises SUVs. While the NHTSA's *Light Truck 2008–2011 Rule,* which requires light trucks to achieve 24.1 mpg in 2011, is a start in the improvement process, it will not be sufficient, and further work should be undertaken to bring the fleet mileage closer to international best practice, if overall policy goals regarding sustainability and security of supply are to be achieved. For example, the highly ambitious vehicle fuel economy regulations that are expected to apply in the European Union from 2012 are equivalent to a 47 mpg standard for gasoline cars in the United States. In general, in the field of vehicle efficiency, present policy goals in the United States are too timid to lead to the achievement of the cost-effective efficiency potential in the vehicle sector. It will also be necessary to investigate the potential for a large-scale fuel switch to diesel engines, which by itself could significantly increase the efficiency of heavier vehicles, especially light trucks.[11] A special efficiency rebate provision applies to car companies selling E85-capable flex-fuel vehicles on the United States market. Since fuel flexibility has little effect on fuel efficiency, the government should consider abolishing this provision in favour of other means of promoting alternative fuel use.

Electricity production in the United States is comparatively inefficient because of intensive reliance on traditional coal-fired power plants. CO_2 emissions are consequently high. This is due to technology choice, the low cost of coal relative to natural gas, fuel prices distorted by subsidies, and the absence of an economic incentive to increase efficiency, or to burn cleaner fuels for power generation. For example, 40% of the increase in electricity demand between 1995 and 2006 was served by simply running existing coal-fired stations for longer hours. Commercially available power generation technology would make it simple to at least slightly improve the efficiency of existing coal plant and significantly improve that of newly constructed plant, but it is not being implemented on a wider scale. The incentive for the choice of these technologies, which suffer from cost-disadvantages compared to subcritical technology, would need to come from a CO_2 pricing scheme, and by giving

11. For example, for a 2008 VW Touraeg SUV, the mileage achieved by the diesel version is 21.5% above that for the gasoline version.

power generators the right incentives to invest, through the application of cost-reflective prices in the electricity retail markets.

Residential energy consumption, measured as delivered consumption, has increased in total and specific consumption per household has not improved since 1987. Also, with the increasing use of electricity, which is being promoted as a fuel by price controls not affecting other fuels, the total impact of residential energy use has risen, because of the lower overall efficiency of electricity, compared to other forms of energy. A good example of the significant potential to increase the efficiency in the energy system while reaping an economic gain is provided by Vermont's Energy Efficiency Utility which has reported electricity savings corresponding to 4% of the state's total electricity demand at a cost 60% below the avoided cost for energy production. Similarly, electric utilities in the western states have in their integrated resource plans that they will meet about 50% of their customers load growth through energy efficiency. Energy consumption in commercial buildings has also increased and, for some types of buildings, even the specific energy consumption per square foot has increased, driven by rapidly growing electricity demand. While building standards in the United States are generally good, there are concerns about their enforcement, like in most other IEA member countries. Also, while a voluntary labelling scheme is in existence through the *Energy Star* programme, the government could consider applying a mandatory scheme to reward the most efficient homes and provide information at the point of purchase, which could be combined with the existing energy-efficient mortgage programme. Another measure to address energy use in urban buildings would be to make more use of district heating/cooling schemes which offer significant advantages compared to individual systems, and also increased security of supply, as any type of primary energy, including waste, can be used, depending on local air pollution rules. Although there is a long history of successful district heating in several cities in the United States, the overall development has not reflected the real potential of this technology, and combined heat and power use remains mostly confined to the industrial sector.

Effective development and enforcement of measures (for example improving energy efficiency in existing buildings through building regulations and more efficient technologies and design) require additional support, such as advice, including on-site consultations by special agencies, consultants, and consumer associations. To ensure consistency of quality and availability of independent advice, public support for such networks is required on a long-term basis. The measures introduced by EPAct 2005 are, therefore, very welcome, and the United States government should extend them over a sufficient time-frame to let them achieve results.

Energy efficiency standards for appliances are of increasing economic importance as appliances become less expensive and energy prices rise.

With more energy-efficient buildings and a rapid increase in the number of appliances in residences, the electricity used by appliances is responsible for a major part of energy bills and is the reason for the increase in consumption. The United States has a long tradition of providing consumers with information on energy demand for appliances through labels. Despite some of the most demanding standards in the world being applied, however, the per-capita household appliance electricity consumption level is still the highest among the larger IEA member countries, and 2.5 times above that of the lowest per-capita consumption, New Zealand. In order to increase the impact of standards, the government could consider experience from other countries' programmes, such as the Japanese Top Runner programme, under which inefficient products are being forced out of the market, instead of relying solely on the power of information. Applying the 1-watt stand-by standard for federal purchases of goods is very commendable, and the government should move to implement it on a statutory basis.

RECOMMENDATIONS

The government of the United States should:

- *Implement all energy efficiency-related provisions in EPAct 2005 as quickly as possible, and consider the extension of those which are subject to sunset restrictions in 2008 and 2009.*
- *Implement the 16 IEA recommendations regarding energy efficiency, where it has not already done so.*
- *Ensure that energy efficiency incentives are long-term to allow the market to respond, and utilise the price mechanism for energy to create demand for efficient products by abolishing subsidies for fossil fuels and internalising environmental costs through taxation or other mechanisms.*
- *Improve the efficiency of public transport by:*
  - *Urgently developing a coherent and comprehensive long-term strategy for sustainable mobility, taking into account social aspects of increasing fuel costs and security of fuel supply. This should include the development of a modern and capable public transport system.*
  - *Applying, and improving upon, currently best available technologies for the reduction of vehicle fuel consumption in the revision of the CAFE standards.*
  - *Abolish the CAFE credits given for selling E85-capable vehicles.*

- *Take measures to increase the efficiency of power generation, through regulation, incentives, and cost-reflective prices.*
- *Support the application of stringent building codes by the relevant code-setting authorities, covering new buildings and renovations and consider the introduction of mandatory building energy labelling.*
- *Review and regularly update minimum energy efficiency standards for appliances to reflect technical developments, taking account of best practices. Explore the feasibility of harmonising standards with other countries to create a larger market for energy-efficient appliances and reduce costs for manufacturers.*

CLIMATE CHANGE

OVERVIEW

Emissions of greenhouse gases (GHGs) in the United States have increased by 16% between 1990 and 2005 (see Table 12). Since 1990, the most substantial increase in volume has been in emissions from energy use, followed by industrial processes. These two categories together account for 90% of United States GHG emissions. Emissions from agriculture, the second most important source, have increased only slightly in the same time, and the overall share of agricultural emissions has decreased.

Table 12

Recent Trends in United States Greenhouse Gas Emissions and Sinks by IPCC Sector

Chapter/IPCC sector	*1990*	*1995*	*2000*	*2005*	*Share (%) 1990*	*Share (%) 2005*	*Change (%) 1990/2005 Total*	*Change (%) 1990/2005 Share*
	Mt CO_2 eq.							
Energy	5 202	5 526	6 069	6 202	83.3	85.4	19.2	2.5
Industrial processes	300	315	339	334	4.8	4.6	11.2	–4.4
Solvent and other product use	4	5	5	4	0.1	0.1	0.0	–14.0
Agriculture	530	527	547	536	8.5	7.4	1.1	–13.1
LUCF[1] subcategory								
(Non-CO_2 emissions)	13	10	21	19	0.2	0.3	45.4	25.0
Waste	192	189	166	165	3.1	2.3	–13.9	–26.0
Total sources	**6 242**	**6 571**	**7 147**	**7 260**	100	100	16.3	0.0
Net CO_2 flux from LUCF	–713	–829	–757	–829	–11.4	–11.4	16.2	–0.1
Net emissions	**5 529**	**5 742**	**6 391**	**6 432**	100	100	16.3	

1. Land-use change and forestry.

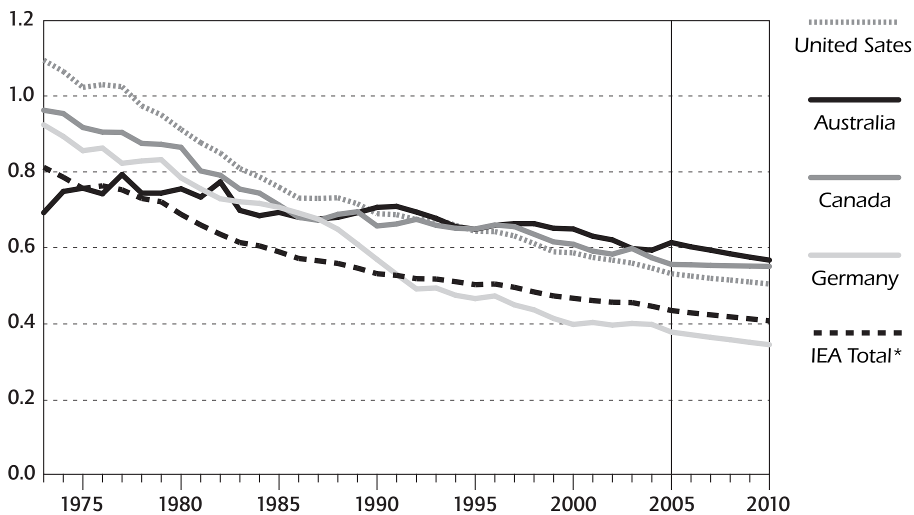
Source: EPA, *United States Inventory Greenhouse Gas Emissions and Sinks 1990-2005* (EPA 2007).

CO_2 emissions from fossil fuel combustion accounted for 79% of all GHG source emissions in 2005, adjusted for global warming potential (see Table 13). The most significant sector for the emissions of CO_2 is electricity generation, which accounted for 41% of total energy-related CO_2 emissions in 2005, followed by transport, which accounted for 33%. Between 1990 and 2005, total energy-related CO_2 emissions increased by 22%. This increase was slower than the growth of GDP in the same period, continuing the trend of reducing emissions intensity in the United States, which started in 1987 (see Figure 12). Energy-related CO_2 emissions are forecast to grow by 68% between 1990 and 2030 in the EIA's business-as-usual scenario.

Figure 12

Energy-Related CO_2 Emissions per GDP in the United States and in Other Selected IEA Countries, 1973 to 2010

(tonnes of CO_2 emissions per thousand USD/GDP using 2000 prices and purchasing power parities)



* 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, 2007; *National Accounts of OECD Countries*, OECD Paris, 2007 and country submissions.

United States energy-related CO_2 emissions per unit of GDP are 0.54 kg of CO_2 per year-2000 USD of GDP, and are 26% above those of the OECD Europe average (see Figure 12) of 0.42 kg CO_2 per year-2000 USD of GDP using purchasing power parities (PPPs), and 18% above the OECD average of 0.45 kg CO_2 per year-2000 USD of GDP using PPPs. United States emissions per unit of GDP have declined by 21% since 1990, while emissions of CO_2 related to TPES have only declined slightly, by 1.2% over the same time.

This indicates that energy supply has not become significantly more efficient, and that most of the emissions reductions are due to efficiency improvements and structural shifts on the demand side.

Table 13

CO_2 Emissions by Sector and Origin, 1990 to 2005

End-use sector	1990	1995	2000	2005	Share (%) 1990	Share (%) 2005	Change (%) Total	Change (%) Share
	Mt CO_2 eq.						1990/2005	
Transport	**1 467**	**1 593**	**1 788**	**1 898**	31.1	33.0	29.4	6.3
Combustion	*1 464*	*1 590*	*1 784*	*1 893*	*31.0*	*32.9*	*29.3*	*6.2*
Electricity	*3*	*3*	*3*	*5*	*0.1*	*0.1*	*73.3*	*42.4*
Industrial	**1 540**	**1 596**	**1 660**	**1 575**	32.6	27.4	2.3	-16.0
Combustion	*857*	*883*	*875*	*840*	*18.1*	*14.6*	*-2.0*	*-19.5*
Electricity	*683*	*713*	*785*	*735*	*14.5*	*12.8*	*7.7*	*-11.6*
Residential	**930**	**995**	**1 132**	**1 209**	19.7	21.0	30.0	6.8
Combustion	*340*	*356*	*374*	*359*	*7.2*	*6.2*	*5.4*	*-13.4*
Electricity	*590*	*639*	*758*	*850*	*12.5*	*14.8*	*44.1*	*18.4*
Commercial	**759**	**811**	**969**	**1 017**	16.1	17.7	33.9	10.0
Combustion	*224*	*226*	*232*	*226*	*4.7*	*3.9*	*0.7*	*-17.3*
Electricity	*535*	*584*	*737*	*791*	*11.3*	*13.8*	*47.9*	*21.5*
United States Territories	**28**	**35**	**36**	**53**	0.6	0.9	85.5	52.4
Total	**4 724**	**5 030**	**5 585**	**5 751**	100.0	100.0	21.7	n/a
Of which electricity generation	*1 810*	*1 939*	*2 284*	*2 381*	*38.3*	*41.4*	*31.5*	*8.1*

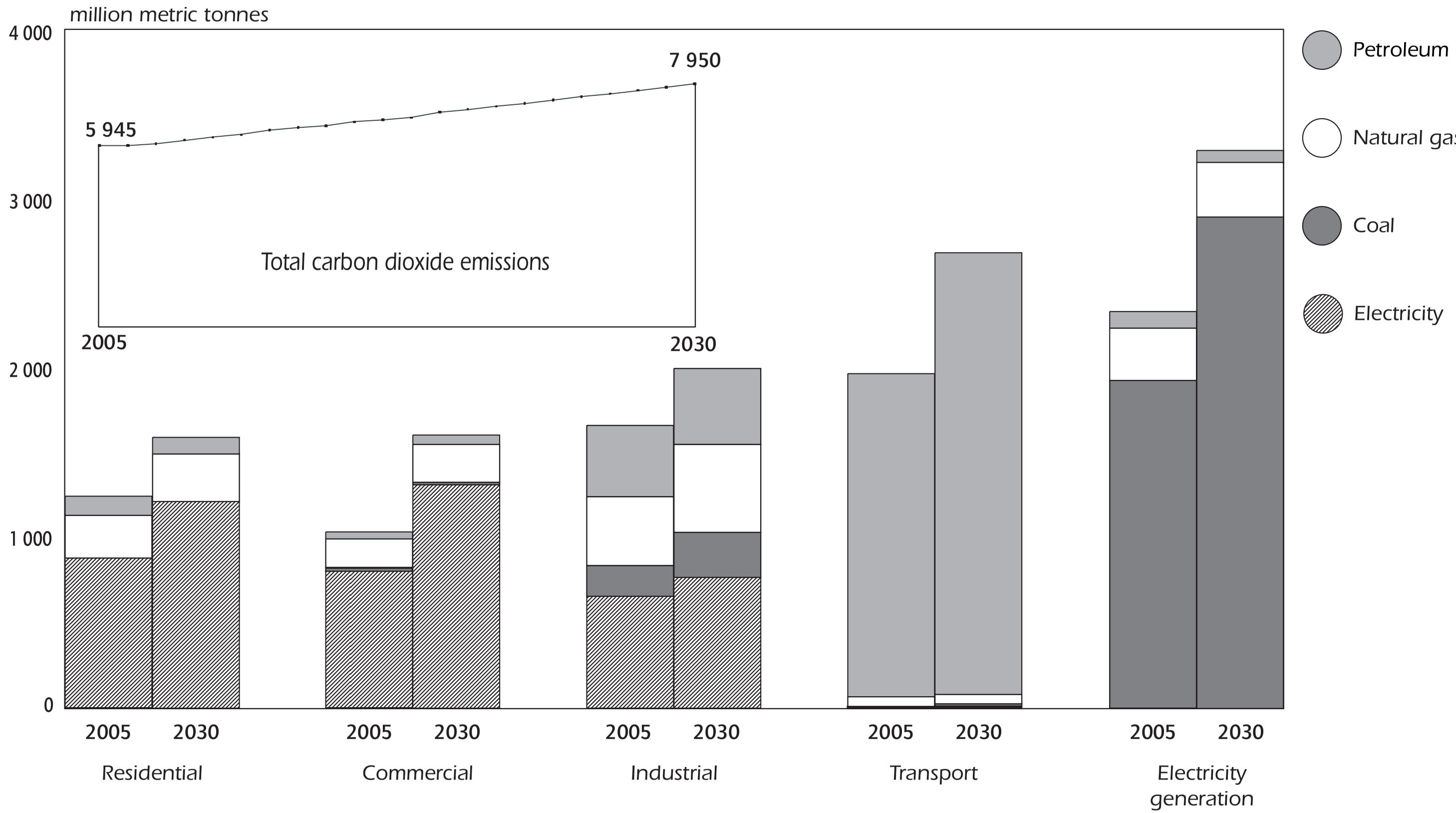
Source: EPA, *United States Inventory Greenhouse Gas Emissions and Sinks 1990-2005* (EPA 2007).

SECTORAL DEVELOPMENT

On the sectoral level, a shift has taken place from emissions in stationary end-use sectors to emissions from electricity generation (see Table 13). This is due to fuel shifts and structural changes in the stationary end-use sectors, where electricity use has grown in importance compared to on-site combustion as a source of energy (see also Chapter 4 for further details on sectoral energy consumption developments).

Figure 13

CO_2 Emissions by Sector and by Fuel, 2005 and 2030



Source: Energy Information Administration, *Annual Energy Outlook 2007* (DOE/EIA-0383(2007), (Washington, DC, February 2007), Table A18.

POLICY

The government recognises global warming caused by anthropogenic emissions as a serious environmental challenge. To address the challenge, it is pursuing a policy which focuses on reducing the GHG emissions intensity of the United States economy, *i.e.* the emissions increase relative to GDP. This policy has allowed absolute emissions increases, since, after its assessment of the current state of low/no-carbon technology readiness, the United States government views a policy to reduce absolute emissions as incompatible with continued economic growth, which it sees as a prerequisite for investment in advanced technologies. This policy differs from that of most other IEA members who are pursuing a policy of controlling absolute emissions increases and reducing these compared to historical emissions, as requested in the Kyoto Protocol. A number of states have set state-level greenhouse gas emission targets, despite the absence of a target on the federal level.

In 2002 the United States set a goal of reducing the GHG intensity of its economy by 18% by 2012. Between 1990 and 2005, total GHG intensity declined by 24.7%, at an average rate of 1.9% per annum, which allowed the goal to be easily achieved. However, the business-as-usual projection at the time this goal was set, in 2002, indicated an improvement of intensity of 14% over the 2002 to 2012 period. In 2006, energy-related CO_2 emissions actually dropped by 1.3% while the carbon intensity of the economy fell by 4.5%, mainly thanks to milder weather reducing heating and cooling requirements.

To achieve the goal of reducing GHG intensity, the United States government is focusing in particular on supporting energy R&D for cleaner energy supply technologies, such as CCS, renewables, methane capture and use, and nuclear. Many of these programmes are carried out on an international level, for example the *FutureGen* partnership. While a strong focus is put on the supply side, support programmes are also available for more energy-efficient technologies. Measures that have been successful in encouraging the deployment of low-emission technologies include incentives such as the Federal Production Tax Credit for wind power. Additional measures designed to reduce emissions in the future include USD 1.65 billion in Clean Coal Tax Incentives, of which USD 1 billion was awarded in the 2007 round for nine clean coal projects; a number of market deployment support programmes for clean technologies; loan guarantees and production tax credits for advanced, low-emitting technologies; and regulatory risk insurance for new nuclear power plant projects. Two other important programmes in this regard are the *Climate Change Technology Program* and the *Climate Change Science Program,* which are cross-cutting, multi-agency programmes with significant funding attached to them. Programmes and projects are described in the relevant chapters of the review, in particular Chapter 3 and Chapter 4.

Currently, there is no federal policy to assign a value to CO_2 emissions, which would internalise the cost of emitting CO_2 into the price of fossil fuels. Nor is there a plan by the United States Administration to create mechanisms that would enable individual states to create such a system with a regional or cross-state coverage, such as a federal registry of CO_2 emissions. However, a number of proposals to address these issues are currently being actively discussed in Congress. While an explicit CO_2 price is not in place, an implicit value for CO_2 is provided by the tax credits for renewables and new nuclear production, which were set at USD 15 per MWh when CO_2 emissions stood at an average of approximately 0.61 tonnes of CO_2 emitted per MWh of power generated. The implied value equated to USD 24.5 per tonne of CO_2, which is not out of line with prices observed in the EU Emissions Trading Scheme (ETS). Since, following inflation adjustments, the current value of the credits is USD 20 per MWh and more carbon-intensive coal-fired capacity and gas-fired peaking units would generally be displaced at the margin, the current implied value in the market-place is substantially greater. In some states, regulatory commissions have set a hypothetical price for CO_2 to help them evaluate proposed project economics, and several states are now supporting renewables deployment using Renewable Portfolio Standards (see Chapter 6).

INTERNATIONAL AGREEMENTS

The United States has signed, but not ratified, the Kyoto Protocol, and is therefore not subject to limiting its emissions under this international agreement. However, it is a member of the United Nations Framework Convention on Climate Change (UNFCCC), and submits regular reports on its emissions to the Secretariat. In September 2007, the President invited the heads of States of major economies to send personal representatives to Washington to discuss a new post-2012 international framework.

LOCAL AIR POLLUTION

Local air pollution is a regional problem in the United States, primarily because of traffic and industrial emissions. Emissions of certain pollutants from power generation which contributed significantly to air pollution in the past have been reduced with the implementation of the 1990 Clean Air Act Amendments.

Since 1990, emissions of local air pollutants have decreased significantly, primarily thanks to the introduction of regulatory measures addressing emissions from power stations. Power sector emissions of sulphur dioxide (SO_2) have fallen by 33% between 1990 and 2005, while those of nitrogen oxides (NO_X) have fallen by 54% between 1990 and 2005. In the same period, the coal generation capacity covered by flue-gas desulphurisation units has increased by 47%, while total coal generation capacity grew by 4%.

In 2002, the President proposed new legislation under the name *Clear Skies,* which aimed to reduce power station emissions significantly by 2018. Since such legislation was not enacted, the EPA introduced two new rules based on the 1990 Clean Air Act for reducing air pollution: the *Clean Air Interstate Rule* (CAIR) and the *Clean Air Mercury Rule* (CAMR) (see Box 5).

Box 5

The Clean Air Interstate Rule and the Clean Air Mercury Rule

Since 2005, the EPA has introduced two important new regulatory frameworks to cover air pollution in large parts of the United States: CAIR and CAMR. These rulings use market-based trading systems to reduce emissions of SO_2, ozone, particulates, NO_X and mercury.

The CAIR covers the 28 states of the eastern United States and the District of Columbia to a line from Minnesota in the north via Iowa, Missouri, Arkansas, to Louisiana in the south, and also Texas. Not all states are covered for all pollutants, but all states are covered for SO_2 and NO_X. The rule replaces the proposed *Clear Skies* legislation, which was proposed by the White House in 2002, but has not been approved in Congress. EPA estimates the average reductions to reach 70% for SO_2 (almost 90% in some states), and 60% for NO_x, compared with 2003 emissions levels. Health and environmental benefits are estimated at USD 85 billion to USD 100 billion for health, and USD 2 billion for visibility benefits by 2015, at a cost of USD 3.6 billion to implement the rule. The final rule was signed on 15 March 2006.

The CAMR was signed on 15 March 2005 and is the first regulation worldwide that directly addresses mercury as a power station pollutant. It is a sub-rule to CAIR, and covers the same states. It is expected to reduce power industry utility emissions of mercury from 48 tonnes to 15 tonnes in 2018, by about 70%. The power industry is responsible for about one-third of annual mercury emissions, equivalent to roughly 1% of global emissions. The rule will utilise a cap-and-trade approach to lower the cost of the mercury emissions reduction, together with a maximum emission standard for new coal-fired power stations (construction of which has started after January 2004), which are also going to be subject to the cap-and-trade regime. The rule has been criticised for using a cap-and-trade approach, since mercury emissions are primarily a local pollution problem, unlike CO_2 or SO_2. When the rule came into effect, an immediate cap of 38 tonnes of mercury emissions was applied.

CRITIQUE

The United States has not ratified the Kyoto Protocol. Doing so would have committed it to reduce absolute GHG emissions by 7% below 1990 levels by 2012. Instead, the United States is pursuing a policy of reducing emissions intensity. The experience of intensity reductions from 1990 shows that CO_2 emissions have successfully been decoupled from GDP growth, and the 18% improvement goal for emissions intensity from 2002 to 2012 should be achievable. The United States has in fact kept overall increases of CO_2 emissions to 18% between 1990 and 2006 with an intensity improvement of approximately 26%, and has achieved this with high economic growth and a significant increase in population. Since 2001, growth in CO_2 emissions has only been 3%, comparable to that of IEA Europe, and lower than that of a number of other countries, some of which are party to the Kyoto Protocol. Relative to some other IEA members, the United States has, therefore, performed well in keeping the growth of emissions in check. Having achieved the fundamental goal of decoupling and controlling emissions, it may now be time to consider more aggressive policies to reduce emissions.

Despite the non-ratification of the Protocol, the United States government has recently become more active in the development of a framework for a post-2012 agreement, *e.g.* by hosting a summit of major economies in Washington in September 2007. This engagement is highly commendable, and the government should consider taking a leading role in constructing a post-2012 framework for the control of GHG emissions.

The United States climate change strategy has disavowed placing a price on CO_2 but has nonetheless placed an implicit value on CO_2 through measures such as financial incentives for nuclear and renewable electricity generation. The current strategy has also focused on measures to reduce GHG intensity, promote climate science, develop advanced technologies, and engage in international collaboration. The United States government should consider extending existing support measures on a technology-neutral basis to all low- and no-CO_2 options. It should also consider moving support from a tax-based to a market-based system.

While the individual measures and programmes developed by the United States government are very commendable, a scheme providing a value for CO_2 is another obvious possibility to provide a market signal supporting clean technologies. Introducing such a system would help investors to reduce the risk by making the currently only implied valuation of CO_2 explicit, and it would, therefore, provide a mechanism by which project developers would be able to internalise the external cost of GHG emissions. Comments by energy market actors indicate that the absence of a mechanism to establish the price of CO_2 is now becoming a critical block to investments in anything but gas-fired and renewable generation, and is also delaying other energy-related project developments such as refineries. The absence of an explicit price for CO_2 is also slowing the commercial deployment of new and cleaner technologies coming out of the DOE's R&D programmes. Providing a value to CO_2 emissions would send a uniform signal to the market.

Establishing a price for CO_2 would be likely to provide the market pull needed to ensure the deployment of more sustainable energy technologies, even in the absence of other federal or state-level incentives. The need for federal action in this matter is increasing, following the move by several states and regulatory commissions that have developed either state-level or regional initiatives that aim to reduce CO_2 emissions, including emission targets, and which are contemplating sub-federal, either state-level or regional trading schemes. These currently include measures such as RPSs, or explicit CO_2 pricing in project assessment. Recognising the businesses' preference for certainty and consistency across the country, efforts are under way by some states to co-ordinate their policies across some state borders, most notably in the western and Pacific states and the north-east, but no action is foreseen by the federal Administration, despite Congressional initiatives. The United States government should, therefore, urgently consider the establishment of a pricing mechanism that assigns an explicit value to CO_2 emissions, learning from the experience of other countries and regions of the world when designing such a mechanism. This should include the establishment of a registry of CO_2 emissions to enable a transparent market to emerge.

There are also technical barriers to the development of sub-federal or non-mandated CO_2 markets in the United States. At present, no mandatory federal registry exists for CO_2 emissions. To enable businesses, states and consumers to trade in these markets, certainty and transparency will be required which could be provided by the federal government, regardless of any decision to move to a CO_2 cap-and-trade scheme.

The 1970 Clean Air Act and its subsequent amendments have steadily and substantially reduced emissions of particulates, SO_2 and NO_X, with significant benefits for human health, air and water quality, and these trends will continue. Emissions of these gases have also been decoupled from both GDP and energy demand growth. A cap-and-trade system for SO_2 emissions, introduced in 1995, has been instrumental in not only significantly reducing emissions, but doing so at a manageable cost to industry. The introduction of the CAIR and CAMR in 2006 is a commendable step to achieve further emissions reductions.

RECOMMENDATIONS

The government of the United States should:

- *Accelerate policy and technology development and deployment/implementation to achieve reductions in total GHG emissions.*

- *In particular, consider the establishment of a federal system to provide a consistent market value for CO_2 emissions nationwide.*
- *Establish a mandatory federal registry for CO_2 emissions from major sources.*
- *Consider national market measures and regulations designed to encourage the deployment of low-emission technologies and the timely retirement of the most polluting technologies in all sectors.*

RENEWABLE ENERGY

OVERVIEW

The contribution of renewable energy sources to TPES in the United States fell from 1990 to 2000, owing to a lower growth rate of renewables production, compared to TPES. The share of renewables then remained stable until 2004, and between 2005 and 2006, renewables production increased rapidly, both in electricity generation and transport. The recent rapid increase is due to a mix of rapidly rising prices for fossil fuels since 2004, deeper environmental concerns, increased hydro availability after dry years in 2000 and 2001, and wider support policies. Renewable electricity portfolio standards (RPSs) now exist in half of all the states, and, together with federal tax credits for wind electricity production and other state-level support schemes, are very successful in stimulating production.

Baseline projections by the EIA are for a relatively slow growth of the contribution of renewables to energy supply between now and 2020 (see Table 14), although the most recent revision of the *Annual Energy Outlook* has now doubled this prediction. This has to be seen in the context of a net decline of the contribution of renewables between 1990 and 2005.

Table 14

Renewables in the United States Energy System, 1990 to 2005

(in Mtoe)

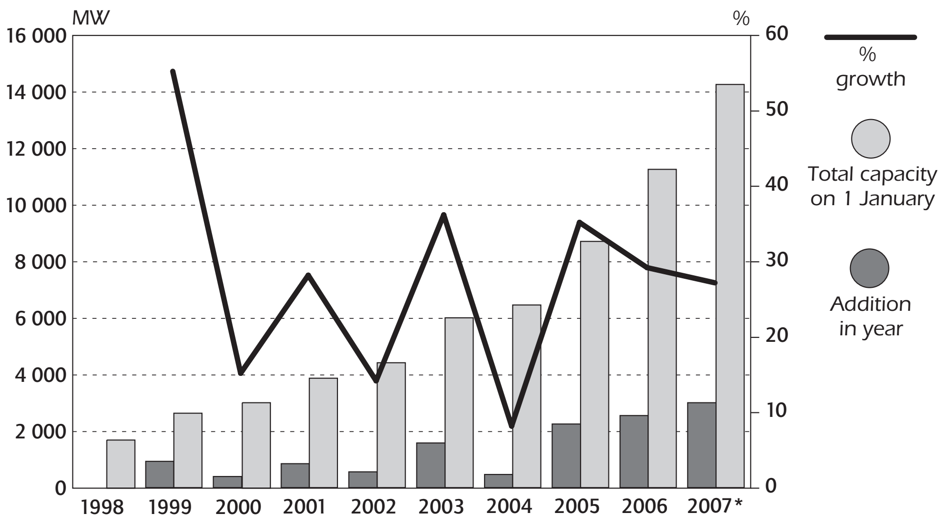
	Mtoe					*Growth (%)*		
	1990	*2005*	*2010*	*2020*	*2030*	*2005/1990*	*2020/2005*	*2030//2020*
Comb. renewables & waste	62	74	96	107	120	19	45	12
Hydro	23	23	26	27	27	0	17	0
Geothermal	14	9	16	18	21	–36	100	17
Solar/wind/other	0	3	6	7	7	n/a	133	0
Total	**99**	**109**	**144**	**159**	**175**	**10**	**46**	**10**
Share of production	6.0%	6.7%	7.7%	7.8%	7.9%	11	17	2
Share of TPES	5.1%	4.7%	5.5%	5.5%	5.4%	–9	18	–1

Sources: *IEA Energy Statistics*, country submission.

EIA predictions foresee a reasonable growth of the renewables contribution between 2020 and 2030. But for some technologies and uses of renewables, in particular wind electricity generation and the use of biomass in transport, these baseline projections may be too conservative in view of the faster growth observed in the market-place.

Figure 14

Wind Capacity Additions and Growth Rates, 1998 to 2007



*estimates.

Source: EIA.

PRODUCTION

The most rapidly growing source of renewable energy supply in the United States is wind power for electricity generation. In 2005, the United States installed 2 431 MW of wind capacity, followed by another 2 343 MW in 2006, and it is expected that over 3 000 MW will be installed during 2007. The total installed capacity now stands at 11 603 MW, and generated some 26 TWh, or 0.6% of US electricity supply. Because of significant R&D efforts, as well as deployment programmes in other countries, the cost of producing electricity from wind power in the United States has dropped from USD 0.8 per kilowatt-hour in 1980 (in current dollars) to USD 0.04 to 0.06 today. Wind power development is driven by the availability of a federal production tax credit, and in years when this expires, new-built rates decline steeply (see Figure 14).

The United States is also increasing its use of biomass, primarily in the transport sector. In the stationary and electricity/heat sectors, however, the use of biomass is decreasing. The first boost for the use of biomass in the transport sector came with the EPAct 2005, which mandated an alternative fuel standard for liquid fuels, and which has since been increased. It was followed by the phasing-out of MTBE as a gasoline additive in the United States in 2006, and its replacement by ethanol, most of which is produced from corn. In the *State of the Union* address in January 2007, the President announced a long-term plan to further increase the contribution from biofuels to the supply of transport energy, with production of biofuels and other alternative transport fuels reaching 35 billion gallons by 2017, equivalent to 15% of gasoline demand under the business-as-usual case. Growth of biofuels production has since increased faster than expected, also aided by a special tariff that is being applied to prevent imported ethanol from taking the market share from United States corn-based ethanol.

No estimation is available for the production of heat from solar-thermal collectors, but if collector shipments are taken as an indication, it has grown rapidly since 1997, when the EIA started collecting the information. From 721 000 m^2 collector surface in 1997, shipments grew by 152% to 1 815 000 m^2 by 2006.

Table 15

Renewables in United States Electricity and Heat Supply, 1990 to 2006 (in TJ)

					Growth	
	1990	*2000*	*2005*	*2006*	*2005/2006*	*2000/2006*
Wind	3 066	5 650	17 881	25 865	744%	358%
Hydro	273 152	253 204	272 447	291 103	7%	15%
Waste	15 323	23 897	22 762	22 525	47%	–6%
Solar	666	529	612	564	–15%	7%
Biomass	71 039	59 496	60 065	63 098	–11%	6%
Solid	68 545	52 075	53 278	54 691	–20%	5%
Gas	2 494	7 421	6 574	6 641	166%	–11%
Total	**363 246**	**342 776**	**373 767**	**403 155**	**11%**	**18%**

Source: *Renewables Information 2007*, IEA/OECD Paris, 2007.

Table 16

Final Use of Biomass, 2000 and 2005

	2000	*2005*	*Growth 2000/2005*
Solid (TJ)	1 801 428	1 681 339	–7%
Industry	*1 294 091*	*1 182 217*	*–9%*
Other	*507 337*	*499 122*	*–2%*
Biogas (TJ)	60 644	81 142	34%
Industry	*57 399*	*80 368*	*56%*
Other	*3 245*	*774*	*–76%*
Total (TJ)	**1 862 072**	**1 762 481**	–5%
Liquid (tonnes)	4 978	12 920	160%
Industry	*0*	*446*	*n/a*
Transport	*4 978*	*12 474*	*151%*

Source: *Renewables Information 2007,* IEA/OECD Paris, 2007.

POLICY

The Energy Policy Act of 2005 (EPAct) calls for an increase in the percentage of electricity generated from renewable sources to 10% by the year 2020, up from the 2005 production of 8.5%. A number of individual states have set goals for renewable electricity production or sales in their jurisdiction that are considerably more ambitious. For example, in 2007, 25 states had RPSs governing the generation or sale of electricity in their state, while three more states had set non-binding goals. In June 2007, the President proposed a new energy bill for cutting the projected use of gasoline by 20% over the next ten years, following his 2007 *State of the Union* address. To achieve this goal, a new Alternative Fuel Standard was announced that will require that the United States use 35 billion gallons of alternative fuels by 2017, reducing projected gasoline consumption in 2017 by 15%.

Investment in, and use of, renewable energy has been encouraged with a range of state and federal government incentives. The federal government is supporting renewables through a mix of tax credits, rebates, and support for R&D, and an alternative fuel standard for renewable fuels in the transport sector (see Table 17). As part of the CAFE standards (see Chapter 4), the government has encouraged vehicle manufacturers to produce E85 flex-fuel vehicles. While many such vehicles are produced, equivalent to 4.7% of all light vehicle sales in 2004, only a small number of E85 filling stations exist (about 1 200, mainly in the corn belt), amounting to just 0.7% of all filling stations, so that most flex-fuel vehicles run mainly on gasoline. A number of individual states use a mix of RPSs (see Box 6), and direct grants, to further increase penetration of renewables in their jurisdictions. The federal and state-level incentives are cumulative. By 2006, 15 states and the District of Columbia had enacted so-called Public Benefit Funds, which use money raised from electricity ratepayers through alternative energy requirements and consumers' voluntary contributions to fund R&D as well as deployment of renewable energy technologies.

The development of wind power is driven to a large extent by a federal production tax credit (initially of USD 15 per MWh generated, but adjusted for inflation and currently worth USD 20 per MWh) and paid for the first ten years of the project's lifetime. The credit is due to expire at the end of 2007, but Congress may decide to extend it. The credit has already expired three times, in 1999, 2001 and 2003, leading to significant reductions in new connections of wind power in the following years, 2000, 2002, and 2004. The value of the tax credit to producers was about USD 338 million in 2005, assuming that all wind electricity produced benefited from it.

Table 17

The 2005 Renewable Fuel Standard and Ethanol Production to 2012
(in million gallons)

	Target	*Production*	*Imports*	*Total achievement*	*Target share*	*Import*
2006	4 000	4 855	653	4 508	113%	13.4%
2007[1]	4 700	2 988	223	3 211	68%	7.4%
2008	5 400	n/a	n/a	n/a	n/a	n/a
2009	6 100	n/a	n/a	n/a	n/a	n/a
2010	6 800	n/a	n/a	n/a	n/a	n/a
2011	7 400	n/a	n/a	n/a	n/a	n/a
2012	7 500	n/a	n/a	n/a	n/a	n/a

1. First six months only.

Source: Renewable Fuel Association.

For ethanol, in addition to the alternative fuel standard, there is a blender's tax credit of USD 0.51 per gallon. At the same time, a special tariff of USD 0.54, as well as 2.5% duty, is imposed on most imported ethanol. The government's intent is to give an incentive for the use of ethanol made from domestically produced corn. The tariff almost precisely neutralises the tax credit, ensuring that the incentive is restricted to domestic production. Some countries, notably those in the Caribbean basin, are exempt from the tariff, with the exemption applying up to a limit of 7% of total ethanol consumption in the United States.

Box 6

The Colorado Renewable Energy Standard (RES)

Background

In 2004, the Colorado voters approved ballot measure Amendment 37 (A37) to create a renewable portfolio standard (RPS) for utilities serving more than 40 000 customers. This was the first citizen-initiated RPS in the country. In 2007, the Colorado State Assembly amended the RPS by extending it to further utilities and by increasing the target. At present, energy suppliers in Colorado are on track to meet the target for 2010.

The reasoning for the establishment of an RPS in Colorado is stated in the legislative declaration of intent accompanying the A37 ballot measure as follows: "In order to save consumers and businesses money, attract new businesses and jobs, promote development of rural economies, minimise water use for electricity generation, diversify Colorado's energy resources, reduce the impact of volatile fuel prices, and improve the natural environment of the state, it is in the best interests of the citizens of Colorado to develop and utilise renewable energy resources to the maximum practicable extent." Additionally, it is stated in the rule that it is the policy of this state to encourage local ownership of renewable energy generation facilities to improve the financial stability of rural communities.

Description

The 2004 RPS defined a Qualifying Retail Utility (QRU) as any utility serving more than 40 000 customers. Within this category were the state's two investor-owned utilities (IOU), three rural electric co-operatives (co-ops), and two municipal utilities. QRUs were given the opportunity to "opt out" of the RPS by a vote of their customers and two of the co-operatives did so shortly after passage of the legislation.The co-operative and municipal QRUs, however, are not subject to Colorado Public Utilities Commission (CPUC) jurisdiction and were allowed to "self-certify" their own programmes.The RPS stipulated that the utility would have to supply 10% of electricity from renewable sources by 2015, with intermediate steps of 3% from 2007 to 2010, and 6% from 2011 to 2014.The RPS gave preferential treatment to renewable electricity generated inside Colorado, by counting every kWh generated inside the state as 1.25 kWh. The RPS ruling allowed trading of certificates within the state.Eligible renewable energy resources under the RPS are solar, wind, geothermal, biomass, new hydroelectricity with a capacity of ten megawatts or less, hydroelectricity in existence on 1 January 2005, with a capacity of 30 megawatts or less, and fuel cells producing electricity from renewable sources.The investor-owned utilities had to file an annual plan on how they proposed to meet the RPS requirements in advance, and an annual report on their performance at the end of each year.The co-operative and municipal QRUs were also to submit to CPUC an annual report at the end of each compliance year but this was for information purposes only.

Another unique provision of the Colorado RPS was the introduction of a band for solar electricity, which has to supply 4% of the target in any given year (*i.e.* in 2011 when the overall RPS target is 10%, 0.4% of electricity supplied by investor-owned utilities in Colorado would have to come from solar). Additionally, half of this amount must come from distributed generation installations up to 2 MW on customer premises. The solar set-aside only applies to the IOUs; the co-ops and municipal utilities are exempt from this provision.

To help the IOUs comply with the solar requirement, the Amendment 37 also established a rebate programme, paying USD 2 per watt to customers investing in solar electricity generation up to 100 kW of capacity. The electricity generated is then net-metered, with surplus exports being credited to the customer's future bill. In addition to the rebate programme, utilities were encouraged to implement a renewable electricity certificate (REC) purchase programme through which they would acquire solar RECs for compliance with the customer-sited solar component of the RPS. The Amendment also stipulated that connection of such a generation installation should not be unduly burdensome. To clarify, in 2006 the CPUC applied FERC's small generator connection rules in Colorado.

To restrict the possible impact on the electricity rates, the retail effect of the rule was capped at 1% of customer bills. Low-cost compliance was aided by generous REC banking provisions, the absence of geographic restrictions on the source of RECs, and the lack of energy delivery requirements associated with RECs used for compliance (*i.e.* unbundled RECs may be used for compliance).

2007 Legislation

The changes made to the RPS by the State Assembly decision in 2007 were substantial, extending the RPS both in time and volume (see Table 18), and adding extra rules.The statute now requires each retail provider of electricity, except for municipal utilities serving no more than 40 000 customers, to be subject to the RPS, albeit at a lesser percentage. No longer are QRUs free to opt out entirely from the standard. The result of this change is that Colorado's 22 rural electric co-operatives and two of its municipal utilities now have compliance requirements.

Table 18

Renewable Portfolio Standard Targets in Colorado, 2004 and 2007

	Investor-owned		*Electric co-operative/municipal*	
	2004	**2007**	**2004**	**2007**
2008 – 2010	3%	5%	Voluntary compliance[1]	1%
2011 – 2014	6%	10%	Voluntary compliance	3%
2015 – 2019	10% for 2015 and beyond	15%	Voluntary compliance	6%
2020 and after	No target	20%	Voluntary compliance	10%

1. Except the three co-ops and two municipal utilities which were covered by the original RPS.
Source: Colorado Public Utilities Commission.

The 2007 revision also introduced a new preferential form of ownership, by counting electricity generated by community-owned projects inside Colorado as 1.5 kWh for every 1 kWh generated. This is dependent on some specific conditions such as local endorsement, and applies to a capacity limit of 30 MW. In addition, to encourage co-operative and municipal utilities to invest in solar, a threefold multiplier is now applied to solar acquisitions made by these utilities. However, it is unlikely that this benefit is sufficient to overcome cost differentials between solar and less expensive renewable resources.

The 2007 legislation that increased the RPS targets also increased the retail rate impact cap from 1% to 2% for the investor-owned utilities, using language removing explicitly any restrictions that the CPUC may seek to apply on a QRU acquisition of renewable electricity so long as the utility stays under the rate cap. For electric co-operatives and municipal utilities, the rate impact limit is set at 1%, reflecting the lower RPS target.

Overall, the 2007 revisions have made the RPS in Colorado more complex, and have considerably increased the target and the challenge for the state's utilities to achieve it.

PLANNING RULES, NETWORK CONNECTIONS, AND SYSTEM INTEGRATION

Onshore wind farms are subject to planning authorisation by the relevant county, the state's public utilities commission or other state siting agency, and require transmission access from the operator of the network they intend to connect to. There are few reports about local resistance to onshore wind farm construction on the scale of that seen in other IEA member countries.The primary concern is about the potential impact of wind farms on bird and bat populations, though aesthetics have also begun to be an issue.

Construction of large offshore wind farms has been proposed at five locations in the United States, with the most prominent proposal off Cape Cod subject to considerable local resistance. Offshore wind farms become subject to federal permitting and require a federal lease if they are over three miles from the shoreline, and the permitting process is more complex than that of onshore projects. At a closer distance from shore, the state is the responsible permitting authority. If the wind farm straddles the three-mile boundary, the state and federal authorities have to issue separate permits for the parts within their jurisdiction. For onshore elements of the farm, *e.g.* the connection to the grid, the county and the local utility are responsible. Since 2005, responsibility for permitting wind farms in federal waters has moved from the Army Corps of Engineers to the Minerals Management Service (MMS) at the DOI. The MMS is currently developing the rules for permit applications.

FERC issued separate standards for the connection of wind generation above and below 20 MW of capacity to transmission networks in 2005.These have generally been welcomed by the wind industry and electricity generators, since they have removed uncertainty about connections from a technical capacity point of view.The industry is still facing a challenge in terms of transmission capacity, which is linked to bottlenecks in transmission capacity in large parts of the country (see Chapter 8).

CRITIQUE

The contribution of renewables to TPES in the United States has declined by 9% between 1990 and 2005, with rapid growth commencing in 2006.While wind generation has increased considerably, this has been offset by reduced production from hydropower facilities over the same period. The overall share of renewables in the total energy mix remains very low, and is unlikely to increase rapidly in the near future, with the exception of biofuels for transport and renewable electricity, where growth is primarily coming from wind, and where the federal government's target for 2020 has almost been achieved. Such "new" renewables should continue to grow at a steady rate from their current small base, given sustained appropriate levels of policy support.

Various support mechanisms for renewable energy are available, on both federal and state levels. The federal and state support for *e.g.* wind power has had good effect, and has at the same time imposed a relatively low cost on the tax- and ratepayers who are funding them. States and the federal government have also made good use of market-based support mechanisms such as portfolio standards imposed on suppliers of electricity. This is commendable. The history of the production tax credit, however, shows that the short-term and intermittent nature of its availability is slowing the development of the industry, leading to boom/bust cycles and adding to costs for new installations. To enable the renewables industry to grow in a sustainable manner and contribute in the long term to the supply of energy, the United States government should consider creating a stable and long-term framework for its support, linked to energy markets, instead of relying on tax credits.

One option would be for such a system to take the form of a federal renewable portfolio standard. The federal government has already mandated a similar mechanism for vehicle fuels, and there is no obvious reason why it should not be possible to have the same mechanism for the support of renewables. The argument that geographic diversity would penalise some states applies in the same way in ethanol production, where states without a corn-producing agriculture are disadvantaged. Introducing a federal RPS would help to streamline state-based systems; it would send a clear signal that renewables are a potential contribution to a clean and secure energy future; and it would help increase the market for these clean technologies in the United States. The effects of existing state-level RPS and potential federal and state carbon-pricing systems need to be taken into account in any reform of the subsidy system, to avoid double subsidies being offered. The development of a central registry standard for tradable green certificates should be part of the RPS development process.

Renewable portfolio standards have now been introduced in 25 states plus the District of Columbia, and these have generally been effective in stimulating renewable generation. With the continued growth and extension of these standards, there is now a risk that the state-by-state nature of these standards is inhibiting the trading of renewable electricity certificates across borders, thereby slowing the potential development of renewable resources. One reason for this is that some RPS policies give an incentive to locate renewables production in regions that may not be best suited for it by providing additional incentives for in-state generation. Another issue in developing the RPS system could be generally different requirements for fuel mix, and different registry requirements, which could increase the cost of compliance for utilities operating across state borders, and make RPS certificates from different states incompatible. This issue stems from the fact that different states, with different renewable resource endowments, have defined renewable energy in various ways.The federal government should, at the same time it is developing a federal RPS, consider establishing a central framework for existing state RPS policies, to ensure compatibility of certificates for trading purposes and consistency across state borders. This could include the creation of a framework outlining good design principles for RPS policies. Such an initiative could encourage the 25 states which currently have no RPS to consider introducing one even if the in-state resource is relatively small, and would drive down the cost of compliance for all consumers in the United States.

The issuance of new large wind and small generator connection standards by FERC is commendable, as is the decision to move the permitting process for offshore wind installations to the MMS. It will now be important for the MMS to quickly develop the rule set under which permitting can occur.

Driven by government policy, there is a rapid increase of ethanol and biodiesel production in the United States. Research is strong in the area of second-generation biofuels from cellulose, and success in developing this resource is critical to achieving the goals set under the most recent policy initiatives. The ethanol production base has expanded rapidly, and the annual targets set in EPAct 2005 have already been exceeded. There are practical limits to how much ethanol production from corn can rise from current levels, as a very substantial share of the corn crop is already devoted to ethanol production. Nevertheless, the flexibility in increasing corn acreage, and the competitive advantage of ethanol from corn at oil prices of above USD 70 a barrel would suggest that further increases in production are possible, as long as the favourable conditions continue. With a change in the competitive situation of domestic ethanol production, the government could, therefore, consider reducing tariffs on ethanol imports to continue to increase the amount of ethanol available in fuel supply at lower-than-average cost to the consumer. This would also increase the security of fuel supply to the country.

Biomass use outside the transport sector has declined despite a good resource base being available in many states. The government should consider ways in which this resource base could be harnessed to increase security of supply and reduce CO_2 emissions. A particular opportunity could exist in co-firing biomass in large coal-fired power stations. The United States could study the experiences with this approach in other IEA member countries.

RECOMMENDATIONS

The government of the United States should:

- *Consider the establishment of a national renewable portfolio standard compatible with cross-border electricity trading and the development of a transparent market in which state green certificates can be traded.*

- *Develop a market-based support framework for renewables to reduce reliance on tax credits.*
- *Ensure that rules to promote biofuels give credit to a full range of biofuel options, both in transport and stationary use.*
- *Consider removing the tariff on imported ethanol to allow imported supplies to the United States to increase.*

EXPLORATION AND PRODUCTION

OVERVIEW

The United States is one of the major oil[12] and natural gas producers in the world, accounting for 8% of global oil and 18% of global natural gas production in 2006 (see Table 19). It is expected that these shares will continue to decline in the future. Despite a continuous decline since 1971, onshore fields of conventional oil in the lower 48 states are still providing the bulk of production. They are expected to continue to do so until at least 2030, while still being supplemented by growing production of offshore and non-conventional oil resources. Offshore production accounts for 26% of total United States oil production in recent years (497 million barrels in 2005). A more significant shift has taken place in natural gas production, where the major part of production is now coming from so-called unconventional resources[13], which provide 44% of total United States production in 2005, compared to 15% in 2000.

Table 19

Total Oil and Natural Gas Production, 1971, 1990 and 2006

(in thousand boe)

				Change		
	1971	*1990*	*2006*	*1971-1990*	*1990-2006*	*1971-2006*
Oil	3 747 061	3 017 411	2 259 795	–19%	–25%	–40%
United States share of world oil production	21%	13%	8%	–38%	–40%	–63%
Natural gas	3 415 772	2 829 130	2 928 337	–17%	4%	–14%
United States share of world NG production	55%	24%	18%	–56%	–28%	–68%
Total	**7 162 833**	**5 846 541**	**5 188 132**	**–18%**	**–11%**	**–28%**
Share of oil in United States production	52%	52%	44%	–1%	–16%	–17%

Sources: *Oil Information 2007, Natural Gas Information 2007*, IEA/OECD Paris, 2007.

12. Throughout this section, references to oil include natural gas liquids.
13. This includes new forms of natural gas such as coal-bed methane, as well as natural gas in formations that were uneconomic to produce under previous regulatory regimes, such as gas in tight or deep formations.

Table 20

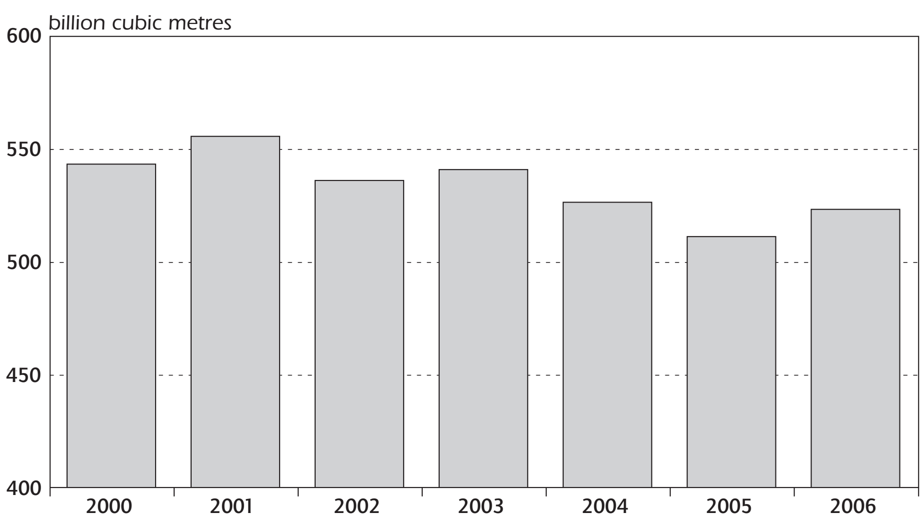
Oil and Natural Gas Production by Production Region, 1990 to 2030

							Change		
	1990	*2000*	*2005*	*2010*	*2020*	*2030*	*2005/1990*	*2030/2005*	*2030/1990*
Oil production in mbd									
Onshore Lower 48 (L48)	4.6	3.3	2.9	2.9	2.9	2.9	–38%	1%	–37%
Offshore L48 deep-water	0.1	0.8	0.8	1.6	1.9	1.9	578%	125%	1426%
Offshore L48 shallow	0.8	0.8	0.6	0.4	0.4	0.3	–30%	–46%	–62%
Alaska	1.8	1.0	0.9	0.7	0.7	0.3	–51%	–69%	–85%
Total oil production	**7.4**	**5.8**	**5.2**	**5.7**	**5.9**	**5.4**	**–30%**	**4%**	**–27%**
Natural gas production in bcm/year									
L48 onshore non-associated conventional	208	169	140	149	122	106	–33%	–24%	–49%
L48 onshore non-associated unconventional	76	165	226	243	257	289	196%	28%	278%
Lower 48 associated diffused	76	80	61	65	66	58	–20%	–5%	–24%
Lower 48 non-associated offshore	133	117	76	84	86	68	–43%	–11%	–49%
Alaska	11	12	13	7	58	61	19%	375%	466%
Total NG production	**505**	**543**	**516**	**548**	**589**	**582**	**2%**	**13%**	**15%**

Sources: EIA Petroleum Navigator, EIA Natural Gas Navigator.

Figure 15

Natural Gas Production, 2000 to 2006



Sources: *2006 Natural Gas Annual* and *Annual Energy Review*, EIA.

PRODUCTION

Onshore oil production continued to decline from 1990 to 2005, but is now expected to stabilise, with the opening of new conventional and unconventional resources, but overall production is decreasing at a slower rate thanks to the development of offshore deep-water resources. This development will increase the average costs of oil production in the United States.

Gas production trends have in recent years been obscured by hurricane activity, namely hurricane Dean in 2004, and more particularly, hurricanes Katrina and Rita in 2005. The latter two resulted in a loss of around 10% of domestic gas output over the three-month period to the beginning of December 2005. Notwithstanding, it appears national gas output peaked in 2001, at just under 560 billion cubic metres (bcm). Output has recovered somewhat in 2006 following the hurricane damage in 2005, to 524 bcm, just below the 2004 output (see Figure 15), and the first half of 2007 saw a further small (2%) increase.

Although many gas-producing states recorded increases in production in 2006, most of the overall increase came from the top three producing states: Texas, Oklahoma and Wyoming. Increased production from these three states together represents almost 73% of the total increase. The largest producing state, Texas, increased onshore production by about 5% in 2006, accounting for nearly half of the overall national increase.

Production continues to respond to higher demand and higher gas prices. Marketed production of natural gas outside the Federal Gulf of Mexico area in 2006 was 4% more than the level for the equivalent time-frame of 2005. The growing production from onshore regions occurred as drilling rates reached record heights. The weekly number of rigs drilling for natural gas, onshore and offshore, hit a new high in 2007 at 1 501, almost 60% more than the January 2001 average. A vast majority of these rigs are onshore; while the number of onshore rigs has been significantly increasing in recent years, the number of rigs drilling for natural gas offshore has decreased. The number of wells producing natural gas and gas condensate increased each year since 2001, with over 448 000 producing wells in 2006, an approximately 16% increase since 2002.

RESOURCES

There is significant potential for continued oil and gas production in the lower 48 states, with the total recoverable resources (discovered and undiscovered) under federal jurisdiction areas alone estimated at 113 billion barrels of oil and natural gas liquids and 21 trillion cubic metres (tcm) of natural gas. This is equivalent to 60% of total oil resources, 35% of total natural gas liquid resources, and 52% of natural gas resources, according to assessments performed by the United States Geologic Survey (USGS) and the Minerals Management Service (MMS). Access to these resources is restricted because of their placement as completely off-limits or at least subject to considerable exploration and production (E&P) restrictions. Drilling and exploration are currently prohibited in all offshore regions along the North Atlantic coast, most of the Pacific coast, part of the Alaska coast, and most of the eastern Gulf of Mexico. Drilling is currently only permitted in the western Gulf of Mexico and some parts of Alaska. Drilling restrictions onshore include the Arctic National Wildlife Refuge (ANWR), consisting of about 19 million acres, about 4% of Alaska's land area and large portions of the Rocky Mountain states.

The MMS estimates that 86 trillion cubic feet (2 400 bcm) of natural gas resources are located in offshore areas under federal leasing moratoria in the Atlantic, the Pacific, the eastern Gulf of Mexico, and the North Aleutian basin. In addition, the USGS estimates that about 9 trillion cubic feet (255 bcm) of natural gas resources are located in the ANWR. Another 5 trillion cubic feet (140 bcm) of natural gas, according to the USGS, are located in state waters where oil and gas drilling is prohibited by statute or administrative decree.

Total proven, *i.e.* recoverable, oil reserves have declined slightly by approximately 3% from 22 billion barrels per day (bpd) to 21 billion bpd between 2000 and 2005. During the same period, 11 billion bpd of oil have been produced. At the 2005 rate of production, reserves would be sufficient for 12 years. In the same period, natural gas reserves have increased by 15.2%, and in 2005 reached around 18 tcm, sufficient for almost 35 years of production at the rate of 2005.

The recent developments in world oil markets and continuing increases in domestic demand in the United States, coupled with the continuing decline of the mature onshore oil and gas fields, have led to increasing interest in the development of the almost 22 billion barrels of proven conventional crude oil reserves concentrated in four states – Texas, Louisiana, Alaska and California. There is also strong interest in the opening-up of 610 million acres of the outer continental shelf (OCS), which are currently off limits to E&P and which are expected to contain large amounts of recoverable oil and gas reserves, and in the development of unconventional oil resources. Recent efforts have been made to free up some of these areas for exploration. The Minerals Management Service has included in its proposed 5-year leasing plan for 2007-2012 sales of one lease in the Mid-Atlantic area off the coastline of Virginia and two leases in the North Aleutian basin area of Alaska. During 2006, offshore leasing bans were lifted in areas of the Gulf of Mexico and North Aleutian basin of Alaska.

Producers have turned to new production areas in recent years to stem the decline in domestic production. These include tight formations in the Barnett Shale area in north-east Texas, deep gas and deep-water gas in the Gulf of Mexico, and coal-bed methane, as well as unconventional oil and liquids production from resources such as oil shale, oil sand, coal-to-liquids, gas-to-liquids and eventually methane hydrate. Their development will depend on the evolution of oil prices. In the high price scenario of the EIA's *Annual Energy Outlook 2007* forecasts, total domestic production of unconventional oil is projected to reach 2 mbd in 2030, of which oil shale is expected to contribute 405 kbd. Significant reserves of these resources exist in the United States, *e.g.* in the form of oil shale in the states on the eastern edge of the Rocky Mountains, in particular Colorado and Wyoming. The development of these resources is subject to considerable technological and environmental challenges which need to be overcome (see Box 7).

Box 7

The Colorado Oil Shale Developments

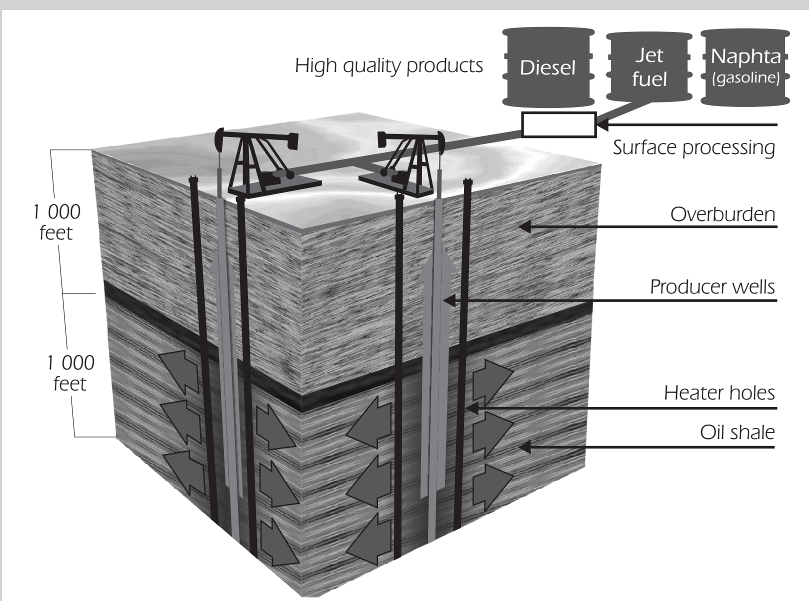
Oil shale is an unconventional resource of oil and gas, which is locked in solid bituminous form in rocks. The production of oil from oil shale has a long history in Sweden and Estonia, but since the end of World War II, has generally been considered uneconomic, and has been superseded by the production of conventional oil. Traditionally, oil shale was produced by crushing rocks and heating up the remains, thereby liquefying the contents. This is a very energy-intensive form of production, which is only economic when the oil content of the rock is high, and where there is sufficient space to dispose of the crushed rock remains.

In the United States, the main resource is the Green River formation, which has four basins across the western states of Utah, Colorado and Wyoming. The recoverable resource in this formation is estimated at 800 billion barrels of oil by the United States government. Roughly 70% of the resource is under federally-owned lands in the three states, giving the federal government a key role in the development of the resource. In the 1980s, attempts were made to commercialise this resource, which were abandoned when oil prices fell. Under the EPAct 2005, the Bureau of Land Management (BLM), an agency of the DOI, was charged with the preparation of a strategy to develop these resources. It is also responsible for the development of a preliminary environmental impact statement (PEIS), to outline the environmental challenges of the production of oil from oil shale. The PEIS draft was sent out to the affected states in June 2006, with a relatively short time of only four weeks given to them to reply.

The major development is currently occurring within the state of Colorado, where Shell is conducting preliminary work to ascertain the economic and technical viability of an *in situ* conversion process to release oil and gas from oil shale without mining and crushing activity. The innovative process chosen by Shell for the conversion of oil shale involves the establishment of a frozen barrier between the field to be developed and the surroundings, to prevent released oil from leaking into aquifers (see Figure 16). The inside of the delineated field will then be heated up by injecting heating fluid into boreholes running up to 1000 metres in depth. This will release oil and gas into producing wells drilled throughout the area. After cooling down, it is expected that oil will solidify again, and the frozen barrier can be abandoned. While still energy-intensive, this process does not involve the production of significant amounts of rock waste which have to be disposed of, and will leave little to no long-term visible impact on the surface. It will also produce gas as well as oil, while traditional production methods could not produce gas. A major challenge is the production of sufficient amounts of energy to heat and cool areas as required. Shell expects that associated gas produced through the process will enable it to run large-scale power and heat production units to support the process. Another significant challenge is the water requirements.

Figure 16

Shell *In situ* Conversion Process



Source: United States Oil Shale and Tar Sands Leasing Program.

POLICY

Sections of EPAct 2005 provide incentives for gas production in the Gulf of Mexico and Alaska, plus royalty relief for gas produced from methane hydrates and for enhanced oil and natural gas production through CO_2 injection. Royalty relief is also provided for oil and natural gas production in water depths greater than 400 metres in the Gulf of Mexico.

Offshore drilling in federal waters and onshore drilling on federal lands is regulated by the MMS, an agency within the United States Department of Interior (DOI). Royalties, bonuses and rents paid by minerals companies for mining on federal land are collected by the MMS and are shared on a 50/50 basis with the state in which the land lies. They have to be distributed by the state again in part to the counties where production occurs. Royalties are connected to the market value of the product in question and are calculated individually for each mine or production site. A bonus payment has to be made to obtain a lease in the first place and rents have to be paid if a lease is taken up, but no production occurs. Leases usually have a minimum of 20 years, and can be extended for as long as production lasts. Congress is currently debating legislative proposals about the reform of royalty payment calculations and conducting an inquiry, following concerns about the potential for manipulation of the payment calculation by the oil industry.

Natural gas exploration and production in the non-federal on-shore areas and offshore state waters are regulated by each state with indigenous production. Each state determines what royalties will be paid on lands or waters under state jurisdiction and develops policies and regulations for licensing and leasing gas- and oil-producing properties. Gas- and oil-producing states co-ordinate their regulatory efforts through the Inter-state Oil and Gas Compact Commission. The commission is an autonomous organisation founded to help states (36 are members) with the development of programmes, policies and regulations for oil and gas production.

INDUSTRY STRUCTURE

Oil and gas production in the United States is fully in the hands of private enterprises, even though over 80% of the recoverable resources are on federal land or federally controlled offshore. There is a total of over 15 000 operators active in oil and gas exploration and production. In 2005, the largest 20 natural gas operators hold approximately 60% of gas reserves and are responsible for 55% of production, while the largest 20 oil operators hold about 66% of oil reserves and are responsible for 63% of production.

The cost of exploration increased significantly between 2000 and 2004, by 75% in real year-2000 dollars, from USD 874 000 to USD 1 533 000. Table 21 provides information on the nominal cost increase by type of well.

Table 21

Nominal Cost per Crude Oil, Natural Gas and Dry Well Drilled

(in thousand USD per well)

Type	*2000*	*2001*	*2002*	*2003*	*2004*	*Change 2004/2000*
Crude oil	593	729	883	1 037	1 442	143%
Natural gas	757	897	992	1 106	1 716	127%
Dry	1 075	1 620	1 673	2 065	1 977	84%
All wells	755	943	1 054	1 200	1 673	122%

Source: EIA Natural Gas Navigator.

The number of active seismic crews increased significantly, from 40 in January 2004 to 64 in December 2006, driven by the rapid increase in the price of oil during the period. This indicates the ability of the providers of crews to rapidly respond to changing market conditions, and their high flexibility. Most of these crews (56) are engaged in three-dimensional survey activity.

NATURAL GAS

OVERVIEW

Natural gas is an important fuel in the United States economy, accounting for 22% of TPES, 20% of TFC and 18% of electricity production in 2005 (see Table 22). EIA forecasts expect that the importance of gas in TPES will increase up to 2020, before falling again, while it will continue to increase in TFC until 2030. This forecast is highly dependent on the choice for future power generation, however. Natural gas contributes significantly to industrial, residential and commercial energy demand in the United States, even though its market share has declined in these sectors since 1990.

The United States natural gas market is robust, and has proven itself to be remarkably resilient in recent years, providing reliable service through several challenges, including severe weather during hurricanes in the Gulf of Mexico in 2004 and 2005 that caused major disruptions of production and transportation facilities, lasting over a number of months.

Table 22

Gas in the United States Energy System, 1990 to 2030

Indicator	*1990*	*2005*	*2010*	*2020*	*2030*	*Growth 2005/ 1990*	*Growth 2020/ 2005*	*Growth 2030/ 2020*
TPES Mtoe	439	509	622	680	676	16%	33%	–1%
TPES share %	*23*	*22*	*24*	*23*	*21*	*–4%*	*7%*	*–11%*
Imports Mtoe	**35**	**101**	**135**	**156**	**163**	**187%**	**54%**	**5%**
Imports share of total NG in TPES %	8	20	22	23	24	150%	15%	4%
TFC Mtoe	303	322	356	381	405	6%	18%	6%
TFC share %	*23*	*20*	*21*	*20*	*19*	*–13%*	*–1%*	*–4%*
Industry sector Mtoe	**124**	**125**	**136**	**139**	**151**	**1%**	**11%**	**8%**
Industry sector share of total NG in TFC %	*31*	*28*	*29*	*29*	*30*	*–10%*	*5%*	*2%*
Other sector Mtoe	**164**	**183**	**202**	**220**	**231**	**12%**	**20%**	**5%**
Other sector share of total NG in TFC %	*41*	*37*	*38*	*37*	*36*	*–10%*	*2%*	*–4%*
NG share of electricity production in %	12	18	20	21	16	54%	15%	–24%

Sources: IEA *Natural Gas Information 2007*, country submission.

SUPPLY

The United States is one of the largest gas producers in the world, and over 80% of demand is supplied from domestic production, which can still be increased considerably. In 2006, net imports were about 16% of overall natural gas consumption, up from 12% in 1996. Since 1990, imports have almost doubled, and they are expected to increase by another 54% by 2020, before stabilising. The United States is a net importer of natural gas by pipeline from Canada, and imports LNG through terminals on the eastern and Gulf of Mexico seaboards. It is expected that imports from Canada will decline in the future because of higher demand for gas in oil production from Alberta's tar sands. LNG facilities are, therefore, seen as important sources of future supply.

The EIA's *Annual Energy Outlook 2007* forecasts anticipate LNG imports rising quickly to about 70 bcm around 2010-2012. They increased by about 55% in the first half of 2007, rising to 18.4 bcm in the first eight months of the year. At this level, LNG accounts for about 4% of United States gas supply. In 2006, the United States was the largest LNG importer in the Atlantic basin, even though this situation may change again. Whether these levels of imports can be maintained will now depend on the relative attractiveness of United States markets against alternatives, notably Asia, the United Kingdom and Spain, but also other parts of continental Europe. As gas prices have risen in other regions in 2007, LNG imports to the United States have declined markedly.

DEMAND

Mild winters and hurricane-caused supply disruptions have recently obscured long-term demand trends. Since 1990, demand for natural gas has grown by 13% in the United States, with most of the growth being satisfied by imports. Growth is now driven primarily by gas use in electricity generation, and gas demand is therefore expected to become more variable.

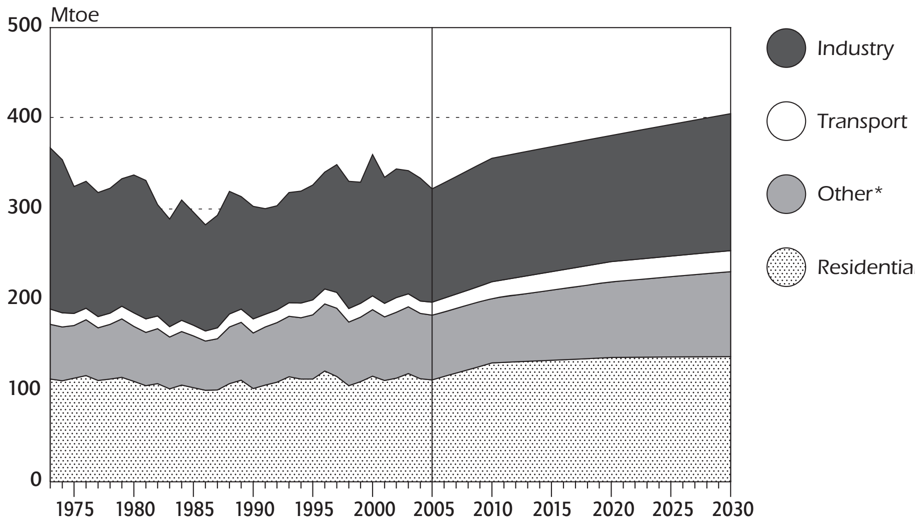
United States natural gas consumption of almost 620 bcm in 2006 dwarfed Germany's consumption of 101 bcm, the next largest gas user in the IEA. Gas is used in a range of stationary applications, including residential and commercial heating, a wide spread of industrial uses, and in the power sector. The residential sector consumed over 9% less natural gas in 2006 than in 2005, thanks to an especially mild winter, indicating the impact of weather variations on demand. Likewise, the commercial and industrial sectors consumed 5% and 2% less, respectively, than in 2005. The electric power sector, however, offset much of the decline by consuming over 6% more natural gas than in the previous year, a trend that continued into 2007. Total consumption declined by almost 2% from 2005 to 2006.

Natural gas as a source of power generation has grown steadily since 1990, when it met little more that 10% of power demand, to the first half of 2007, when it reached 20% and was the number-two source of power behind coal, but ahead of nuclear. The United States added more than 130 GW of new gas-fired capacity between 2002 and 2005, with a further 11 GW in 2006. This is in contrast to other fossil-fuel generation, where investment was very subdued during the same time. Since 2003, gas use in power production has increased by 21%, highlighting the rapidly growing impact of this sector on natural gas demand. More than half of new power plants currently under construction are gas-fired, and there is no indication that this trend will change. Annual gas use for power in the United States is now close to 180 bcm, nearly double Germany's total gas use. Gas-fired electricity demand remained strong in recent years despite sharply increased prices.

Gas-fired generation is expected to be used increasingly to smooth out intermittent renewable generation in the future, and to provide more mid-merit and peak electricity generation, notably in summer. Gas use in power tends to peak in summer, to meet air-conditioning demand, although overall gas use remains winter peaking, with winter peaks about 60% higher than spring and autumn lows.

Figure 17

Final Consumption of Natural Gas by Sector, 1973 to 2030



* includes commercial, public service, agricultural, fishing and other non-specified sectors.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2007 and country submission.

Industrial gas demand, which has historically been the major demand driver, has been declining since 1997. Gas prices have more than doubled from 2002 to mid-2007, and as a consequence, the highly price-sensitive industrial demand is one of the significant uncertainties in the United States. Also, during the gas supply disruptions of 2005, industrial gas use was most affected, first by some large industrial installations using gas being knocked out and secondly by the rapid price increases. The EIA anticipates significant growth in the industrial sector, reversing the decline of 20% seen in the period 2000-2006, but it is not certain if the demand reduction in the period was not in fact permanent demand destruction.

REGULATION

The Federal Energy Regulatory Commission (FERC), an independent agency of the United States Department of Energy, is responsible for the regulation of the inter-state gas industry, including LNG import terminals. The United States Coast Guard and the states are responsible for the planning and safety regulation of LNG terminals and their connection points onshore. For purely intra-state gas undertakings, the state regulatory commission is the responsible economic regulator. Issues such as standards are regulated by a number of bodies, including the Department of Transportation.

Box 8

The Hackberry Case and LNG Import Terminals

The Hackberry LNG terminal case, decided by FERC in December 2002, marks a major regulatory departure and an effort to encourage development of economically viable LNG facilities in the context of reforms that are more broadly directed at promoting competition. While FERC has consistently supported open access requirements for the gas transmission pipelines that account for some 98% of the inter-state gas market, thereby promoting competition in the market, it voted not to impose such requirements on the LNG terminal in Hackberry, Louisiana. In essence, FERC voted to treat LNG import facilities as supply sources rather than as part of the transportation chain. While LNG terminals are in fact part of the transportation chain, it was clear that sales of natural gas from the LNG plant would compete with other sales of natural gas in the Gulf Coast region in a deregulated competitive commodity market.

FERC specifically stated that it hoped the policy embodied in Hackberry would encourage the construction of new LNG facilities by removing some of the economic and regulatory barriers to investment. Since the construction of LNG import terminals is capital-intensive, FERC believed it was more likely for a company to make an investment in the terminal infrastructure if they knew they would have the opportunity for sole access to the terminal's storage capacity, rather than having to make it available to a competitor.

Transport

The natural gas pipeline network in the United States is extensive, with 300 000 miles (480 000 km) of inter-state transmission pipeline operated by over 200 pipeline companies. Inter-state transport facilities, including pipelines, storage and liquefied natural gas, are regulated by FERC. It is responsible for regulating pipeline rates, permitting the construction of new or expanded pipelines and facilities, and certain environmental aspects. FERC regulation ensures open, non-discriminatory access to gas transport for all shippers.

Natural gas distribution by investor-owned companies or publicly-owned suppliers is regulated by state public utility commissions (PUCs) which are responsible for regulating the services provided by gas distribution utilities, including consumer rates. Many states are now opening up functions like supply acquisition, billing and metering to competition, while continuing to regulate local transportation grids.

Natural Gas Provisions of the Energy Policy Act of 2005

The Energy Policy Act of 2005 (EPAct 2005) contains several provisions intended to encourage or facilitate the development of domestic oil and natural gas resources and the domestic infrastructure for importing LNG.

One section clarifies the role of FERC as the final decision-making body on LNG facilities. The act did not intend to alter roles granted to the states to review other aspects of the projects beyond FERC jurisdiction, such as those under other federal laws, including the Coastal Zone Management Act, the Clean Water Act and the Clean Air Act.

The act also gives FERC the authority to permit a natural gas company to provide facilities for gas storage at market-based rates if it believes the company will not exert market power.

INDUSTRY STRUCTURE

The United States natural gas market is dynamic and highly competitive, with a very active spot and futures market. Deregulation of gas production prices and restructuring of the natural gas market, a process extending now over several decades, have increased market efficiency by ensuring that price signals are quickly and transparently transmitted between producers and consumers, and regional markets are more integrated, including with Canada and Mexico.

The industry has a high degree of private ownership with little vertical integration. Production, transmission and distribution are usually separate entities with only a few cases of upstream or downstream integration. A few large gas distributors own transmission pipelines, but this is quite rare. The only public ownership in the United States gas industry is found in gas distribution. Publicly-owned gas utilities (distributors) account for only about 7% of all domestic gas sales. There are some 1 400 local gas distribution utilities in all, varying in size from many small companies with a few thousand customers to several which have over a million customers. In addition, there are about 950 publicly-owned natural gas distribution systems that are regulated by local authorities. Since 1992, a new form of company has emerged in the independent gas marketer, which, in addition to marketing gas supply, can arrange for a "package" of sales and transportation services. There are now about 250 unregulated independent natural gas marketers, and 900 companies operating pipelines.

INFRASTRUCTURE

LNG Import Terminals

There are currently four onshore and one offshore LNG terminals in the Gulf of Mexico, one operating and another under construction on the west coast of Mexico, and one under construction in Canada, capable of supplying the

United States market. Four more terminals are under construction in the GOM and one near Boston in the north-east. Twelve terminals have been approved but are not yet under construction, and over a dozen applications are pending. Currently operating terminals in the whole of North America have an annual import capacity of around 60 bcm. Facilities under construction, plus expansions to existing facilities should more than double this capacity, theoretically enabling imports equal to one-fifth of United States demand. If all the currently approved terminals were developed, which seems unlikely given historical experience, LNG import capacity would grow to 150 bcm annually, or 30% of United States demand.

Pipelines

Pipeline transportation and underground storage are vital and complementary components of the United States natural gas system. While mainline gas transmission lines provide the crucial link between producing area and market-place, underground gas storage facilities help maintain the system's reliability, cope with the strong seasonality of demand, and improve the capability to transport gas supplies efficiently and without interruption.

Between 2002 and 2006, more than USD 13 billion was spent by the gas pipeline industry to install 10 000 miles of pipelines. Over the past two years, more than 80 natural gas pipeline construction projects have been completed, an increase of 15% over total capacity available in 2002. Of the 42 natural gas pipeline projects completed in 2006 in the United States, half were located in the Rocky Mountains states of Colorado and Wyoming, and in the Barnett Shale area of north-east Texas. Projects completed in the Rocky Mountains area increased capacity by 3.2 billion cubic feet per day (90 mcm/d), while those completed in the north-east Texas area added another 3.1 billion cubic feet per day. Projects in these areas have laid the groundwork for several large-scale, long-distance, inter-state pipelines that are scheduled for development over the next several years. Nonetheless, the ability to move gas out of this region remains constrained for the near term, as shown by higher prices for gas in the eastern and Pacific states.

During the period 2007 to 2010, the United States natural gas industry is expected to almost double its level of investment in pipeline infrastructure upgrading compared to levels seen between 2002 and 2006, providing a 13% deliverability increase. Pipeline companies have proposed nearly 200 projects that could provide significant additional capacity to the national network by the end of the decade. Much of the planned expansion is based on the presumed need to serve growing markets for electric power generation, particularly in the west, where utilisation levels on pipelines delivering gas to California have exceeded 95% on a continuing basis.

Box 9

The Rockies Express Pipeline[14]

Background

The Rockies Express Pipeline (REX) is a 2 700-kilometre pipeline under construction which will be the first pipeline directly connecting the producing areas located in the Rocky Mountains with eastern markets. It is the largest new built pipeline in the US in years and is expected to cost some USD 4.5 billion. The Rocky Mountains producing area (Colorado, Utah and Wyoming) contains nearly 22% of total natural gas reserves in the United States. Currently dry natural production in this area is 89 bcm per year, much higher than its 17 bcm per year consumption, which leaves plenty of gas for export. According to the EIA, production will increase a further 26 bcm per year[15], meaning more potential for exports if infrastructure is in place. Production is currently constrained by availability of pipeline capacity to take the gas to market.

The pipeline is composed of three parts. The first part is REX-Entrega and is a 528-kilometre pipeline purchased by Rockies Express Pipeline LLC in February 2006. The second part, the REX-West, is 1 147 kilometres long, which will be finished in January 2008 and will connect Colorado to Missouri. Both the REX-Entrega and the REX-West pipeline have a 15.5 bcm per year capacity. The final part is the REX-East, which will connect the REX-West pipeline to Ohio. Capacity on this part of the pipeline is 18.5 bcm per year. REX made an application for approval for REX-East with the Federal Energy Regulatory Commission (FERC) and plans to start construction during the summer of 2008. The east part is supposed to be partially in service in December 2008 and fully in June 2009. The project is being anchored by long-term, firm transportation contracts offered through an open season with a number of shippers for virtually all of the 18.5 bcm per year of capacity.

Existing Infrastructure

Currently there is only one pipeline that directly connects the Rockies to other states, which is the westbound 2 700 kilometre Kern River pipeline from Wyoming to California. Total capacity of this pipeline is 19 bcm per year. Besides the Kern pipeline, gas can also be transported through interconnections with inter-state pipelines that pass through the region – mostly pipelines connecting south-west producing areas (Texas and

14. Part of this information is based on the paper: "Natural Gas in the Rocky Mountains: Developing infrastructure", EIA, September 2007.
15. 19% increase in production between 2004 and 2010.

Oklahoma) to eastern consuming regions. Pipeline capacity to export gas from the Rocky Mountains producing area totalled 88 bcm per year in 2006, and with the addition of the REX pipeline, will increase to around 100 bcm per year by the end of 2008. Therefore, it is likely that additional pipeline capacity will be required to prevent future transportation bottlenecks for deliveries out of the Rockies production region.

Alaska Natural Gas Pipeline Developments

The Alaska North Slope has considerable proven gas reserves of about 35 trillion cubic feet (nearly 1 000 bcm) and estimated resources of another 200 trillion cubic feet (5 700 bcm). The Federal Alaska Natural Gas Pipeline Act of 2004, coupled with revised tax provisions, was intended to give a significant boost to the construction and operation of an Alaskan pipeline to bring North Slope natural gas to the lower 48 states.

The Alaska Natural Gas Pipeline development is dependent on the state of Alaska selecting a viable commercial proposal under the *Alaska Gasline Inducement Act*, which provides up to USD 500 million in matching funds to help the project complete an Environmental Impact Statement, conduct an open season, and complete the required regulatory application. Recent increases in construction costs and trends in natural gas prices, which have been high and volatile, are important factors that will determine the economic viability of the pipeline. Many issues are unresolved, and even the most optimistic timeline does not anticipate gas delivery from Alaska to the lower 48 state markets before 2018.

Storage

Total United States working gas capacity in operational storage facilities is estimated by the Energy Information Administration (EIA) at 105 bcm. Actual gas storage levels for the six years 2002-2007 have averaged over 90 bcm at the start of the heating season at the beginning of November.

Since 1998, an inventory of underground natural gas storage in the United States has developed in response to market requirements for the service. Over the past years, little or no operational disruptions have occurred in the natural gas market-place due to a lack of either working gas capacity or injection/withdrawal capability. Up to 2010, more than 83 underground natural gas storage projects have been proposed for development. Completion of these projects would represent a 6% increase in working gas storage capacity in the United States by the end of the decade.

Figure 18

Natural Gas Infrastructure

The 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, 2006.

High-deliverability salt cavern storage, which currently represents 16% of total United States underground natural gas storage deliverability, potentially could rise to a 25% share. The multi-cycling capability of salt cavern storage, coupled with its operational ability to react quickly to daily, even hourly, variations in customer needs, has made it very attractive to storage developers in the United States gas market, whose profitability often depends upon their capability to maximise turnover volumes.

During the especially hot summer of 2006, two weekly net withdrawals from underground storage were recorded. These withdrawals marked the first times that working natural gas stocks experienced a weekly net decline during the months of May through September. A combination of electricity and fuel market developments accounts for this atypical inventory behaviour. The growth in consumption of natural gas for electricity generation suggests that withdrawals from storage during the summer to meet air-conditioning demand are likely to become more regular in the future.

PRICES

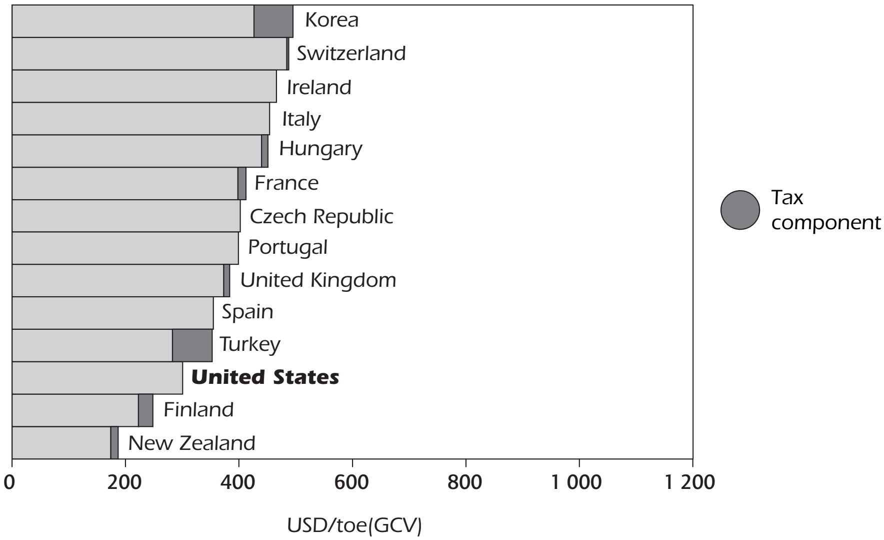
City gate gas prices have risen from around USD 3 per million British thermal units (MBtu) in 1999 to USD 7 per MBtu in 2006/07. They remain competitively priced compared to competing energy sources, notably oil, but prices show comparatively high volatility in a well-functioning market that is characterised by a strong link between end-user price and spot price. The United States gas market, therefore, differs from that of many other IEA countries, where long-term contracts and/or quarterly indexation to oil prices are the drivers of gas prices. This may be because a large share of United States gas use occurs in the power sector, where little oil is used, and generation is dominated by coal. No federal excise tax is levied on natural gas sales, even though some states levy excise tax.

Wholesale natural gas prices over the last several years have been volatile, fluctuating significantly on a daily basis as well as with erratic monthly and seasonal price averages. Market tightness has led to spot prices responding quickly and sometimes significantly to even relatively small changes in demand, transportation constraints or other market conditions. Currently, prices are driven by market conditions that include high crude oil prices, a weak natural gas production response despite record drilling levels, continued strong demand, and vulnerability to major supply disruptions due to hurricanes in the Gulf of Mexico region. Tightness in gas markets was relieved by lower heating demand during the mild winter of 2006, coupled with growth of onshore unconventional natural gas production, above-average storage inventories, and recovery from hurricane damage in 2005. This development led to a decrease in average wellhead prices compared to the high prices of 2005 and early 2006.

Figure 19

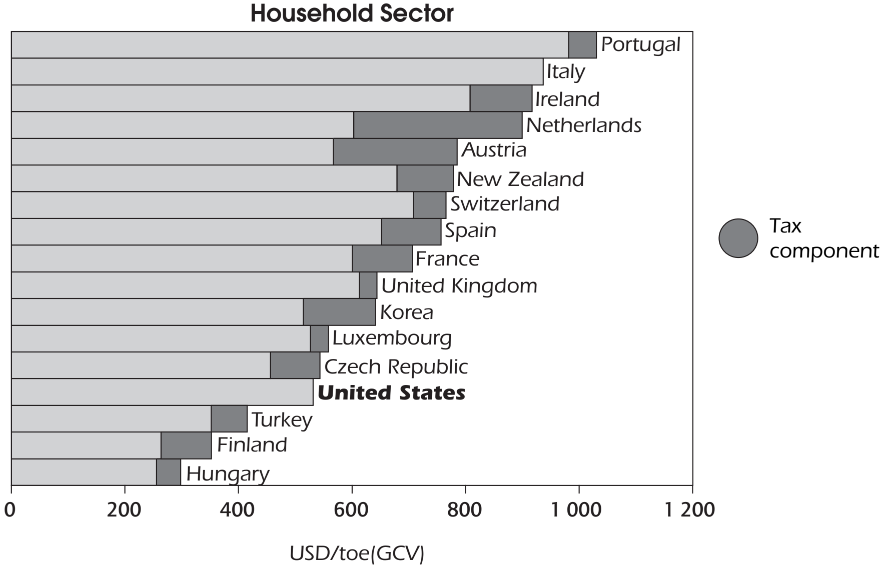
Gas Prices in IEA Countries, 2006

Industry Sector



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

Household Sector

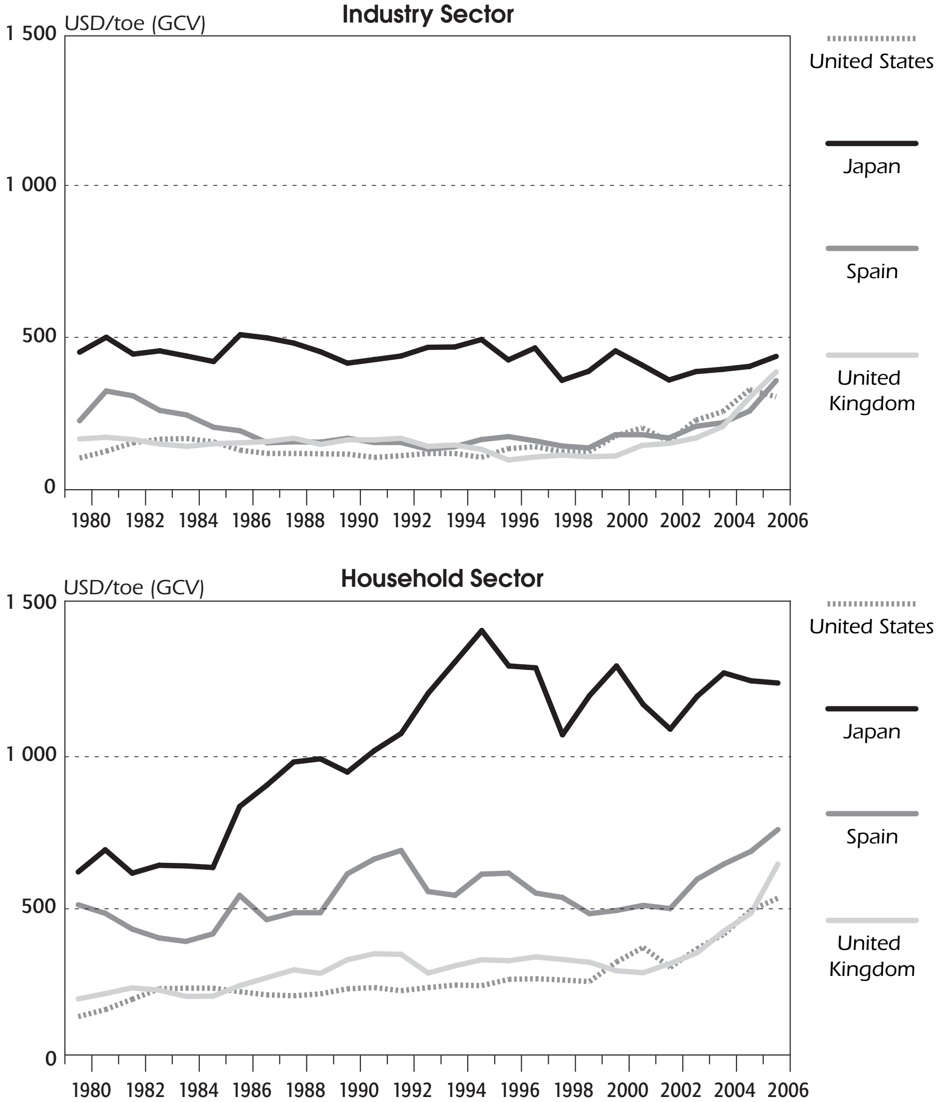


Note: Tax information not available for the United States. Data not available for Australia, Belgium, Canada, Germany, Greece, Japan, Norway and Sweden.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2007.

Figure 20

Gas Prices in the United States and in Other Selected IEA Countries, 1980 to 2006



Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2007.

For example, gas spot prices exhibited a marked fall between mid-December 2005, when the Henry Hub spot price peaked at USD 15.40 per MBtu on 13 December, and 22 February 2006, when the spot price was USD 7.54 per MBtu. Notwithstanding this volatility, the central trend over the course of the decade has been of gas market conditions that have supported a steady increase in natural gas prices, from a wellhead price of USD 3 per MBtu in 2002, to more than USD 7 in 2005, moderating somewhat to around USD 6.50 in 2007. For most industrial and power consumers, prices have roughly doubled over the five years to 2007. Industrial gas demand had been a source of price/demand buffering owing to its price sensitivity, but that ability may now have been significantly reduced as price developments since 2002 may have destroyed a significant part of industrial demand, possibly permanently.

OIL

OVERVIEW

The United States is the world's largest user of oil, with a daily demand of 20.7 mbd in 2006. It is also the largest importer of oil, with 12.4 mbd of net imports in 2006. Imports increased from 32% of domestic demand in 1985 to 60% in 2006. Total consumption of oil increased by 24% since 1990 (see Table 23). According to DOE projections out to 2030, in the "business as usual" scenario, the consumption of liquids and petroleum products will continue to increase, mainly for transportation, which accounts for 75% of total consumption in 2005, and will increase its share to 82% by 2020, while the other sectors of the economy will experience declining demand for oil, because of substitution with other fuels up to 2020. The share of oil in TPES is very high and unlike in other IEA member countries, continues to grow.

Table 23

Oil in the United States Economy 1973 to 2030

(in million barrels)[1]

							Change	
Sector	*1973*	*1990*	*2005*	*2010*	*2020*	*2030*	*2005/1990*	*2020/2005*
Industry	1 175	1 088	1 314	1 278	1 278	1 343	21%	–3%
Share of total oil consumption	*22%*	*21%*	*20%*	*18%*	*16%*	*15%*	*–3%*	*–18%*
Transport	3 066	3 665	4 730	5 424	6 227	7 066	29%	32%
Share of total oil consumption	*59%*	*70%*	*73%*	*76%*	*78%*	*80%*	*4%*	*10%*
Other	1 000	460	453	423	431	423	–1%	–6%
Share of total oil consumption	*19%*	*9%*	*7%*	*6%*	*5%*	*5%*	*–20%*	*–21%*
Oil in TFC	**5 241**	**5 212**	**6 497**	**7 125**	**7 935**	**8 833**	**24%**	**20%**
Oil share in TFC	*53%*	*53%*	*54%*	*54%*	*54%*	*55%*	*2%*	*0%*

1. Converted from Mtoe assuming 7.3 barrels per metric tonne of oil equivalent.

Source: IEA SLT database.

Table 24

Refining Capacity Changes 1990, 2000 and 2007

	1990	*2000*	*2007*	*Change* *2007/1990*	*2007/2000*
Number of refineries					
Active	205	158	145	–29%	–8%
Idle	11	3	4	–64%	33%
Total	216	161	149	–31%	–7%
Daily capacity in thousand barrels					
Active	15 063	16 512	17 009	13%	3%
Idle	560	197	446	–20%	126%
Total	15 623	16 709	17 455	12%	4%

Source: EIA.

REFINING

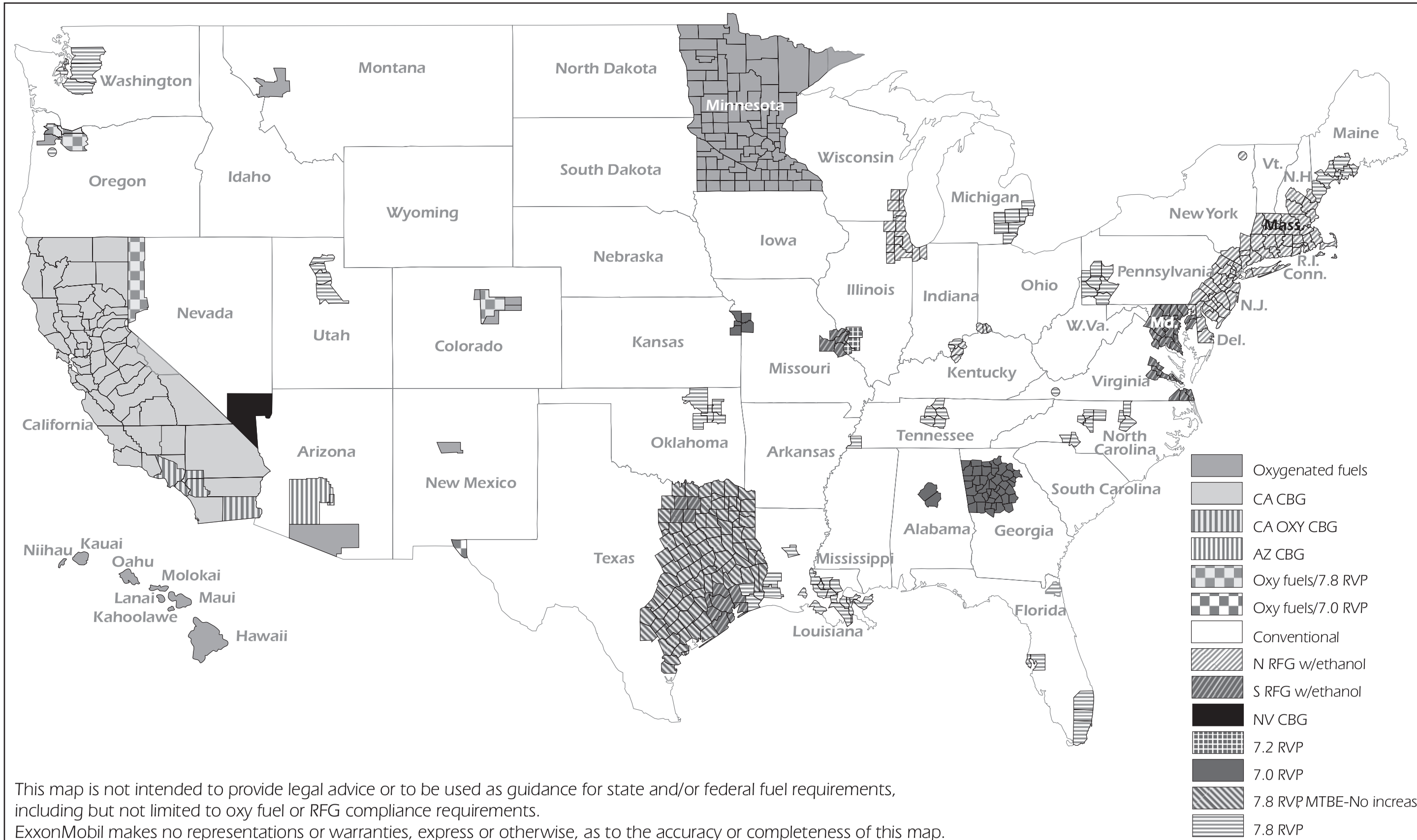
Since 1990, the number of refineries in the United States has continued to decline substantially, while daily capacity has increased by 12% (see Table 24). This indicates a concentration of capacity in fewer, but larger installations, in line with the development in the oil industry as a whole, which saw significant concentration during the period.

Growth in refining capacity has not been in line with growth in petroleum product demand. This is most important in the transportation fuel product range, which is most important in the United States. Of total refinery output, 45% is motor gasoline, followed by distillate fuels, most of which are used in road transport, at 25%, and aviation kerosene at 9%. The supply of motor gasoline and distillate fuel oil increased by 34% each from 1990 to 2007, and that of aviation kerosene by 15%. The ratio of domestic refining capacity[16] to domestic demand for refined products has, therefore, decreased from 100% to 95%, with the balance provided from the import of refined products, up to 1 million barrels per day in 2006. Additional refining capacity is now expected to be added, halting and maybe reversing the decline of the ratio, thereby decreasing the dependence of the United States on international product markets. Two important capacity addition projects were decided in 2007, one of 180 000 barrels per day (b/d), and one of 320 000 b/d. Further investment, including in pipelines, will be required in the future to prepare United States refineries for the handling of the growing amount of Canadian heavy crude produced by the tar sands projects now coming on stream.

16. Defined as active daily capacity.

Figure 21

Regions with Diverging Fuel Specifications in 2007

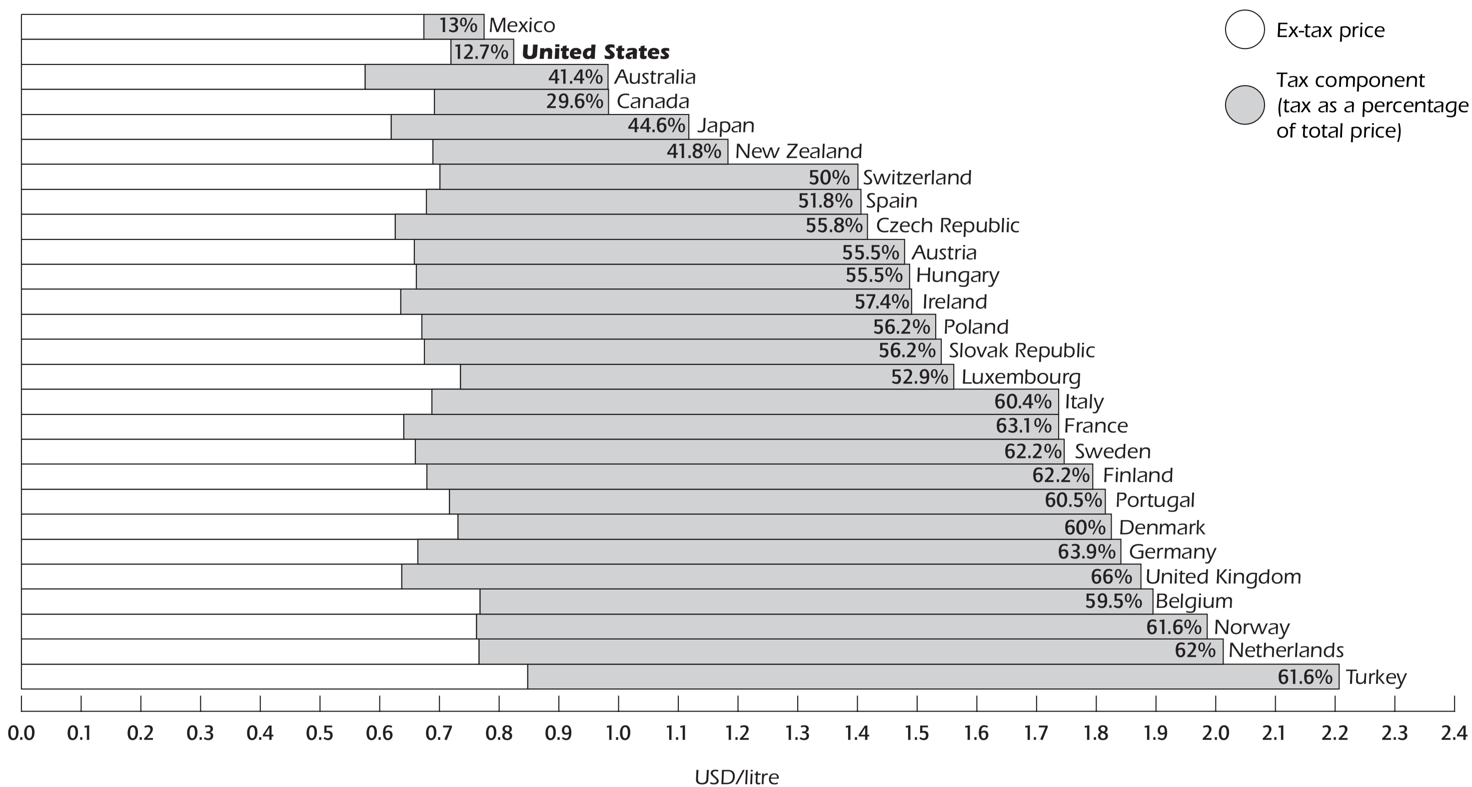


The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the IEA.

Source: DOE.

Figure 22

OECD Unleaded Gasoline Prices and Taxes, Second Quarter 2007



Note: data not available for Greece and Korea.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2007.

DISTRIBUTION AND MARKETING POLICIES

The United States petroleum industry is fully privately-owned. The distribution network is based on common carrier and proprietary pipelines, barge and tanker fleets, and storage installations. Companies active in the sector can be fully integrated or operate as independent traders in specific market segments. Since the last review, a number of inquiries have been held into the functioning of the gasoline markets, in particular after the significant price rises following the 2005 hurricane disaster. Some states have the power to implement price ceilings, and Hawaii has attempted to set a ceiling, but abandoned the attempt. Particular concerns have focused on the impact of futures trading on energy prices, and a Government Accounting Office investigation recommended stronger control by the trade regulator.

Environmental policy has a significant impact on oil markets through the alternative fuel requirement stipulated in the EPAct 2005 (see Chapter 6), the varying requirements for gasoline formulation between states and in some states, the very low limits on vehicle diesel engine emissions, which restrict the sales of these vehicles in the United States. Figure 21 shows regions/states with different fuel specifications. After the supply disruptions of hurricanes Katrina and Rita in 2005, the EPA quickly moved to waive many of these requirements for a time. Studies undertaken afterwards suggested that prices declined as a consequence of this added flexibility within the market.

PRICES

The price for oil products in the United States is the lowest among IEA/OECD member countries, due to a very low tax component. Pre-tax prices are at the lower end of the IEA scale as well, with only five member countries reporting lower pre-tax prices than the United States. This indicates that the oil product and refining market in the United States is generally very competitive. The low taxation levels and the fact that oil is traded in US dollars on the world market, make the transport fuel prices much more responsive to world market developments than, for example, European or Japanese prices.

EMERGENCY PREPAREDNESS

OVERVIEW

The United States meets the minimum stockholding requirements of the IEA through a combination of crude stocks held by the strategic petroleum reserve (SPR) and stocks of both crude and products held by industry. Stocks held directly by the government equate to some 52 days of net imports currently, while privately held stocks in industry equate to a further 66 days, resulting in a total net import coverage well above the minimum 90-day requirement.

Demand growth for oil products in the period to 2030, coupled with an expected decline in domestic production, will result in increasing dependence on imports to meet demand. Rising net imports pose challenges to future emergency preparedness in the United States, including the need for expansion of refining capacity to avoid a growing dependence on product imports. Moreover, as net imports rise, a static level of public stocks will gradually decrease in terms of days' cover. As a consequence, the volume of SPR stocks will need to increase just to maintain the current level of net import coverage.

POLICY

The Administration's emergency policy is to respond quickly to a major supply disruption with the release of crude oil from the SPR, relying on market forces to allocate the oil effectively. In addition to the crude oil stocks held by the SPR, in 2001 the Northeast Home Heating Oil Reserve was established, holding 2 million barrels of distillate oil in four leased storage facilities located in New Jersey, Connecticut and Rhode Island. Apart from these volumes, all government stocks are held by the SPR in the form of light crude oil, in salt domes located on the Gulf coast. There is no stockholding obligation on industry.

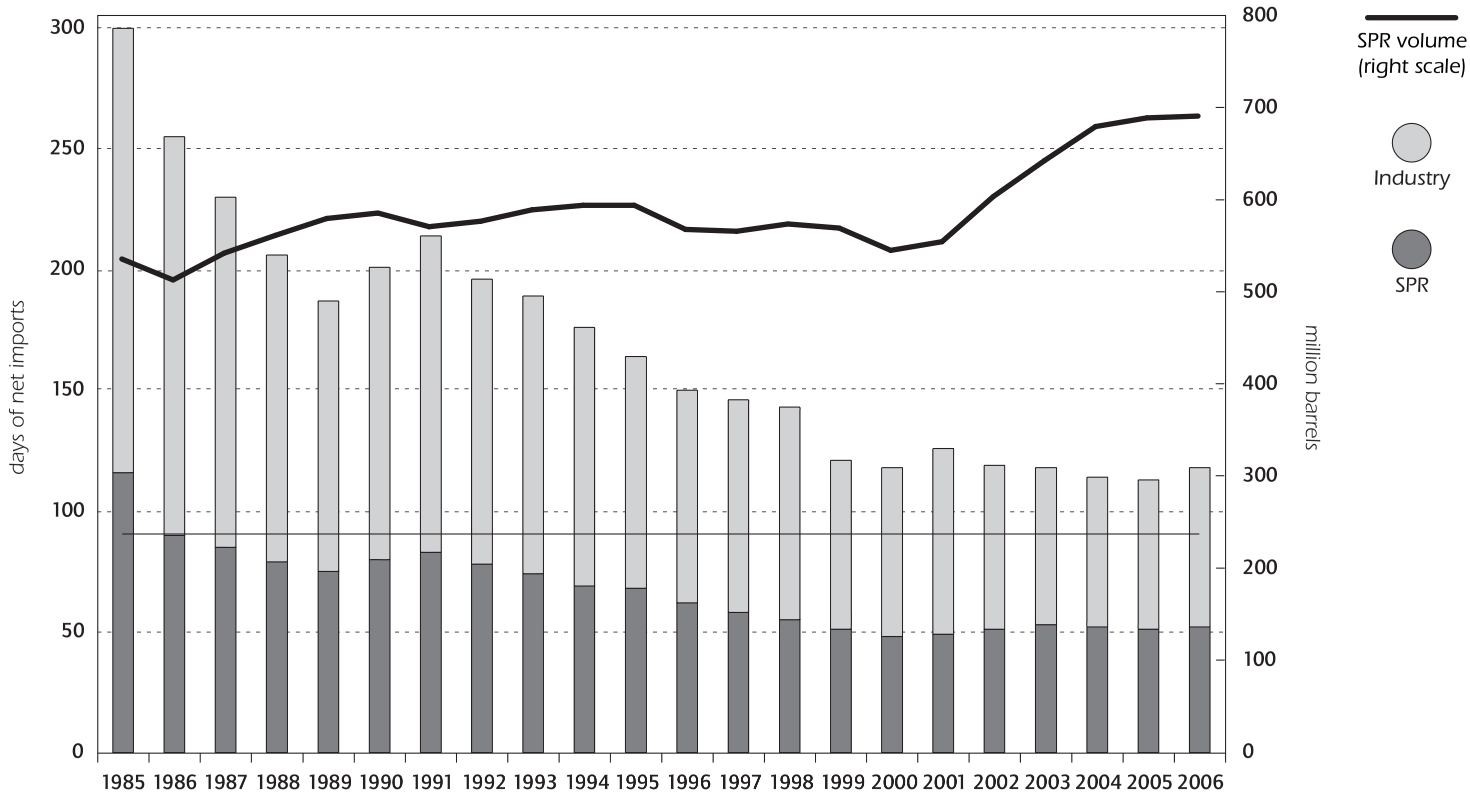
The Energy Policy and Conservation Act (EPCA) signed in 1975 established the SPR, authorising petroleum reserves of up to 1 billion barrels. The Energy Policy Act of 2005 directed the Secretary of Energy to acquire oil as expeditiously as practicable to fill the SPR to this authorised capacity. By mid-2007, the SPR was holding some 690 million barrels.

In order to meet the 2005 directive, it is necessary to expand upon the volumetric storage capacity currently available across the SPR's four storage sites. Located along the Texas and Louisiana Gulf coast, these have a combined capacity to hold up to 727 million barrels. To reach 1 billion barrels capacity, the SPR office will expand upon two of the existing sites by a combined amount of 113 million barrels and will develop a new site in salt domes at Richton (Mississippi) with a capacity of 160 million barrels.

In January 2007, the President encouraged the Congress to authorise an increase in the SPR to 1.5 billion barrels by amending the EPCA. Upon such a change, further consideration would be given as to the location and types of oil to be held.

Figure 23

Total Oil Stocks at End-Year



Source: EIA.

COAL

OVERVIEW

Coal is the United States' most abundant fuel, and current EIA projections assume an increasing role for coal under existing policies. During the period from 1973 to 1990, coal use in the United States TPES increased rapidly compared to other energy sources, by 3.7 times the rate of total TPES growth, backing out oil-fired power generation. Since 1990, the growth of coal use has moderated to be largely in line with TPES growth.

SUPPLY

Production

In 2006, the United States produced about 20% of world steam coal and about 8% of world brown coal. Since 1990, production of steam coal has increased by 24.3%, while the share of world production has fallen from 26% to 20%. The production of brown coal has fallen by about 4%, although the share of world brown coal production has increased from 7% to 8% during the same period. In 2006 the United States also produced some 6% of world coking coal, compared to over 16% in 1990. Since 1990, United States coking coal production has declined by more than one-half.

The United States has significant recoverable reserves of coal, accounting for approximately 27% of world reserves. Currently estimated reserves are sufficient for 234 years at the 2006 rate of production.

Coal is produced in four regions: the Appalachian Region running from Pennsylvania and Indiana in the north to Alabama in the south; the Interior Region, which is mostly concentrated on Michigan and Illinois in the east and north, and Iowa, Missouri, Kansas and Oklahoma in the west and south; the Powder River basin, which covers parts of Wyoming and Montana, and is the most productive coal-mining region in the United States and one of the richest coal deposits in the world; and the Western Region which covers large parts of Arizona, New Mexico, Utah, Colorado, Wyoming and Montana. There are also important lignite resources in North Dakota and Montana. Wyoming is the top coal-producing state.

The number of active mines in the United States stood at 1 415 in 2005, of which 90 were west of the Mississippi, and 1 308 east of the river. A further 17 mines were working on collecting coal from refuse. The 16 opencast mines in the Powder River basin alone accounted for 38% of coal production in 2005. Production east of the Mississippi accounted for 44% of total production in the same year, and west of the Mississippi for 56%. Most of the coal is produced in opencast mines, which accounted for 67% of total production in 2006.

Notwithstanding significant price increases on world markets for coal, coal in the US is very cheap compared to oil or gas, with mine-mouth prices ranging from USD 50/tonne for Appalachian coal to USD 10/tonne for Powder River basin coal.

Table 25

Coal Production by Type of Coal, 1978 to 2006

(in Mtce)

						Average annual change		Total change	Share	
Type	*1978*[1]	*1980*	*1990*	*2000*	*2006*[2]	*1978-1990*	*1990-2006*	*1978-2006*	*1978*	*2006*
Coking coal	93.4	119.2	94.5	55.0	42.6	0.1	-4.9	-54%	18%	5%
Steam coal	417.8	499.8	637.1	686.0	742.8	3.6	1.0	78%	79%	90%
Brown coal	15.6	20.8	38.7	37.4	37.1	7.9	-0.3	138%	3%	5%
Total	**526.8**	**639.8**	**770.3**	**778.4**	**822.5**	**n/a**	**n/a**	**56%**	**100%**	**100%**

1. First year for which split data are available.

2. Estimated.

Source: *Coal Information 2007*, IEA/OECD Paris, 2007.

Transport

Because of the distances involved between the major production centres in the western states and the major consumption centres in the east, coal production is heavily dependent on rail and waterway transport. During the period since the last review, rail transport in particular proved to be inadequate to meet the growth in coal production and demand, and significant bottlenecks hampered the supply of coal to power stations, with the year 2005 seeing the most significant problems. In 2006, the situation eased with increased investment by the rail companies.

International Trade

The United States is a net exporter of coal. Exports more than doubled between 1973 and 1990, and reached almost 100 million tonnes in 1991 before falling back to 1973 levels by 2006 when exports stood at 45 million tonnes. Since 1990, imports of coal have increased significantly, and the United States is heading towards becoming a net importer. But roughly 60% of coking coal production is exported, accounting for 56% of coal exports in 2006. The major customer for steam coal is Canada, taking 70% of exports in 2006. The trade pattern for US coal imports is strongly influenced by logistics; imports tend to be in the south-west, close to ports, and far away from domestic supplies. Colombia is the major supplier and growing strongly.

Coal combustion for electricity production is the most important use of coal in the United States, accounting for over 93% of coal use in 2005 (see Table 26). The share of coal in electricity production has remained relatively stable since 1980, reflecting increasing use of natural gas for power generation. These changes in power production technology are due partially to the availability of large-frame gas turbines, and partially to more stringent environmental regulations affecting the use of coal. The most important of these regulatory changes was the amendment of the Clean Air Act in 1990, which introduced regulation of sulphur emissions from coal use. Very small amounts of coal are used in residential heating.

Table 26

Coal in the United States Economy, 1973 to 2005

(in Mtce)

						Average annual change		*Total*	*Share*	
Sector	*1973*	*1980*	*1990*	*2000*	*2005*	*1973-1990*	*1990-2005*	*1973-2005*	*1973*	*2005*
Transformation[1]	348.6	442.6	579.2	763.3	731.6	3.0%	1.6%	110%	76.8%	94.4%
Industry	85.9	68.9	64.1	41.5	40.1	–1.7%	–3.1%	–53%	18.9%	5.2%
Other	19.4	11.3	13.6	3.2	3.3	–2.1%	–9.0%	–83%	4.3%	0.4%
Total	**453.9**	**522.8**	**656.9**	**808.0**	**775.0**	**n/a**	**n/a**	**71%**	**100%**	**100%**
Coal share of electricity production in %	44.2	51.2	52.0	51.2	50.4	1%	0%	14%	n/a	n/a

1. Includes electricity production.

Source: *Coal Information 2007*, IEA/OECD, Paris 2007.

The EIA is predicting a significant increase in coal-fired power generation capacity in the United States between now and 2030, and individual utilities have announced large-scale investment plans based on the utilisation of pulverised coal combustion technology. According to the EIA *Annual Energy Outlook 2007* predictions, coal should account for 28% of newly commissioned capacity between 2006 and 2010, 48% between 2010 and 2020, and 67% between 2020 and 2030. Coal-fired capacity is expected to contribute 40% of demand growth, estimated to reach 400 TWh between 2006 and 2012.

GOVERNMENT POLICY

The federal government's policy is to encourage the continued use of coal by supporting the deployment of clean coal technologies through DOE R&D programmes and market-based regulation by the EPA, giving incentives to power station operators to reduce the emissions of SO_2, NO_x, mercury[17], and PM_{10} from coal combustion. The DOE programme is heavily focused on the FutureGen initiative (see Box 10). State regulation of electric power producers may affect coal use as well, *e.g.* by rate-setting or environmental requirements. The most important of these regulatory initiatives is the recent move by California to effectively forbid utilities to sell coal-generated power in the state of California.

The United States government is providing significant incentives to coal producers under two separate but related tax-incentive schemes. The synfuel tax credit, enacted in 1978, last amended in 1998 and due to expire at the end of 2007, is worth around USD 2 billion per year to the industry, and subsidises reproducible chemical alterations in coal. It was originally meant to give an incentive to producing new types of fuel out of coal, but the coal produced by the 57 plants currently benefiting from the tax credit is used in the same way as unaltered coal. With one exception, the plants are located in the east. Under a section of the Highway Reauthorisation and Excise Tax Simplification Act (2005), a USD 0.5 per litre tax incentive is offered for limited production of liquid fuels from coal. This is due to expire at the end of 2009, but legislation currently in Congress may extend it or establish a new subsidy scheme. It is unclear whether any of this subsidy is actually being paid at the moment.

In addition to DOE R&D efforts and the existing incentives, the EPAct 2005 is offering loan guarantees, loans and direct grants to advanced coal use facilities, of USD 1.8 billion over 9 years from 2006 to 2014, with the specific provision that 70% of the amount has to be spent on gasification projects. It is also offering USD 1.3 billion in tax credits to advanced coal projects, USD 800 million of which are ring-fenced for gasification projects. Gasification projects can claim up to 20% of the investment for the tax credit, while other advanced coal projects can claim up to 15%.

The federal government is also playing a critical role in coal production by making available federal land for mining (for further details on royalties, see section on Exploration and Production Policy above). For example, Montana's coal royalties varied between 2004 and 2007 from a high USD 15.8 million in 2004 to a low USD 14.3 million in 2006. In 2004

17. See Box 5 in Chapter 5.

Montana accounted for 8.2% of United States coal production, and the royalty income was equivalent to USD 0.79 per short tonne of coal produced in Montana, or 8% of the average mine-mouth price of Montana coal, and 4% of the average coal price in the United States.

Box 10

The FutureGen Initiative

Background

FutureGen is the name of a joint coal and power industry/DOE research initiative which should lead to the construction of a commercial-scale demonstration plant featuring the most advanced coal conversion technologies for power generation. It is expected to enter operational status by 2013.

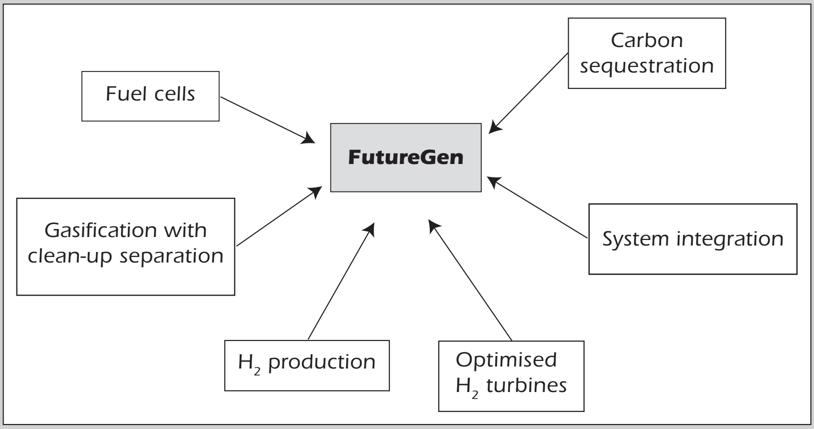
In February 2003, the President of the United States announced the USD 1 billion, 10-year FutureGen initiative which, when completed, would become the world's first zero-emission coal plant. A programme plan was submitted to the Congress in March 2004 by the DOE, and the FutureGen Industrial Alliance Inc. was formed in September 2005. A co-operative agreement was signed between DOE and the FutureGen Industrial Alliance Inc. in December 2005 to initiate the first phase of the project. The Alliance issued a competitive site solicitation and has announced its short list of four candidate sites to host the project: Mattoon or Tuscola, both in Illinois, or Heart of Brazos near Jewett or Odessa, both in Texas. In July 2006, the DOE began the formal environmental compliance process by issuing a Notice of Intent for an environmental impact statement for FutureGen.

Technology

This FutureGen venture will combine electricity and hydrogen production from a single facility with the elimination of virtually all emissions of air pollutants, including SO_2, NO_x, mercury, and particulates, as well as a 90% reduction of atmospheric CO_2 emissions, through a combination of efficiency improvements and carbon capture and storage. The FutureGen power plant will serve to demonstrate the most advanced technologies, such as hydrogen fuel cells. The low-emissions, fossil-based power system portfolio has three focus areas: advanced power systems, distributed generation/stationary fuel cells, and co-production/hydrogen. Figure 24 shows the various technologies to be integrated into the demonstration plant.

Figure 24

Technology Integration in FutureGen



Source: FutureGen Initiative.

Membership

The FutureGen Alliance consists of 12 organisations. Among these are companies which represent approximately 20% of the United States coal-fired electricity generation and over 40% of United States coal production. As an open consortium, the Alliance is geographically diverse within the United States, including both coal producers from the eastern and western coal regions and coal-fuelled electricity generators from across the United States. It also includes international coal producers such as BHP Billiton, Rio Tinto and China Huaneng Group, producers and users of a full range of coal types.

Progress in 2007 and 2008

In May 2007, environmental impact volumes (EIVs) were released by the Alliance for each candidate site. On 25 May 2007, the DOE released a draft of the environmental impact statement. Also during May 2007 the Alliance released a conceptual design report, reporting on the completion of conceptual designs on several plant configurations and the associated preliminary cost estimations. Preliminary planning activities for permitting processes have also been initiated during 2007, and the initial phase of the project definition was completed. In terms of international involvement, India and South Korea have signed Framework Protocol Agreements to join the Government Steering Committee, and other countries have also been invited to join. Community meetings were held near the four candidate sites in June 2007 to engage with the public and encourage participation in the planning process. The estimated cost stood at USD 1.5 billion, of which 75% was to be government-funded. On 18 December 2007, however, a DOE statement was released in which a restructuring was announced because of cost overruns in the project. Early in January 2008, it was announced that Mattoon, IL, had been selected as the site for the project, and that costs had increased to USD 1.8 billion.

Next Steps

The design process will decide on which technologies will be included in FutureGen, and will develop the test scope for validating FutureGen as a viable power station. The DOE will establish the Government Steering Committee operations to bring international governmental participation. The initiative will also continue outreach activities to gain public acceptance of the project and to bring additional domestic and international participants into it by a co-ordinated effort of DOE, the Alliance and international partners.

INDUSTRY STRUCTURE

The United States mining industry is entirely in private hands, even though significant deposits lie on federal lands in the west, and are leased out to operators by the federal government. In 2006, coal mining directly or indirectly employed some 120 000 people, and the industry estimated the value of production at USD 28 billion. The three largest coal producers accounted for over 40% of annual coal production in 2006, with the top producer, Peabody Energy, alone accounting for 18.5%.

CRITIQUE

EXPLORATION AND PRODUCTION

United States natural gas production appears to have peaked in 2001, and oil production is expected to continue its decline. Increased gas production in the future is likely from Rocky Mountains areas such as Wyoming and Colorado, as well as deep-water Gulf of Mexico, and from unconventional sources such as coal-bed methane, or tight sands. Increased oil production is likely from offshore areas, and unconventional resources, but it is unlikely to change the underlying trend of decline. New infrastructure and technological developments are important for the opening of new production. For example, the development of the Rockies Express gas pipeline should spur E&P for gas in the Rocky Mountains, where consistently low prices for gas have so far slowed growth, by providing access for gas producers to eastern United States markets. Deep-water Gulf of Mexico is a likely prospect in terms of oil and gas reserves, but the costs of production are very high with current technology. Unconventional gas resources are also increasing rapidly as a share of production, but are held back by high costs for E&P and technological and environmental challenges.

The picture for gas production is of an industry where increased drilling activity, driven by high prices, is offsetting the maturity of United States gas reserves, and where unconventional sources are contributing a greater share of output. The EIA *Outlook* shows at best a flat production curve, and even that will be dependent on continuing high prices, new technology and techniques for developing unconventional resources.

Production is also hampered by large areas containing likely reserves being either restricted or completely off-limits for access to exploration activity. These areas are estimated by the EIA to hold four years of United States gas demand. In order to fully develop the potential of both unconventional resources and the outer continental shelf, a regulatory regime is required which gives the correct incentives to exploration and production, while maintaining appropriate levels of royalties to the public who owns the reserves. Other IEA member countries have managed to maintain high exploration and production rates in mature areas and stimulate the development of frontier areas, while taking a considerable share of the income from natural resources. Reforming the United States mineral royalty system by considering the introduction of some aspects from these countries designed to encourage E&P may be a way forward to reconciling public interest in long-term oil and gas production with that of the industry.

The large potential for production of conventional and unconventional resources is driving the debate on opening up the reserves at the federal and state levels, which has been accelerated by the provision of significant incentives to production in EPAct 2005. The production of unconventional gas, *e.g.* coal-bed methane, is primarily driven by current gas price movements. The major concern about the development of these reserves relates to the local environmental impact, and the availability of water and gas required for oil production from unconventional reserves such as oil shale. Before this production can be accessed, however, important questions about infrastructure have to be resolved. Alaska alone is estimated to be able to deliver as much as 10% of United States gas demand if the existing reserves are developed, but even the most optimistic estimates do not show any gas delivery from there in the next ten years, because of questions about the development of pipelines connecting Alaska to the lower 48 states.

While it is necessary to consider the environmental impact and sustainability problems of producing these resources, it is clear that the dispute between the states and the federal government over ownership and access to federal land and coastal waters, as well as continuing debate between the federal government and Congress, have created high levels of uncertainty for companies willing to invest in the development of these resources. Given the constitutional situation and the distribution of powers, the federal government will have to consider states' views on the matter of opening up new areas to exploration, or of producing unconventional resources. These projects should be pushed forward as much as is possible in conjunction with the states, taking account of their views. The example of the short time given to the western states to review the preliminary environmental impact statement on oil shale developments in 2007 shows that trying to push developments rapidly in the face of, at best, reluctant state administrations may be counter-productive in the long term, and not in the best interest of the industry.

NATURAL GAS

The United States natural gas market is the largest in the world in terms of demand. The market is liquid, transparent, responsive, highly competitive, and works very well, providing a model for gas markets worldwide. This increases security of supply. For example, the transparency of the gas storage situation allows changes in storage to immediately feed through into the gas wholesale price. Demand for gas is expected to become more variable, with gas being used to smooth out intermittent renewable generation, providing more mid-merit and peak electricity generation. Overall demand has increased significantly with natural gas becoming the fuel of choice for new power generation, but this overall increase masks important sectoral differences. Considering the current power generation mix, the increase in the use of this relatively clean fuel in power generation is a commendable development, but it is not without risks, and the government should continue to provide incentives to ensure a diverse fuel base, taking into account environmental concerns.

While domestic gas production supplies over 80% of the needs, imports are continuing to increase and a shift in the origin of imports from pipeline gas from Canada to LNG procured in the nascent Atlantic LNG market, is currently under way. This shift will expose the United States natural gas market to international price developments for natural gas, and to competition with other LNG users, in particular Spain and the United Kingdom, where prices are subject to different influences such as the continental European oil price indexation, allowing arbitrage opportunities to develop. This increasing international dependence will create risks for the United States gas market, but it can also have beneficial effects, by providing diversification of supply entry points. It can also lead to the Henry Hub becoming an international benchmark for gas prices in the Atlantic market, and in 2007 Henry Hub set a floor under internationally traded LNG prices.

Recognising the importance of accessing growing LNG production, the EPAct 2005 commendably contained measures to encourage the development of LNG import infrastructure. FERC has been granted final authority to permit the construction of LNG facilities, together with the United States Coast Guard, but also has to consult state Administrations on safety issues. However, industry has expressed concerns that problems can still be created by overlapping state and federal jurisdictions and by the lack of a clear, enforceable timetable for facility reviews. While the complexity of the permitting process has been reduced by EPAct 2005, the problem itself has apparently not been solved, and this continuing complexity in permitting has mitigated against the development of a clear timetable for the development of new LNG import facilities. To solve this problem, it will be necessary for the federal government to co-operate closely with states, and try to develop a regulatory approach that will take account of the concerns of states, while allowing necessary developments to go ahead. Another challenge in the development of LNG import facilities is the current tightness of supply. A secure source of supply is needed to make a new terminal economic.

The current lack of such an approach has mitigated against the geographic diversification of LNG import points which is required for security of supply. This has led to a concentration of new and expanded terminals in the GOM region. While it is welcome that terminal construction is possible, such a concentration in a single geographical area significantly increases the risk of losing this important infrastructure temporarily or permanently in the case of extreme weather events, such as hurricanes. For this reason, although GOM terminals offer important advantages, such as ease of access to pipeline networks and the lack of regulatory barriers, the construction of new terminals and additional pipelines should focus on the west coast and the north-eastern United States, where the government has identified the need to reinforce gas infrastructure. Canadian and Mexican terminals could positively contribute to achieving this goal. The government should, therefore, consider ways to ensure that the complexity of the permitting process is reduced to ensure that geographical diversification of import terminals can take place, taking into account the very positive safety record of LNG installations in all IEA member countries.

Economic regulation barriers to the development of new LNG terminals have been removed since the last review, and this is very commendable. The 2002 Hackberry decision appears to have been an economic driver for new developments. Even though the Hackberry decision could be considered "anti-competitive" in theory by reducing the number of potential suppliers to the system, it was deemed to be pro-competitive in practice, on the grounds that the underlying market environment is competitive and that a new LNG terminal would provide an additional source of gas to compete in that environment. This case is an excellent example of pro-investment and pro-competitive regulation, and other IEA member countries should closely study the decision and consider applying similar principles in their domestic regulation.

Developing additional gas storage will be particularly important in meeting peak gas demand, especially from the electricity sector. The United States storage market is well placed to meet this challenge, thanks to its strong linkage to the market. New storage will increasingly need to be of the high-delivery type, such as salt caverns. The EPAct 2005 also provided measures to encourage storage, and this is commendable.

OIL

The United States is the world's largest user and importer of oil, used approximately 28% of the world's daily oil production in 2006, and in the words of the President, is "addicted" to oil. Dependence on oil is higher than in most other IEA member countries, and continues to increase. Growing domestic demand and declining domestic production mean that the dependence on international markets will continue to increase in the future. The most important challenge for the United States energy policy in the oil sector is to reverse this trend in the use of oil.

The supply disruption caused by the hurricanes Katrina and Rita in 2005, increasing geopolitical risk, and steep rises in the price of oil and gas since 2002 have contributed to the rise of oil supply security as a major concern in United States policy. Increasing supply security of the oil market should be achieved by the federal government through developing a clear policy aiming to decrease the "oil addiction", and eventually consider increasing vehicle fuel prices. The low level of vehicle fuel taxation in the United States invites consideration of using the tax mechanism to increase the energy supply security of the country. This policy should include action on the supply side, most importantly the reduction of the dependence on foreign sources of energy through the development of alternative and renewable sources of energy, as well as supply diversification. Of even greater importance, however, is to act on the demand side. Without a strong push to curb demand through policies increasing energy efficiency in transport, supply-side policies are less likely to be successful, and will in any case be more costly to the economy.

Refinery investment has not developed as expected following the passage of EPAct 2005, despite good margins in the refining industry, leading to increasing dependence on product imports, even though some recently announced projects may reduce this risk. Continuing uncertainty for investors is one reason for the reluctance to bring forward projects. For example, it is unclear how the policy goal to replace a large share of gasoline produced from oil with biofuels will affect the long-term investment plans of the refining industry in the United States. The continuing uncertainty about the future regimes to reduce GHG emissions is also contributing to uncertainty. The federal government should undertake an assessment of the impact of the biofuels policy on refining capacity needs in the future.

Boutique fuels exist in various regions of the United States. This contrasts with *e.g.* the EU market, where one specification covers the whole market. These differing specifications are contributing to fragmentation of the countrywide market, increasing prices by creating small, islanded markets; they are an additional challenge for refinery planning and management; and in the case of supply shocks, can make rapid shifts of supply from unaffected areas difficult. The powers of the EPA to lift such specifications in the case of supply shocks are very welcome in this regard, and the government should undertake an assessment to develop a better understanding of the potential impact of these different specifications on the gasoline market and security of supply.

EMERGENCY PREPAREDNESS

The planned increase in the strategic petroleum reserve to 1 billion barrels of crude oil is commendable. This expansion is necessary to avoid a further decline in the number of days of import covered by the reserve because of growing imports. The United States government's emergency strategy relies upon sufficient volumes of the SPR and a refinery sector able to turn out products at a pace necessary to meet consumer demands in a crisis. Demand growth will put increasing pressure on this policy.

The holding of refined products as part of the strategic reserve would go a long way towards addressing the risk of insufficient refining capacity available at the time of a supply disruption, as was experienced in the period after hurricanes Katrina and Rita hit the Gulf of Mexico. Moreover, the concentration of oil stocks and refineries on the GOM coast has resulted in the United States being vulnerable to climate-induced supply shocks such as was experienced in 2005. Further expansion in strategic reserves should consider a wider geographical distribution.

COAL

Developments in climate change policy, and the possibility of a cost being attached to CO_2 emissions in the future, are undoubtedly slowing construction of new coal-fired capacity, despite impressive investment plans by utilities. Eliminating or reducing these uncertainties will be necessary to ensure that coal can continue to play a role in providing fuel diversity and security in the United States.

At present, there are no federal requirements forcing improved technology in coal-fired electricity production. The regulation of air pollutants is market-based, allowing utilities to continue to run highly polluting plants under grandfather rights, or construct new plants based on old technology if they can procure emission permits at low cost. While minimum emission limits exist, these are by themselves not sufficient to force the installation of clean/cleaner coal technologies.[18] While these technologies may often not be economically competitive with traditional subcritical pulverised combustion technologies, this regulatory situation is increasing their competitive disadvantage, unless environmental externalities are fully reflected in the market price for electricity. This is not yet the case, and the commercial drivers for moving to high-efficiency technology, in particular CO_2 removal, remain weak.

The introduction of clean coal technologies, such as selective catalytic reduction and flue-gas desulphurisation (removing NO_X and SO_2 respectively) or in the future CO_2 capture and storage (CCS), is, therefore, at present fully dependent on government and public regulation that either forces the installation of specific technologies, or uses market mechanisms to encourage the installation of removal technologies or changes in fuel use to reduce emissions. To sustain the higher initial investment required in CCS technologies, the government has introduced support for their development by offering loan guarantees for the most advanced plants. The government should consider accompanying this mechanism with a gradual increase of the minimum requirements to force the adoption of best practice in coal-fired power generation. Such a long-term approach would give investors security about future market conditions, and allow them to invest in the knowledge that their investment is protected to some extent from sudden changes in regulation.

The EPAct 2005 provided significant incentives to advanced coal use facilities, with a strong bias towards gasification technologies, which also look likely to be chosen for FutureGen. It is questionable whether this bias is warranted, given the current state of the technological development, and it may become necessary to review the support schemes in the future if the expectation in terms of availability timelines and capital cost for gasification technology are not met. The government should consider keeping all options for advanced coal technology open.

The expiration of the synfuel tax credit at the end of 2007 is a highly commendable development, since the tax credit had only minor positive effects, and was largely used to subsidise the use of coal. Extension of the

18. Clean coal technologies include technologies to reduce particulates (PM_{10}), SO_2, NO_X, mercury, CO, and CO_2 from the flue-gas stream of coal-fired power stations. Modern supercritical or integrated gasification processes, which have a significantly higher combustion efficiency compared to the subcritical plants that dominate in the United States, would reduce the emissions per kWh of all air pollutants.

existing tax credit or the introduction of a new tax credit for coal liquefaction should be carefully considered, and any measure taken should ensure that the tax credit benefits only the actual production of alternative fuels with due regard to environmental impacts.

RECOMMENDATIONS

The government of the United States should:

Exploration and Production

- *Improve the regulatory process and the allocation of permits between the different levels of responsibilities in order to establish a clear legal framework and to allow environmentally sustainable E&P of all resources, giving particular attention to environmental impacts.*
- *Continue to encourage littoral states to allow offshore oil and gas E&P, taking into account legitimate environmental concerns.*
- *Carry out the offshore resource assessment exercise foreseen in EPAct 2005.*
- *Consider a reform of the minerals royalty system that encourages E&P in mature areas and high-risk areas, applying the experience from other IEA member countries.*

Natural Gas

- *Vigorously implement the EPAct 2005 provisions to ensure timely pipeline development linking LNG terminals and new production areas to the markets, in order to increase energy security and supply diversification.*
- *Work with states to develop a permitting process which will allow diversification in the location of LNG terminals and other infrastructure away from the physically vulnerable Gulf of Mexico region.*

Oil

- *Reduce oil dependence by introducing vigorous supply diversification and demand-side policies.*
- *Prepare a better environment for refinery investment and increase security of supply by:*
  - *assessing the impact of the proposed alternative fuel and efficiency requirements on refinery investment;*
  - *assessing the impact of different fuel quality requirements in a number of regions of the United States on refining and security of supply.*

Emergency Preparedness

- *Go forward with plans to increase the strategic petroleum reserve to its authorised volume of 1 billion barrels in order to avoid a decline in the level of days of net imports covered and further improve oil security by expanding the strategic reserve to 1.5 billion barrels;*
- *Consider the holding of refined petroleum products as part of any expansion of strategic reserves.*
- *Consider placing a significant share of crude and product stocks in the strategic reserve away from the Gulf of Mexico to reduce their vulnerability to weather events.*

Coal

- *Establish an environmental regulatory framework based on best available technology standards that increases investor confidence and allows the United States coal industry to continue to contribute to security of supply with modern plants.*
- *Continue to push forward the FutureGen demonstration project and CCS technology research, and especially demonstration.*
- *Establish effective incentives to encourage early movers in the commercial deployment of CCS technologies.*

ELECTRICITY

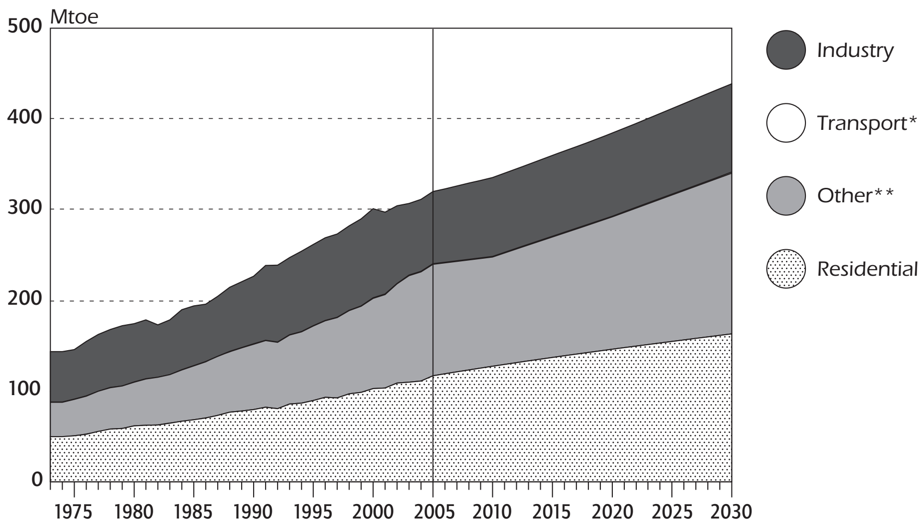
OVERVIEW

Electricity demand has increased by 41% between 1990 and 2005, and is expected to continue to grow, albeit at a slower rate. Power demand can be expected to grow by nearly 10%, from 2006 to 2012, and peak power demand by around 17% from 2007 to 2017, according to North American Electric Reliability Corporation (NERC) forecasts.

Growth has been and will continue to be led by the commercial and residential sectors, where electricity is expected to account for almost 50% of sectoral energy consumption by 2020. The strong commercial growth (60%) is predicated on a continued rise in service industries, while residential needs are driven by higher population, which continues to shift to warmer regions, needing more cooling, as well as per-capita floor space increases. EIA estimates that approximately 300 GW of new capacity will be needed to service this demand.

Figure 25

Final Consumption of Electricity by Sector, 1973 to 2030



* negligible.

** includes commercial, public service, agricultural, fishing and other non-specified sectors.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2007 and country submission.

Table 27

Electricity in the United States Economy, 1990 to 2020

	1990		*2005*		*2020*		*Change 2005/1990*		*Change 2020/2005*	
	TFC	*Share*	*TFC*	*Share*	*TFC*	*Share*	*TFC*	*Share*	*TFC*	*Share*
Sector	*Mtoe*	*%*	*Mtoe*	*%*	*Mtoe*	*%*	*Mtoe*	*%*	*Mtoe*	*%*
Industry	75	19	79	18	91	19	7	–4	15	9
Other	152	38	240	48	292	50	58	27	22	4
Total	**226**	**17**	**319**	**20**	**383**	**20**	**41**	**16**	**20**	**1**

Source: IEA.

INDUSTRY STRUCTURE

OWNERSHIP

The institutional structure of the industry is complex and fragmented, with relatively little government presence (apart from dominance in two regions). Less than half of the investor-owned utilities (IOUs) are in the form of the traditional vertically integrated utility, owning transmission and distribution, while three-quarters of the publicly-owned or co-operative utilities are only involved in retail distribution. Retail sales are dominated by IOUs, which have more than two-thirds of sales to final customers, while wholesale power purchases are primarily undertaken by power marketers and energy service providers. Independent power producers (IPPs) tend to sell at the wholesale level, and to be virtually absent from retail markets.

Net generation is dominated by traditional utilities, which account for 60% of generation by volume, while IPPs account for 31%. The share of IPPs has increased rapidly since 2000, when it stood at 12%, but the rapid growth of the IPP share has slowed in recent years.

The energy mix of electric utilities differs from that of non-utility power producers, dominated by independent power producers. Total capacity owned by utilities has increased as the pace of restructuring in the electric power industry has slowed. During the height of electric power industry restructuring in the early 2000s, electric utilities divested and sold many of their generating units to IPPs, thus reducing generating capacity in their portfolios. Now that a number of states have slowed restructuring, electric utilities have slowly added new capacity, totalling about 13 GW over the period 2001 to 2005. IPPs have increased capacity by 120 GW of which 100 GW is gas-fired. Power generation by this group has grown by 400 TWh over the 2001-2005 period, accounting for almost all growth in national electricity demand.

GENERATION

In 2006, the United States electricity sector had a generating capacity of 906 GW based on availability, and net power production was 4 065 TWh. Electricity generation is dominated by coal, which accounts for half of power production, with nuclear and natural gas around one-fifth each. Natural gas overtook nuclear to become the second-biggest source of power in 2006. Renewables, including hydro, produced 9.5% of electricity.

In terms of capacity utilisation, in 2006 nuclear plants operated at about 90% capacity and coal plants at around 73%, indicating high utilisation of baseload. Gas has a very low capacity factor of around 22%, indicating that the role of gas in the system is to act primarily to supply medium and peak power demand, especially in summer. Hydro availability has been constrained in recent years by dry conditions in several regions.

Total generating capacity increased by about 17% between 2001 and 2005. Most of that increase occurred early in the time period. Natural gas capacity accounted for almost all of it, since there were only small net increases in coal (300 MW per annum over the period) and nuclear capability, the latter from capacity extensions at existing plants. Wind capacity more than doubled to 8.7 GW, and is expected to continue to increase at a rapid rate.

A large part of the currently installed capacity will have to be replaced and modernised over the coming years, at the same time as significant investment in electricity networks will be required. The EIA and the electricity industry estimate that 300-350 GW will have to be replaced or added to the United States generation fleet by 2030 to continue to be able to serve demand.

From 1998 to 2005, natural gas was viewed as the most economically feasible energy source to meet future power demand. Natural gas prices were relatively low and the capital costs were lower than for other plant types. Lead times were shorter, and regulatory and siting issues less constraining. Since 2005, natural gas prices have risen considerably, making natural gas-fired plants a less economic means of meeting energy demand. Despite this, gas-fired power plants represent about half of new capacity currently under construction, and most capacity additions over the period to 2010 and even 2015 are expected to be gas-fired, reflecting current trends in plants under construction. EIA's *Annual Energy Outlook 2007* estimates that demand will grow by 400 TWh over the period 2006 to 2012, of which 250 TWh will be met by new CCGT capacity and the remainder by new coal capacity.

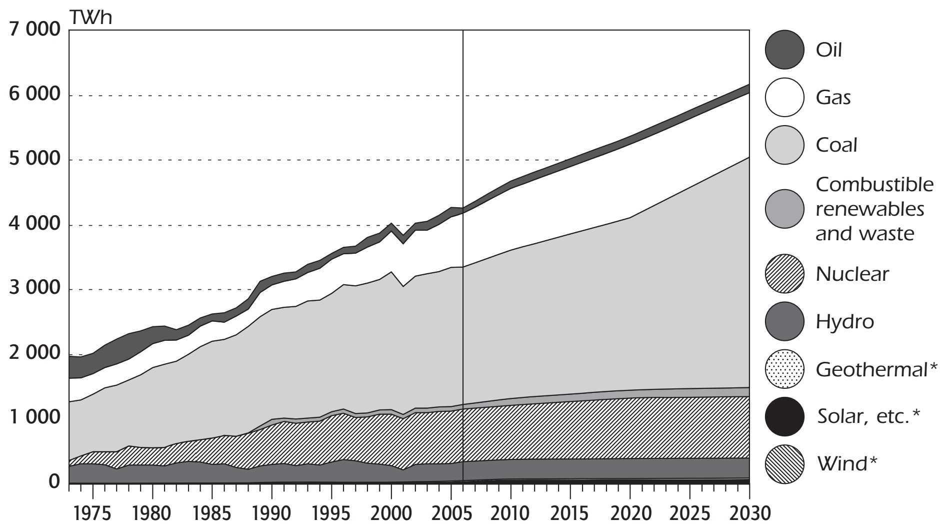
There are 12.5 GW of coal-fired plant currently under construction for entry into service between 2009 and 2011. Pulverised coal technology is the main choice for capacity additions for this fuel. Beyond 2015, coal-fired plants are expected to play a more important role, and to eventually make up more than half of capacity additions over the period 2006-2030, leaving gas with 36%

of new capacity up to 2030. Thanks to the influence of state-level renewable energy standards, renewable capacity is expected to provide around 6% of this new capacity. New nuclear capacity is expected to provide around 4%.

State renewable portfolio standards and federal production incentives have been enacted to stimulate the construction and operation of plants utilising renewable energy sources, but there are significant differences between states, with more than half of them not having a portfolio standard. Non-utility generators have responded by building and operating a majority of the non-hydro renewable capacity in the United States. Geothermal, biomass/waste, and solar capacity have increased slightly from 2001 to 2005. Wind is the dominant new renewable energy source, generating 17 TWh of output in 2005, and 26 TWh in 2006.

Figure 26

Electricity Generation by Source, 1973 to 2030



* negligible.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2007 and country submission.

NETWORKS[19]

The northern United States transmission network systems are closely integrated with parts of the Canadian network. Transmission networks are owned by private or public utilities, and operated either by vertically integrated utilities, or by independent system operators (ISOs), which may combine several networks to form a regional transmission operator (RTO).

19. See also section on Network Reliability below.

The United States transmission networks are facing a number of constraints in terms of their ability to accommodate additional generation and demand load flows. Planning to reduce these constraints is focusing on increasing overall reliability of the systems, and on accommodating expected future additions to the generation fleet of the United States. A recent assessment of long-term reliability by NERC of October 2007 states that there is a continuing trend of under-investment, particularly in new transmission infrastructure.

REGULATION

STRUCTURE

The US electricity industry is subject to regulation at the local, state and federal levels, with some exemptions.[20] Intra-state activities are subject to regulation by state regulatory commissions, which approve plant and transmission line construction, and in all states approve retail prices for their jurisdictional electric utilities. Where a utility activity crosses state boundaries, which in practice means all electricity that is sold at wholesale price, it is subject to federal regulation by FERC. Wholesale prices, plus other matters such as hydro and nuclear plant permitting issues, are under federal regulation.

MARKET REFORM

The Federal Energy Regulatory Commission has broad authority under various federal acts to regulate the inter-state electricity market, most notably wholesale (business-to-business) transactions. Under this authority, FERC has actively promoted competition as the best protection for electricity consumers. In recent years, the focus of FERC has been on ensuring non-discriminatory access to transmission facilities for competing electricity generators. A number of states have also provided for non-discriminatory access to local power distribution networks, extending the scope for competition to retail (end-use) supply.

States have the responsibility for making decisions about intra-state power market liberalisation. FERC and the federal government have encouraged liberalisation to go ahead. Following problems with market liberalisation in California around the year 2000, liberalisation has either been suspended, or been decided against, in a number of states. At the moment, liberalisation is active in 14 states and the District of Columbia. It has been suspended in eight states.

20. In general, Hawaii, Alaska and Texas are not subject to federal regulations. Hawaii and Alaska are not interconnected with any other US state, and Texas only has direct current interconnections, exempting it from federal oversight.

In the transmission markets, there have been continuing issues about transmission as a barrier to liberalisation. These have involved concerns about discriminatory access, charging, in particular adding charges when transmission boundaries are crossed by electricity flows (so-called *pancaking*), and lack of investment in capacity.

In view of the continuing obstacles to competition emanating from transmission capacity and access right constraints, in December 2000, FERC issued Order 2000 to encourage the voluntary formation of Regional Transmission Organisations (RTOs). The basic objective was to encourage vertically-integrated, transmission-owning utilities to cede operational control of their high-voltage power lines to a limited number of unaffiliated RTOs. With access to the grid controlled by independent RTOs, there would no longer be an economic incentive to discriminate between competing suppliers. In addition, FERC assumed that regional entities would be better positioned than local utilities to incorporate system-wide congestion costs into transmission prices, eliminating the accumulation of transmission charges across utility boundaries, and be better placed to plan for cost-effective transmission expansion, thereby alleviating the remaining obstacles to competition.

In July 2002, FERC issued a Standard Market Design proposal to govern the structure and operation of wholesale national power markets. The FERC idea was that all utilities that own, operate or control inter-state transmission should conform to this standard design. Key elements included stronger inducements for utilities to participate in RTOs, active monitoring and mitigation measures to prevent market abuse, a centralised spot power market to complement decentralised bilateral contracts for power, steps to enhance price and market transparency, and measures to encourage construction of needed power plants and transmission infrastructure. Following the experience with the failed liberalisation process in some states, progress to form RTOs has effectively halted, and there does not appear to be effective political support for reviving the initiative.

In February 2007, FERC issued Order 890 entitled *Preventing Undue Discrimination and Preference in Transmission Service*. This order was designed to further reform the open access transmission regulatory framework. Among key provisions, Order 890 requires that: public utilities develop consistent methodologies for calculating available transfer capability and publish those methodologies to increase transparency. The idea is to increase non-discriminatory access to the grid by eliminating the discretion that transmission providers have in calculating transfer capability; each transmission provider's planning process must meet nine specified planning principles: co-ordination; openness; transparency; information exchange; comparability; dispute resolution; regional co-ordination; economic planning studies; and cost allocation. The goal of this provision is to have a co-ordinated, open and transparent planning process.

National Energy Plan

The National Energy Plan, issued in 2001, recommended that DOE and FERC work to make the transmission system more reliable and develop legislation providing for enforcement of reliability by a self-regulatory organisation subject to FERC oversight. It also provided for mandatory and enforceable reliability standards. As a consequence, DOE created an Office of Electric Transmission and Distribution (now renamed as the Office of Electricity Delivery and Energy Reliability) to focus on ways of raising grid reliability and investment. Following the widespread August 2003 blackout, the DOE *Transmission Reliability Program* accelerated efforts to install real-time grid early warning equipment and software in the eastern part of the country.

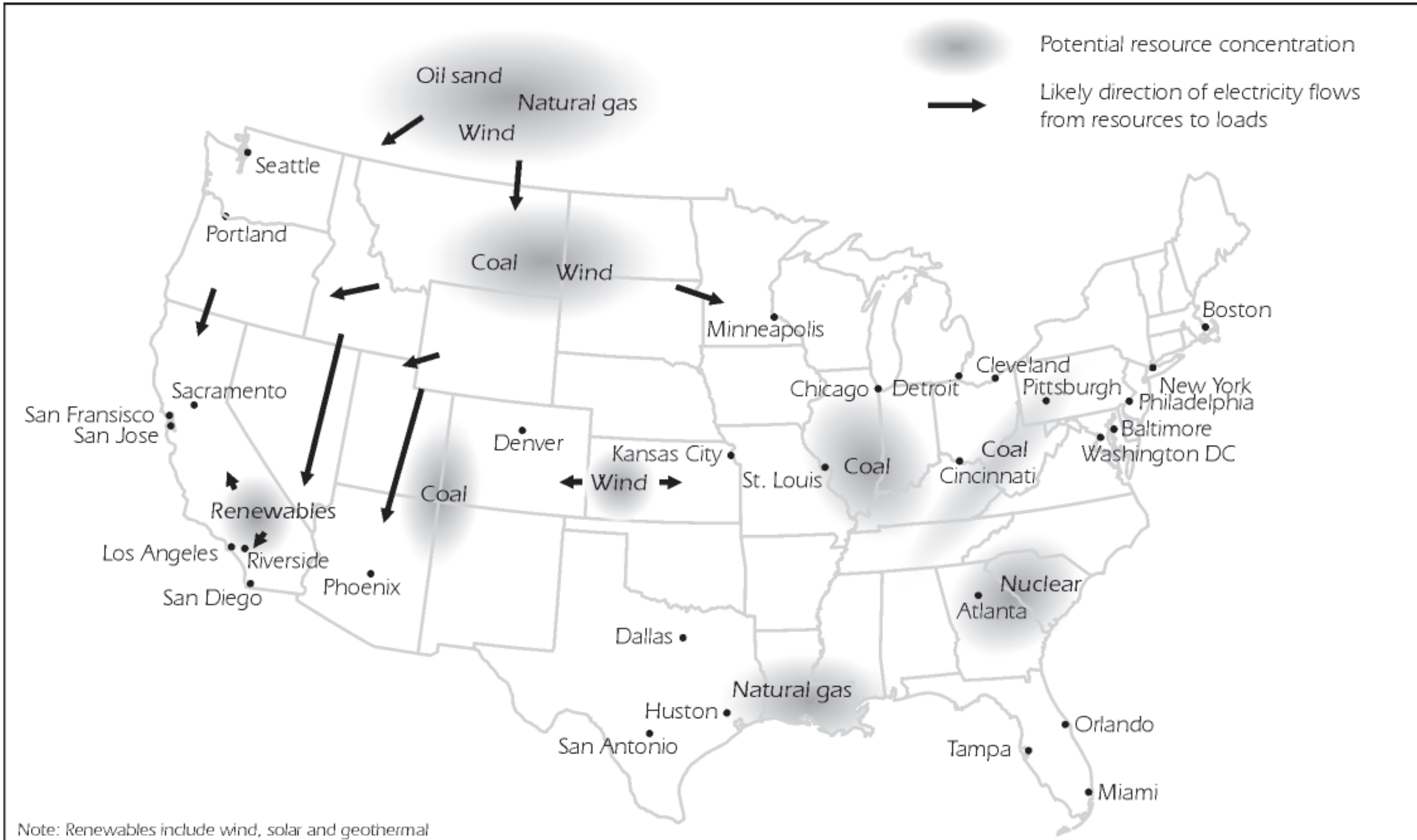
The National Energy Plan also recommended that federal agencies act to remove constraints on the transmission grid. DOE, therefore, issued a National Transmission Grid Study in May 2002 with 51 recommendations to facilitate power grid investment. DOE and FERC then worked to develop incentive rate proposals, including a higher rate of return for new grid investments, for investments in advanced technologies and operating practices, and for grid owners who join a Regional Transmission Organisation (RTO), proposals which are embodied in a pricing policy that FERC has issued for public comment. In July 2003, FERC approved standardised procedures and agreements for the grid interconnection of electricity generators larger than 20 megawatts. In November 2003, FERC issued market behaviour rules to help prevent market abuse, provide a more stable market-place, and help attract investment capital to the gas and power sectors.

Energy Policy Act 2005

EPAct 2005 instructed the DOE to conduct a study of electricity transmission congestion in all the states (excluding Texas), and, if appropriate, designate areas affected by congestion as national interest transmission corridors. The first report in 2006 identified areas of critical congestion concern (Atlantic coast from New York to northern Virginia, southern California), congestion areas of concern, and conditional areas of concern. The latter are areas where potential large-scale development of wind, coal or nuclear capacity might strain existing transmission capacity (see Figure 27). DOE is looking to states, utilities and regional transmission organisations to show leadership in developing transmission, generation, or demand-side solutions to these existing and emerging problems. DOE expects that positive government and industry decisions will be needed in the next few years to address these issues, and it will publish periodic progress reports in addition to required national transmission congestion studies every three years.

Figure 27

Conditional Transmission Constraint Areas



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the IEA.

Source: DOE *National Transmission Congestion Study*, August 2006.

EPAct 2005 also provided FERC with a back-stop siting authority (under limited conditions) over normal state siting authority for new transmission lines that are in a DOE-designated national interest transmission corridor. In October 2007, DOE issued an order for two national corridor designations: the Mid Atlantic Area National Corridor, and Southwest Area National Corridor. These corridors include areas in two of the nation's most populous regions with growing electricity congestion problems, and they may become subject to judicial review before they can be implemented. The state of Pennsylvania has already filed a court suit regarding the decisions on the Mid Atlantic National Corridor.

EPAct 2005 directed the Secretaries of Agriculture, Commerce, Defense, Energy, and the Interior (the Agencies) to designate, under their respective authorities, corridors on federal land in the 11 western states for oil, gas and hydrogen pipelines and electricity transmission and distribution facilities (energy transport corridors). The Agencies determined that designating corridors as required by Section 368 constitutes a major federal action which may have a significant impact upon the environment within the meaning of the National Environmental Policy Act (NEPA) of 1969. For this reason, in November 2007 the Agencies issued for public comment a draft programmatic environmental impact statement, "Designation of Energy Corridors on Federal Land in the 11 Western States" to address the environmental impacts from the proposed action and the range of reasonable alternatives. The proposed action calls for designating more than 6 000 miles of energy transport corridors across the west.

EPAct 2005 again addressed mandatory reliability standards (see Box 11), but the implementation of these standards is still being debated in Congress. In July 2006, following an application for certification submitted by NERC in April 2006, FERC certified NERC, which was previously a voluntary association, as the nation's designated Electricity Reliability Organisation (ERO). Owing to the integrated nature of the North American power grid, the Canadian National Energy Board recognised NERC in September 2006 as the single North American ERO. NERC reliability standards are already mandatory and enforceable in the Canadian provinces of Ontario and New Brunswick.

Box 11

Mandatory Reliability Standards for Electricity Transmission

The blackout of 2003 highlighted the role of reliability standards. The blackout was large, affecting around 50 million people and 290 generating units with some 62 GW of capacity along about 54 000 km of transmission lines. It lasted nearly two days, with full restoration requiring four days in some areas. Its impact was felt in a large part of eastern Canada and the north-eastern United States.

At the time of the blackout, users, owners and operators of transmission or generating facilities on the power grid complied voluntarily with reliability standards set by the North American Electric Reliability Corporation (NERC). Voluntary compliance with these standards worked well in a time where most utilities were vertically integrated and there was little or no competition between generating or supply companies. As competition grew, with independent power producers accounting for approximately 25% of electricity generation in 2003, there were growing pressures on integrated utilities to reduce investment in the networks to gain a price advantage. This may have reduced reliability, and raised the issue of establishing mandatory compliance with reliability standards.

A task force was set up to report on the cause. The United States Canada Task Force on the Power System Outage, in its report of November 2003, attributed the sequence of events that initiated the blackout in large part to failure to comply with NERC reliability standards. The blame was laid partly on a utility, FirstEnergy, and partly on the Midwest Independent System Operator. Several procedural violations of NERC reliability standards were noted by it, as well as other violations of NERC reliability standards related to system monitoring capability.[21]

Largely because of the task force considerations, EPAct 2005 contains mandatory provisions to help ensure reliable operation of the electric power system. EPAct 2005 aims to give FERC authority to approve and enforce rules to assure the reliability of the bulk power system. The law requires all users, owners and operators of the nation's transmission grid to comply with FERC-approved reliability standards. EPAct 2005 authorised the creation of a self-regulatory electric reliability organisation to develop and enforce mandatory reliability standards and requires FERC to certify an entity to be the electric reliability organisation (ERO) for the United States. The ERO is responsible for developing and enforcing mandatory reliability standards, subject to commission approval, that provide for an adequate level of reliability of the bulk power system in the United States, Canada and northern Mexico.

DEMAND-SIDE MANAGEMENT

Demand-side management (DSM) has historically been an important contribution to the security of electricity supply in the United States, and reduces the environmental impact of electricity use. From 1995 to 2006, the contribution of DSM has declined in relative terms compared to electricity demand growth in

21. See also *Learning from the Blackouts*, OECD/IEA Paris, 2005.

the area of energy efficiency. In absolute terms it declined in the area of load management (see Table 28). While there has been a decline in total since 1995, between 2000 and 2006 the impact of DSM grew once more.

Use of DSM varies by region. For example, a 2006 review of the integrated resource plans of major utilities in the west shows plans to meet 50% of their customers' load growth with energy efficiency. The last two years have seen a strong resurgence as well as new emphasis in the electric utility industry and its state regulatory commissions in utility-delivered energy efficiency, particularly through the preparation by their leaders, followed by various implementation steps of a National Action Plan for Energy Efficiency. There is now an emerging view in the utility industry and among its state regulators that energy efficiency can be used as a bridge fuel (as natural gas was used in the 1990s) to not-yet-ready zero and lower-carbon generation.

Table 28

Large Utility DSM Annual Effects by Programme Category, 1995, 2000 and 2006

	1995	*2000*	*2006*	*Change 2006/1995*	*Change 2006/2000*
Annual effects – Energy Efficiency					
Actual peak load reduction (MW)	13 212	12 873	15 959	21%	24%
Energy savings (thousand MWh)	55 328	52 827	62 951	14%	19%
Annual effects – Load Management					
Actual peak load reduction (MW)	16 347	10 027	11 281	–31%	13%
Potential peak load reduction (MW)	33 817	28 496	21 270	–37%	–25%
Energy Savings (thousand MWh)	2 093	875	865	–59%	–1%
Combined annual effects: Energy Efficiency & Load Management					
Actual peak load reduction (MW)	29 559	22 900	27 240	–8%	19%
Energy Savings (thousand MWh)	57 421	53 702	63 816	11%	19%
Net annual peak demand (MW)	**589 860**	**680 941**	**760 108**	**29%**	**12%**
Annual electricity sales (thousand MWh)	**3 163 963**	**3 592 357**	**3 816 845**	**21%**	**6%**
Actual peak load reduction relative to peak demand (MW)	5%	3%	4%	–28%	7%
Energy savings relative to net annual demand	2%	1%	2%	–8%	12%

Source: EIA, *Electric Power Annual 2006.*

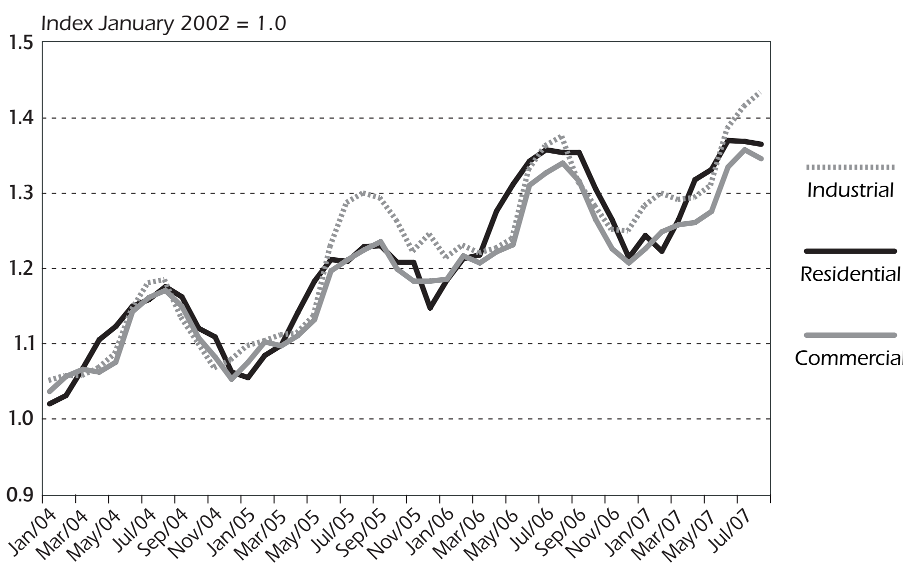
PRICES

Recent years have seen significant electricity price rises in retail and wholesale markets, caused by higher gas prices (the marginal fuel for power generation in many locations) and the end of below-market rate freezes in a number of retail markets (see Figure 28). The acceleration of gas prices from 2000 to 2006 has created significant pressure to reduce the role of gas in the generating mix, but with nuclear and coal power plants running close to their maximum potential in many areas, this scope is limited, and gas price rises are therefore being reflected in higher power prices, especially in summer.

The state regulatory commissions have authority to regulate retail rates charged to consumers for their private (and some co-operative and public) electric utilities. Under this authority, many states have acted to allow competition in the retail (business-to-consumer) market by allowing their consumers a choice of suppliers. In general, the states with the highest electricity rates, such as California and states in the north-east, have done the most to promote competition to apply downward pressure on prices.

Figure 28

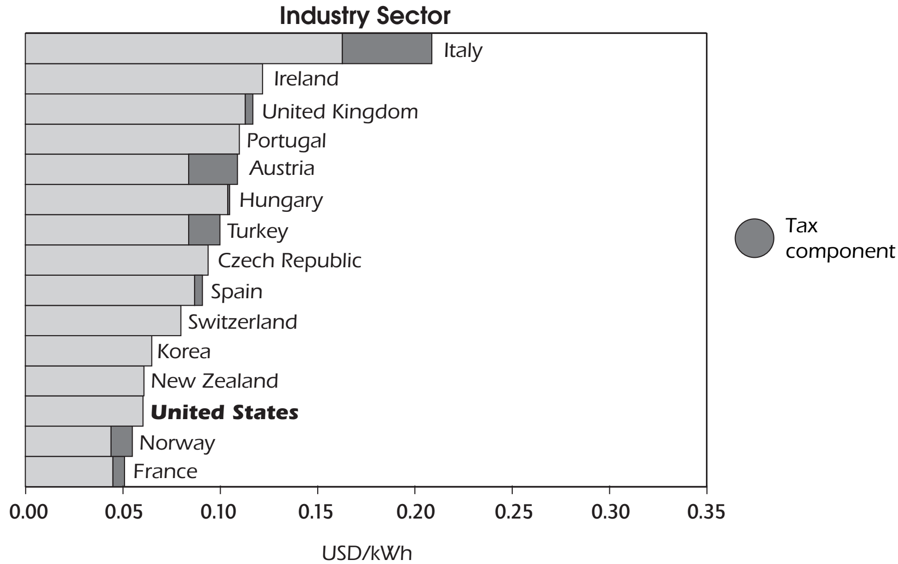
Monthly Flash Estimates of Electric Power Data, August 2007



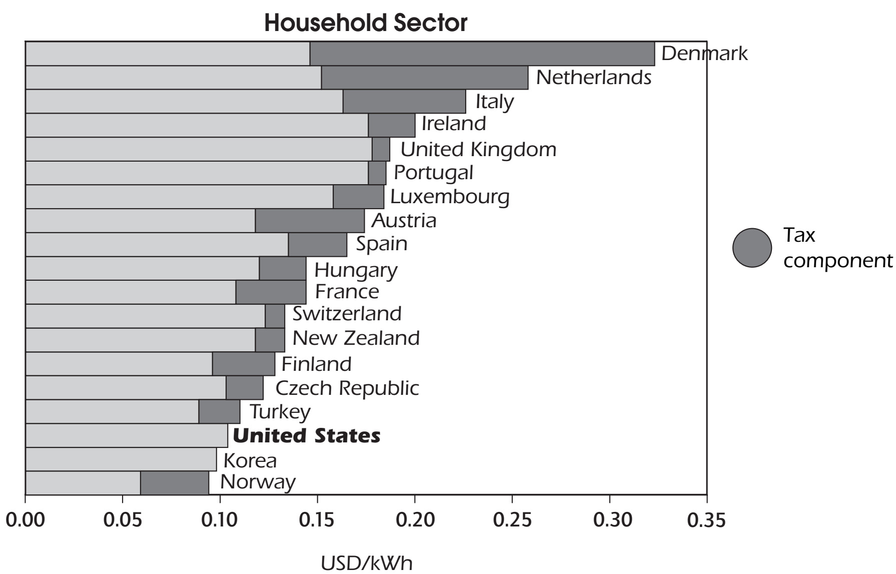
Source: IEA.

Figure 29

Electricity Prices in IEA Countries, 2006



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



Note: Tax information not available for Korea. Price excluding tax for the United States. Data not available for Australia, Belgium, Canada, Germany, Greece, Japan and Sweden.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2007.

CRITIQUE

The United States electricity industry has faced a number of challenges and reforms since the last review. These include the National Energy Policy of 2001 and EPAct 2005, with their strong focus on ensuring reliability and investment; the blackout of 2003, which raised serious questions about the adequacy of the existing regulatory framework at a time of liberalisation; and the aftermath of the California electricity crisis, in which attempts to make progress towards liberalisation slowed down, with many states rejecting the idea, and other states attempting to roll back the progress of market liberalisation and competition because of concerns about the risks associated with it. Other states, however, remain committed to the process.

Many of the challenges that the electricity industry faces could be solved by a careful balancing of costs, benefits and risks when making investment decisions in generation, transmission and about DSM. Prices that reflect real costs and that are the result of real competition are, therefore, a necessary instrument for balanced decision-making by investors and consumers. States that have embarked on liberalisation have, however, often done so within a framework of muted price signals – price caps in wholesale markets which have in turn resulted in the need for capacity markets to ensure that capacity investment goes ahead despite insufficient incentives, rate freezes and limited retail competition for end customers. While the reticence about further markets reform or liberalisation is understandable to some degree given the poor experience in some markets, it should be kept in mind that the fundamental problem with liberalisation in many states lay with implementation and not with the idea of liberalisation itself. There are well-functioning, fully liberalised markets in some states and regions, such as Texas and several north-eastern states, and in other IEA member countries that prove that liberalisation can work to the benefit of the consumers and the industry. A common feature of these markets is that, unlike the negative examples in the United States, they have placed strong emphasis on creating a framework of fully cost-reflective prices. This has resulted from successful and comprehensive implementation of liberalisation measures, and these efforts have substantially improved the framework in which balanced decisions in operation and investment of the electricity industry can be made. It is, therefore, important that both state and federal governments continue to press forward with reform, learning from the successful experiences in other markets, and avoid the demonstrated errors which have led to the problems in some markets.

The reforms undertaken since 2000 in the sector have substantially broadened the scope for effective competition in the electric power sector. They have achieved the objective of large-scale divestiture of generating facilities by traditional utilities that had been vertically integrated, as well as large-scale construction of generating facilities by non-utility generators. The result has been a commendable and rapid increase in the share of independent power producers.

On the wholesale and transmission levels, despite progress towards liberalisation, several significant obstacles to competition in electric power markets also remain. Most importantly, responsibilities for transmission grid expansion to alleviate congestion over the longer term are unclear, and hence transmission investment is judged to be inadequate by NERC. There have also been continuing complaints that transmission owners outside RTOs continue to discriminate against independent power companies, and that discriminatory behaviour is growing harder to monitor as the number and diversity of market participants increase. It appears that the existing levels of functional separation have not produced sufficient separation between the transmission system operation and power marketing activities of utilities outside RTOs to fully protect other transmission users against discriminatory behaviour. While several ISO/RTOs have been formed, interconnections and harmonisation across regions remain incomplete, and congestion of transmission lines has actually increased. This impedes competitive power flows, while real-time procedures for relieving congestion are often non-existent, and decisions in a congestion situation are made with little consideration of the value of alternative power flows. In addition, there is a problem of transmission customers outside ISO/RTO areas having to pay a separate access charge every time power crosses a transmission ownership boundary, raising overall transmission costs and thereby reducing the markets' geographic scope for competition. FERC should work towards the removal of these obstacles, and allocate clear responsibilities for investment into the network to ensure continued ability of the networks to support and increase competition. The best way forward would be an extension of existing RTOs to cover wider areas, and clear incentives for transmission investment within the RTO areas. The Pennsylvania-New Jersey-Maryland (PJM) market already shows that complex ownership structures can be reconciled with high levels of transparency, advanced incentive structures, and secure supply across a wide geographical area. It should be a model for the organisation of electricity supply in other regions of the United States.

Increasing generating capacity will contribute to security of supply and increased competition. Net capacity additions are, however, not keeping up with growth in demand (see for example the NERC assessment of October 2007). Two key policy areas which are affecting investment in generating capacity are climate change and local siting decisions. The federal government should eliminate the climate change-related uncertainty for investment as soon as possible by creating an integrated, nationwide, and comprehensive mechanism for putting a price on carbon emissions. Regarding local siting decisions, it can be expected that improving the environmental performance of generating stations will increase their acceptability to the public, since many concerns about new stations are directly related to this issue.

Currently envisaged levels of new renewable capacity should be absorbed into the generating mix without creating undue problems, notwithstanding their intermittency and their location in relatively remote areas such as the northern plains. Transmission developments will, however, be critical and backup capacity will be required. The government, including at the state level, and FERC should focus on the development of this capacity. To reduce the overall cost of increasing the contribution of renewables to the United States economy, renewable power policy should be harmonised at the federal level.

Significant transmission capacity investment will not only be required to link new renewable generation sources, but also to increase security of supply and reduce the cost of electricity transmission. DOE has commendably implemented the congestion zone assessment as set out in EPAct 2005, identifying the areas with the most urgent need for investment. Regional Transmission Organisations are developing which should facilitate this investment where it crosses state borders. FERC has an important back-stop authority over inter-state transmission lines, but this is being challenged by the states. To address the challenges to transmission siting, FERC should, therefore, continue to co-ordinate and collaborate with state regulatory agencies to ensure a streamlined approach to transmission siting. Proper incentives and the creation of more and larger ISOs/RTOs are also critical to ensuring transmission investment in the right locations. In this regard, it is highly laudable that FERC has acted promptly to implement the mandatory reliability standards which will provide such an incentive if and when they are passed by Congress.

The United States has historically been one of the world leaders in the area of DSM programmes and demand participation in markets, and utilities have special programmes to develop demand-side contributions. This and other energy efficiency short-, medium- and long-term policies can have significant positive impacts in reducing the need for the otherwise even more daunting investment requirement in new generation and transmission capacity. Nevertheless, since 1995 the contribution of DSM has declined in the United States, relative to demand growth, and in the area of peak demand reduction in absolute terms. While there has been improvement since 2000, partially rectifying the prior decline, it will be necessary to focus again on developing and maintaining the industry capacity to deliver demand-side savings, and to develop approaches that will enable demand-side contributions to be made in a market-based framework. The development by the electricity industry and its state regulators of a National Action Plan for Energy Efficiency is thus welcome. To further increase the contribution of the demand side, it will, therefore, be necessary to develop regulatory approaches that create the right incentives for utilities to engage on the demand side. Recent trends by state regulatory commissions to create these incentives are commendable. High market transparency and the ability to trade will be required to achieve this. Cost-reflective prices and competition automatically add many of the incentives and much of the information needed for targeted and balanced efforts.

The EIA's *Annual Energy Outlook 2007* forecasts about the future power generation fleet in the United States are predicting a strong investment in coal, particularly after 2015-2020. The relative contributions that individual fuels make to capacity additions, replacements, and to actual power generation do, however, depend critically on fuel price relativities. Gas prices and environmental costs are key factors for this. The most important assumption underpinning these forecasts is that existing climate change policies will be continued. This assumption may no longer be valid. Indeed it seems clear that climate uncertainty, or the possibility of a cost attaching to carbon dioxide emissions, is already slowing the construction of new coal plants, and it is difficult to envisage that this "wait-and-see" attitude will change if the policies remain unchanged. Adoption of different policies, however, could undoubtedly shift the generation mix in the United States away from traditional, low-cost coal in favour of lower-carbon alternatives, initially gas, but also renewables, and possibly nuclear, unless coal-based, lower CO_2-emission technologies become commercially available, in the time-frame for investment noted above.

RECOMMENDATIONS

The government of the United States should:

- *Provide leadership and continue to increase liberalisation and competition in electricity markets drawing on the experience of other IEA member countries by:*
  - *Pursuing effective separation of network management and power marketing to ensure non-discriminatory network access.*
  - *Ensuring independent regulation focusing on the creation of the right incentives and cost-reflective prices.*
  - *Increasing the capacity for interconnection between states to enable competitive wholesale markets to work.*
- *Continue work to stimulate a diverse and adequate generation mix, by:*
  - *Lowering uncertainty on national climate change policy.*
  - *Harmonising national renewable policies.*
  - *Removing uncertainties affecting the development of new capacity.*

- *Continue to assess transmission needs and develop policies to encourage transmission investment and consider the use of a forward-looking national transmission requirement statement to assist regional transmission planning.*
- *Increase demand-side participation through transparent and cost-reflective pricing to reduce generation investment needs, and remove regulatory barriers to utility energy efficiency programmes.*

NUCLEAR ENERGY

OVERVIEW

The United States has the world's largest fleet of nuclear power plants (NPPs), which provided 19.4% of the country's electricity in 2006. With the recent restart of one unit after a 22-year shut-down, there are now 104 operating units on 65 sites spread across 31 states, with a combined capacity of around 100 GWe. The 2006 output of 787.2 TWh was the second-highest on record, surpassed only in 2004 with 788.5 TWh.

The overall performance of NPPs has improved markedly over the years, contributing significantly to record generation levels. The average capacity factor, which rarely exceeded 60% in the 1980s, has risen from around 70% in the early 1990s to remain steady at around 90% in recent years. In addition, many NPPs have had capacity uprates, adding some 4 400 MWe to total capacity since 1992, with a further 2 500 MWe expected over the next five years. Nuclear generation has thus been rising, holding its share of total generation steady at approximately 19–20% between 1990 and 2006.

Since the last IEA review, the process for extending the licences of existing plants beyond the original 40 years has become well established. The Nuclear Regulatory Commission (NRC) has so far granted 20-year extensions to 48 units, with a further ten under review and 27 more applications expected in the next few years. Eventually, most, if not all, existing plants are expected to be granted extensions.

The Tennessee Valley Authority (TVA), a large federally-owned utility, announced in August 2007 that it will complete construction of unit 2 at its Watts Bar plant in eastern Tennessee, which was suspended in 1988 when it was about 60% complete. If the 1 180 MWe plant enters operation in 2013, as now planned, it will be the first new nuclear capacity in the United States since Watts Bar unit 1 began operation in 1996.

INDUSTRY STRUCTURE

Consolidation of NPP ownership has been a continuing trend, both as a result of mergers and acquisitions in the utility sector and through purchases of existing nuclear plants by large nuclear utilities from smaller operators. This has been a major factor in improving performance, as the larger utilities have been able to use their greater experience and resources to operate the plants more efficiently. The total number of utilities owning nuclear capacity fell from 87 in 1999 to 27 in 2005, with the largest 10 owning about 70% of the total capacity.

INVESTMENT AND LICENSING

INVESTMENT

Although the existing nuclear plants are now expected to produce more power for a longer period of time than seemed possible even a few years ago, to maintain the share of nuclear energy in power production it will be necessary to begin investing in new plants within the next few years. EPAct 2005 contains several measures intended to encourage nuclear investment. As noted in Chapter 2, production tax credits will be available for the first 6 000 MWe of new nuclear capacity (to be shared pro-rata between plants which start construction before 2013), federal risk insurance (known as stand-by support) will provide up to USD 500 million of cover for regulatory and litigation delays during construction of the first six NPPs, and loan guarantees should also be available for up to 80% of the eligible project cost of some new plants. EPAct also extended the Price-Anderson Act, which limits nuclear liabilities, to 2025.

Of these measures, loan guarantees are potentially the most significant in encouraging new orders, particularly in regions with deregulated electricity markets. The DOE issued rules and procedures to implement the legislation on loan guarantees with respect to new NPPs in October 2007. The actual provision of loan guarantees will, however, require further legislative approval, and Congress is likely to place limits on the total amount of loans which can be covered.

Some public utility commissions have also indicated their support for investment in new nuclear plants. In some cases, they have agreed in principle to include such investment in the rate base in stages as the project progresses, rather than including it all on completion of the plant. This will allow utilities to recover some of their investment before the new plant enters operation, thus considerably reducing financing costs and risk.

LICENSING

The NRC is an independent federal agency responsible for the licensing and regulation of all civilian nuclear activities, including nuclear power stations and fuel cycle facilities. Since the last IEA review, the NRC has implemented significant reforms in the licensing process for new nuclear power plants. In addition, the DOE has been working with several electric utilities and the nuclear industry since 2002 on *Nuclear Power 2010*, a cost-sharing programme to address siting, reactor design and licensing issues. This includes financial support for some early licence applications under the revised NRC procedure.

The main licensing step is now an application for a Combined Construction Permit/Operating Licence (COL). This is intended to reduce licensing risk for investors by avoiding the need to obtain a separate operating licence once construction is complete, with the risk that operation will be delayed or even that an operating licence will be denied. In addition, the COL process can be simplified and potentially shortened by using one or both of two preliminary licensing steps: early site permitting (ESP) and reactor design certification. The former allows potential sites to be licensed as generically suitable for NPP construction, while the latter (applied for by the NPP designer/vendor) is a non-site-specific generic design approval. The first ESPs were granted in 2007, while at the time of writing four NPP designs had been certified with a further six under consideration by the NRC.

In response to the changed licensing process and the incentives for new nuclear plants contained in EPAct 2005, utilities and other investors have announced preliminary plans for more than 30 new nuclear units, mostly in the south-eastern states and Texas. The NRC is confident that it can process all the expected applications in a timely manner. However, the COL process remains untested, and estimates are that it will take at least 3 to 4 years from application to issue of a licence. This means the first COLs will not be granted before 2010 or 2011 at the earliest. In the best-case scenario, if the licensing process does proceed according to this schedule, and assuming there are no significant construction delays, the first one or two new NPPs could enter operation before the end of 2015. It is likely to take at least a few years longer for a larger number of new plants to be completed, given the limited construction capability.

In September 2007, NRG Energy became the first company to apply for a COL, and more than 10 further applications are expected by the end of 2008. Table 29 gives some detail on applications known to be under consideration at the time of writing. These include several different reactor designs, namely the ABWR and ESBWR of General Electric (GE) and Hitachi, Westinghouse's AP1000, Areva's EPR, and the APWR of Mitsubishi Heavy Industries.

Table 29

Status of Potential New Nuclear Power Plant Projects

Company	*Site(s)*	*Design, number of units*	*Early site permit (ESP)*	*Predicted COL application submission*
Alternate Energy Holdings	Bruneau, ID	EPR[1]	-	FY[2] 2009
Amarillo Power	Vicinity of Amarillo, TX	EPR	-	FY 2009
Ameren UE	Callaway, MO	EPR	-	FY 2008
Constellation (UniStar)	Calvert Cliffs, MD plus two other sites	EPR (3)	Will go to COL but submit siting information early	First submission – FY 2008
Detroit Edison	Fermi, MI	Not yet determined	Not yet determined	FY 2008
Dominion	North Anna, VA	ESBWR (1)	Under review, approval expected 2007	FY 2008
Duke	William States Lee, Cherokee County, SC	AP1000 (2)	-	FY 2008
Duke	Davie County, NC	Not yet determined	Under consideration	Not yet determined
Duke	Oconee County, SC	Not yet determined	Under consideration	Not yet determined
Entergy	River Bend, LA	ESBWR (1)	-	FY 2008
Entergy (NuStart)	Grand Gulf, MS	ESBWR (1)	Approved April 2007	FY 2008
Exelon	Clinton, IL	Not yet determined	Approved March 2007	Not yet determined
Exelon	Matagorda and Victoria County, TX	Not yet determined	-	FY 2009
Florida Power & Light	Turkey Point, FL	Not yet determined (2)	Not yet determined	FY 2009
NRG Energy / STPNOC	Bay City, TX	ABWR (2)	-	Under review
PPL Corp.	Susquehanna, PA	Not yet determined	Not yet determined	Not yet determined
Progress Energy	Harris, NC; Levy County, FL	AP1000 (2); AP1000 (2)	-	Harris - FY 2008; Levy County- FY 2008
South Carolina Electric & Gas	Summer, SC	AP1000 (2)	-	FY 2008
Southern Company	Vogtle, GA	AP1000 (2)	Under review, approval expected early 2009	FY 2008
Texas Utilities	Comanche Peak, TX	APWR (2)	-	FY 2008
TVA (NuStart)	Bellefonte, AL	AP1000 (2)	-	FY 2008

1. European pressurised reactor.
2. FY indicates the US fiscal year, which runs from 1 October of the previous year to 30 September.
Source: Nuclear Energy Institute.

RESEARCH AND DEVELOPMENT

The network of national laboratories in the United States includes some of the world's leading nuclear R&D facilities and expertise, and the government continues to support a range of nuclear power-related R&D activities. Some of these, such as the Advanced Fuel Cycle Initiative, are expected to become part of the Global Nuclear Energy Partnership (GNEP). In addition, the United States is a major contributor to the Generation IV programme to develop advanced nuclear plants and fuel cycles in co-operation with other countries. The Next Generation Nuclear Plant project aims to demonstrate one such advanced design by funding construction of a prototype.

Box 12

The Global Nuclear Energy Partnership

The Global Nuclear Energy Partnership (GNEP) was announced by President Bush in 2004 and launched in 2006 after funding had become available. It aims to develop policies and technologies to allow the deployment of nuclear power more widely around the world while avoiding proliferation of sensitive technologies and materials. A key element is the development and demonstration of advanced fuel cycles which include the recycling of used nuclear fuel while avoiding the separation of plutonium. Another important aim is to reduce the amount of high-level radioactive waste for repository disposal.

A framework for international co-operation to achieve these aims is being developed. In September 2007 the United States and 15 other countries signed a GNEP statement of principles, and several other countries are also considering joining GNEP. The DOE is also working with the international nuclear industry to develop plans for demonstration fuel cycle facilities. However, many details of GNEP remain under discussion both domestically and with other governments. In addition, sustained funding for GNEP-related programmes will be required if the aims of the programme are to be achieved, which will require approval by Congress.

NUCLEAR FUEL AND RADIOACTIVE WASTE MANAGEMENT

FUEL PRODUCTION

The United States has a large and diverse nuclear fuel industry which encompasses all stages of the front end of the fuel cycle. It is also a major participant in international markets for uranium and nuclear fuel services, being a net importer in most sectors.

The country benefits from significant uranium resources, concentrated in Wyoming and New Mexico. Production of uranium concentrate was around 1 600 tonnes in 2006, more than double the low point reached in 2002, and is set to increase further in the coming years. However, with annual requirements running at around 19 000 tonnes, most uranium will continue to be imported. The major supplier countries are Australia, Canada and Russia.

Much of the material supplied from Russia is derived from former military material under an agreement which expires in 2013. Uranium supplies from Russia are thus expected to fall sharply after that date. The Russian material is delivered to the United States Enrichment Corporation (USEC) in the form of low-enriched uranium, and thus currently accounts for around 40% of United States annual enrichment requirements. It is displacing a large proportion of USEC enrichment capacity at the Paducah gaseous diffusion plant in Kentucky. Other imports of enrichment services from Russia are not permitted, but the two countries are negotiating over the access of Russian enrichment suppliers to the market, after the agreement on former military material expires in 2013.

Meanwhile, USEC is developing a new enrichment facility using centrifuge technology (which is more efficient and less costly than gaseous diffusion) at Piketon in Ohio, and plans to close Paducah once the new facility is in operation. A subsidiary of the British-Dutch-German enrichment company Urenco is also constructing a centrifuge enrichment facility in New Mexico. The combined capacity of the two new centrifuge plants in 2013 is expected to be around 50% of annual United States requirements. In addition, General Electric (GE) is actively developing laser enrichment technology which it hopes to begin deploying commercially at its Wilmington, North Carolina site by 2012, and Areva of France is seeking a US site for a further centrifuge plant which it hopes to have in operation by 2014.

One of the largest uranium hexafluoride (UF_6) conversion facilities worldwide is operated by ConverDyn at Metropolis, Illinois, and is capable of covering well over half of domestic demand. Most fuel for United States reactors is fabricated at one of four domestic facilities operated by the three main NPP vendors. Areva NP (jointly owned by Areva and Siemens) operates plants at Lynchburg, Virginia, and Richland, Washington; a GE joint venture with Hitachi and Toshiba, Global Nuclear Fuel, operates a plant at Wilmington, North Carolina; and Westinghouse (majority owned by Toshiba) produces fuel at Columbia, South Carolina. There is thus a competitive market for fuel fabrication services for most reactor designs.

NUCLEAR WASTE

The NPPs in operation in the United States produce about 2 000 tonnes of used fuel annually, which is currently stored on site in water-filled pools or in dry storage flasks. The Nuclear Waste Policy Act of 1982 gives the federal government responsibility for the disposal of used fuel and high-level waste (HLW), funded by a fee of one-tenth of a cent per kWh of nuclear electricity generated.

In 2002 the selection of the Yucca Mountain site in Nevada for construction of an underground repository was confirmed by Congress and the President. The DOE is preparing to apply for a construction licence for the repository in 2008, with the aim of beginning construction in 2011. However, opposition to the project remains strong and the DOE has stated that the repository is unlikely to open before 2020. This is a significant delay compared to the plans at the time of the last IEA review. The timetable for the DOE taking delivery of used fuel from sites around the country therefore remains to be decided, with discussion continuing as to whether a system of interim storage should be implemented, at Yucca Mountain or elsewhere, to enable used fuel to be moved from some reactor sites before the repository enters operation. For the longer term, in the absence of large-scale recycling as envisaged in the GNEP programme (see Box 12), the currently planned capacity of Yucca Mountain will be insufficient for all the additional used fuel from lifetime extensions of existing power stations, and from newly built ones. In such a case, either an extension of capacity at Yucca or a second repository will eventually be required.

CRITIQUE

The United States government and Congress have recognised the importance for the long-term energy security of the United States of maintaining a significant nuclear component in the nation's energy supply. They have taken a number of steps to ensure the continued successful operation of the existing fleet of nuclear plants, to encourage investment in a new generation of plants in order to expand nuclear capacity in the 2015 to 2020 time-frame, and also to support research, development and demonstration of advanced nuclear plants and fuel cycles for the longer term. In particular, substantial incentives for investment in new NPPs were included in EPAct 2005. All these moves are highly commendable.

These appear to have had the desired effect, with plans being prepared for over 30 new nuclear units and 13 licence applications expected by the end of 2008. However, it is only after a licence is granted that a final decision will be made by a utility and its investors on going ahead with construction. Although some appear confident of starting construction immediately upon a licence being granted, others are proceeding more cautiously. They are investing a limited amount in planning and licensing work in order to make the nuclear option available to them, but have not yet committed to go ahead with construction.

Given the direct costs which the EPAct incentives will entail for the federal budget, they are necessarily limited to the first few new reactor orders. To ensure that a nuclear renaissance is not limited to just a handful of plants, the government should, therefore, consider how the longer-term policy framework can encourage continuing investment in nuclear capacity, preferably by introducing support measures based on market principles, and which do not burden the federal budget. The viability of some of the projects now being considered, particularly those which are not among the first few and which will thus not benefit from the EPAct incentives, may depend on such longer-term measures.

The economics of new NPPs are likely to be affected by measures to limit carbon dioxide emissions which are widely expected to be introduced at state, regional or federal level in the next few years. Given nuclear power's very low CO_2 emissions and security of supply benefits, future support could, therefore, be provided by including it in the scope of a potential CO_2 trading scheme or a clean energy portfolio standard.

In particular, the longer-term expansion of nuclear power will require an established system for used fuel management. Compared to the plans presented at the last IEA in-depth review in 2001, the current plans are a significant delay, and it is uncertain if even this schedule is achievable given continued and strong objections made by the state of Nevada. The United States government should make every effort to ensure that a final waste disposal site for high-level radioactive waste is in operation by 2020, and should consider additional options beyond those currently envisaged to make certain that an effective system for used fuel management does become available.

RECOMMENDATIONS

The government of the United States should:

- *Maintain the pace in implementing the measures in the Energy Policy Act of 2005 to encourage investment in new nuclear power plants, with the aim of meeting the stated milestones for licensing and construction of new plants.*
- *Consider if further measures may be necessary to encourage continued nuclear investments beyond the initial units supported by the EPAct measures, within the broader framework of energy and environmental policy.*
- *Continue to pursue the licensing and construction of a final repository for used fuel and high-level radioactive waste, in accordance with decisions already taken by the government and Congress, and consider interim arrangements for the storage of used nuclear fuel.*

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 Agency. The *Shared Goals* are set out in Annex D.

REVIEW TEAM

The in-depth review team visited Washington, D.C., Golden, CO and Denver, CO from 18 to 22 June 2007. During the visit, the team met with government administrators, energy suppliers and various other organisations and interest groups, and addressed the major issues relating to the country's energy situation. Particular thanks go to the US House and Senate Committees who managed to make time for a meeting with the team during the negotiations for the energy bill.

The team is grateful for the co-operation and assistance of the many people it met during its visit. Thanks to their willingness to share information and their open hospitality, the visit was both highly productive and enjoyable. The team wishes to make special mention of the understanding and courteous professionalism displayed by our colleagues at the Department of Energy in preparing and accompanying the visit. The members of the team were:

Claire Durkin
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Sophie Galey-Leruste
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Ministry of Economy and Labour, Germany

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TUBITAK-Marmara Research Centre, Turkey

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Ian Cronshaw
International Energy Agency

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Andreas Biermann
International Energy Agency (Desk Officer)

Andreas Biermann managed the review and drafted the report with the exception of the nuclear chapter, which was drafted by Martin Taylor from the NEA, the energy R&D chapter which was drafted by Jeppe Bjerg from the IEA Energy Technology Office, and the gas and electricity chapters, which were drafted by Ian Cronshaw from the IEA's Energy Diversification Division. Monica Petit and Bertrand Sadin prepared the figures. Marilyn Ferris provided editorial assistance.

ORGANISATIONS VISITED:

- Agricultural Research Service
- Alliance to Save Energy
- American Council for an Energy-Efficient Economy
- American Gas Association
- American Public Power Association
- American Institute of Architects
- American Petroleum Institute
- American Solar Energy Society
- Association for the Study of Peak Oil
- Buildings Owners and Managers Association
- Coalition for Smarter Growth
- Colorado Governor's Energy Office
- Colorado Department of Natural Resources
- Colorado Department of Local Affairs
- Colorado Department of Public Health and Environment
- Colorado Public Utilities Commission
- Ceres
- Department of Energy
  - Office of Policy and International Affairs
  - Office of Fossil Energy
  - Office of Energy Efficiency and Renewable Energy
  - Office of Electricity Delivery and Energy Reliability
  - Office of Nuclear Energy
  - Office of Environmental Management
  - Office of Science, and Environment, Safety and Health

- Department of Transportation
- Department of State
- Dow Chemicals
- Edison Electric Institute
- Energy Information Administration
- Environmental Protection Agency
- Federal Aviation Authority
- Federal Energy Regulatory Commission
- FreedomCAR Initiative
- House Science Committee, Congress
- Lawrence Berkeley National Laboratory
- Mining and Minerals Service
- National Association of Manufacturers
- National Association of Regulatory Utility Commissioners
- National Association of State Energy Officials
- National Highway Transportation and Safety Authority
- National Renewable Energy Laboratory, including:
    - National Bioenergy Center
    - National Center for Photovoltaics
- North American Insulation Manufacturers Association
- Nuclear Energy Institute
- Nuclear Regulatory Commission
- Senate Energy Committee
- Shell Colorado
- Solar Energy Industry Association
- University of Colorado
- Western Governors Association
- Xcel Corporation

EPACT 2005 PROVISIONS FOR ENERGY EFFICIENCY

The Energy Policy Act of 2005 (EPAct 2005) substantially expanded provisions for energy efficiency across a range of sectors. All efficiency-related sections are outlined in detail below, but it has to be kept in mind that not all of them have achieved final approval yet. On the other hand, some provisions of the act have already been extended in separate tax legislation.

INDUSTRY ENERGY EFFICIENCY

Section 106 authorises DOE to enter into voluntary agreements with firms in energy-intensive industries to reduce the energy intensity (defined as energy per unit of physical output) of their production activities, with the goal of not less than 2.5% annual reduction in energy intensity for each year from 2007 through 2016.

Section 1703 directs DOE to establish a loan guarantee programme for advanced energy technologies, including industrial energy efficiency projects and production facilities for fuel-efficient vehicles.

IMPROVEMENTS IN EFFICIENCY STANDARDS AND LABELS

The act requires EPA to update or revise the adjustment factors in tests that are used to estimate vehicle fuel economy for labels on automobiles. The revisions are to take into consideration the higher speed limits, faster acceleration rates, variations in temperature, use of air-conditioning, shorter city test cycle lengths, reference fuels, and the use of other fuel-depleting features that apply to today's cars, as compared with cars that were typical when the adjustment factors were last set forth in 1995. Such revisions seem likely to reduce the estimated city and highway fuel economy for most automobiles. With revised labels showing lower fuel economy for some vehicles, consumers may be motivated to buy more efficient models.

The act also requires NHTSA to study the feasibility and effects of reducing the amount of fuel consumed by automobiles by a significant amount by model year 2014. The effects examined are to include impacts on gasoline supplies, the automobile industry, vehicle safety and air quality.

Section 135 establishes new or revised energy conservation standards for a number of residential and commercial products (see the table).

EPAct 2005 Efficiency Standard Additions and Revisions

Residential	*Commercial*
Ceiling fans	Commercial refrigerators and freezers
Compact fluorescent lighting fixtures (medium base)	Determination of standards for battery chargers and external power supplies
Dehumidifiers	Fan-type unit heaters
Torchiere lighting fixtures	Coin-operated clothes washers
	Low-voltage dry-type distribution transformers
	Illuminated exit signs
	Traffic signal indicator light module
	Pedestrian signals
	Automatic ice-makers
	Commercial ice-cream freezers
	Mercury vapour light ballasts
	Tubular fluorescent lamp ballasts (34, 60, 95 watts)
	Pre-rinse spray valves
	Air flow through duct work
	Refrigerated beverage vending machines
	Commercial package air-conditioning and heating equipment

TRANSPORTATION RESEARCH AND DEVELOPMENT

Section 706 requires the Secretary of Energy to establish a grant programme for applied research on flexible fuel hybrid vehicles. Section 711 requires the Secretary of Energy to accelerate research on technologies for hybrid vehicles, though no new funds have been authorised. Section 712 requires an EPA programme to encourage the domestic production and sales of efficient hybrid and advanced diesel vehicles. The programme must include grants to domestic vehicle manufacturers to encourage production and provide consumer purchase incentives. Such sums as necessary are authorised between FY2006 and FY2015.

Sections 721-723 establish a competitive grant programme, administered by *Clean Cities*, to fund up to 30 geographically dispersed advanced vehicle demonstration projects. Grant recipients will be limited to state and local government agencies and metropolitan transportation authorities. Applications must include a registered participant in the *Clean Cities* initiative. Participants can be public or private entities. Projects are limited to USD 15 million with 50% cost share. Grant funds can pay for:

- Alternative fuel vehicles (including neighbourhood electric vehicles).
- Fuel cell vehicles.
- Ultra-low sulphur diesel vehicles.
- Acquisition and installation of fuelling infrastructure.
- Operation and maintenance of vehicles, infrastructure and equipment.

Section 756 requires EPA, in consultation with DOT, to develop a deployment programme that supports the deployment of engine idle reduction (IR) technologies and promotes improved air quality and reduced emissions for heavy-duty vehicles. Heavy-duty vehicles include vehicles that have a gross vehicle weight rating greater than 8 500 pounds and are powered by a diesel engine (*e.g.* trucks and locomotives). The act also directs EPA to conduct analysis on emissions reduced and fuel saved by IR measures.

The act authorises USD 50 million per year in FY2006-2008 for accelerated R&D to improve batteries and other rechargeable energy storage systems, power electronics, hybrid systems integration, and other technologies for use in hybrid vehicles. The act also authorises USD 75 million per year in FY2006-2008 for R&D on advanced fuels and combustion systems, with a goal to develop new low-emissions, high-efficiency diesel engine technologies, including homogeneous charge compression ignition.

TAX CREDITS

Section 1341 allows a tax credit of as much as USD 3 400 for consumers who purchase the most fuel-efficient vehicles. This includes fuel cell vehicles, hybrid vehicles, alternative fuel vehicles and advanced lean burn technology motor vehicles (a clean-burning diesel engine that operates with more air than is necessary for the complete combustion of the fuel) and qualified hybrid motor vehicles. For each manufacturer, the new tax credit stops after it sells a total of 60 000 eligible vehicles, with the count starting at the beginning of 2006. The credit expires at the end of December 2009, 2010 or 2014, depending on the type of vehicle.

The act provides tax credits for energy efficiency improvements in the building envelope of existing homes and for purchase of high-efficiency heating, cooling, and water heating equipment. Efficiency improvements and/or equipment must be placed in service from 1 January 2006 through 31 December 2007 and must serve a dwelling in the United States owned and used by the taxpayer as a primary residence. The maximum credit for all improvements combined is USD 500 during the two-year period. Buyers of qualified energy-efficient properties are eligible for tax credits up to the total expenditures on such properties. The credit can also be applied to labour costs for assembly and original installation.

The act provides a 10% credit for qualified energy efficiency improvements. To qualify, a component must meet or exceed the criteria established by the 2000 International Energy Conservation Code (including supplements) and must be installed in the taxpayer's main home in the United States. The following items are eligible:

- Insulation systems that reduce heat loss/gain.
- Exterior windows (including skylights).
- Exterior doors.
- Metal roofs (meeting applicable *Energy Star* requirements).

In addition, there is a credit for costs relating to residential energy property expenses. To qualify as residential energy property, the property must meet certification requirements prescribed by the Secretary of the Treasury and must be installed in the taxpayer's main home in the United States. Eligible property and maximum credit amounts are as follows:

- USD 50 for each advanced main air-circulating fan.
- USD 150 for each qualified natural gas, propane, or oil furnace or hot water boiler.
- USD 300 for each item of qualified energy-efficient property (electric heat pump water heaters, electric heat pumps, geothermal heat pumps, central air-conditioners, and natural gas, propane, or oil water heaters).

The act establishes tax credits for manufacturers of high-efficiency residential clothes washers, refrigerators and dishwashers produced in calendar years 2006 and 2007. Manufacturers only receive these credits for the increase in production of qualifying appliances over a three-year rolling baseline, and only appliances produced in the United States are eligible. Credits available to manufacturers are as follows:

- Dishwashers: A credit based on an energy savings calculation is available for models that meet the 2007 *Energy Star* criteria.
- Clothes washers: USD 100 for models that meet the 2007 *Energy Star* criteria.
- Refrigerators: USD 75 for models that save at least 15% relative to 2001 federal standards (available only in 2006); USD 125 for models that save at least 20% relative to 2001 federal standards; USD 175 for models that save 25% or more relative to 2001 federal standards. Each manufacturer is limited to a total of USD 75 million for all credits under this provision. Of that cap, no more than USD 20 million can be claimed for the lowest tier of qualifying refrigerators.

The act establishes a tax deduction for energy-efficient commercial buildings applicable to qualifying systems and buildings placed in service from 1 January 2006 through 31 December 2007. This tax deduction was subsequently extended through 2008 by Section 204 of the Tax Relief and Health Care Act of 2006 (H.R. 6111).

A tax deduction of USD 1.80 per square foot is available to owners of new or existing buildings who install interior lighting; building envelope, or heating, cooling, ventilation, or hot water systems that reduce the building's total energy and power cost by 50% or more in comparison to a building meeting minimum requirements set by American Society of Heating, Refrigerating and Air-Conditioning Engineers Standard 90.1-2001. Energy savings must be calculated using qualified computer software approved by the Internal Revenue Service. Deductions of USD 0.60 per square foot are available to owners of buildings in which individual lighting, building envelope, or heating and cooling systems meet target levels that would reasonably contribute to an overall building saving of 50% if additional systems were installed.

The deductions are available primarily to building owners, although tenants may be eligible if they make construction expenditures. In the case of energy-efficient systems installed on or in government property, tax deductions will be given to the person primarily responsible for the system's design. Deductions are taken in the year when construction is completed.

The act establishes tax credits of up to USD 2 000 for builders of all new energy-efficient homes, including manufactured homes constructed in accordance with the Federal Manufactured Homes Construction and Safety Standards. Initially scheduled to expire at the end of 2007, the tax credit was extended through 2008 by Section 205 of the Tax Relief and Health Care Act of 2006 (H.R. 6111). The home qualifies for the credit if:

- it is located in the United States;
- its construction is substantially completed after 8 August 2005;
- it meets the energy saving requirements outlined in the statute; and
- it is acquired from the eligible contractor after 31 December 2005, and before 1 January 2009, for use as a residence.

Site-built homes qualify for a USD 2 000 credit if they are certified to reduce energy consumption by 50% relative to the International Energy Conservation Code standard and meet minimum efficiency standards established by the DOE. Improvements in building envelope components must account for at least one-fifth of the reduction in energy consumption. The statute does not identify the specific efficiency measures eligible for the tax credit.

Manufactured homes qualify for a USD 2 000 credit if they conform to Federal Manufactured Home Construction and Safety Standards and meet the energy savings requirements of site-built homes described above; they qualify for a USD 1 000 credit if they conform to the same federal standards and reduce energy consumption by 30% relative to the International Energy Conservation Code standard. In the latter case, improvements in building envelope components must account for at least one-third of the reduction in energy consumption. Alternatively, manufactured homes qualify if they meet *Energy Star*-labelled homes requirements.

SMART METERING

Section 1252 amends Public Utility Regulatory Policies Act of 1978 to require that each state, for its jurisdictional utilities (and local governing boards for electric utilities not under state jurisdiction) must consider whether to adopt a standard where each electric utility shall offer each of its customer classes, and provide individual customers upon customer request, a time-based rate schedule under which the rate charged by the electric utility varies during different time periods and reflects the variance, if any, in the utility's costs of generating and purchasing electricity at the wholesale level. The time-based rate schedule shall enable the electricity consumer to manage energy use and cost through advanced metering and communications technology. The mandatory consideration must follow a prescribed public procedure, with the consideration allowed to result in a decision not to adopt.

GOALS AND STANDARDS FOR ENERGY EFFICIENCY IN FEDERAL BUILDINGS AND PROCUREMENT

The act re-establishes and extends several earlier goals and standards to reduce energy use in existing and new federal buildings. Section 203 requires that to the extent it is economically feasible and technically practicable, the total amount of renewable electric energy consumed by the federal government during any fiscal year shall not be less than the following:

- 3% in FY 2007-2009.
- 5% in FY 2010-2012.
- 7.5% in FY 2013 thereafter.

The amount of renewable energy credits is doubled for electricity produced and used on site at a federal facility, produced on federal lands and used at a federal facility, or if it is produced on Indian land as defined in title XXVI of the Energy Policy Act of 1992 and used at a federal facility.

PROCUREMENT OF ENERGY-EFFICIENT PRODUCTS

Federal agencies are required to purchase products certified as energy-efficient under the *Energy Star* programme or energy-efficient products designated by the *Federal Energy Management Program* (FEMP), provided that the products are found to be cost-effective and reasonably available.

Section 782 requires federal fleets to begin leasing or purchasing fuel cell vehicles and hydrogen energy systems no later than 1 January 2010. DOE shall provide incremental cost funding and may provide exemptions if the vehicles are not available or appropriate for fleet needs.

Section 783 directs any federal agency that uses electrical power from stationary, portable or microportable devices shall lease or purchase a stationary, portable or micro fuel cell to meet any applicable federal energy savings goal. Those devices purchased by federal agencies are encouraged in order to:

- stimulate acceptance by the market of stationary, portable and micro fuel cells; and to
- support development of technologies relating to stationary, portable and micro fuel cells.

CONGRESSIONAL BUILDINGS

The Architect of the Capitol is required to plan and implement an energy and water conservation strategy for Congressional buildings consistent with that required of other federal buildings.

ENERGY USE IN FEDERAL BUILDINGS

Under the act's guidelines, federal agencies can now retain all savings from energy, water and waste water improvements, but must use these savings for energy, water and waste water improvements. Previously, all federal agencies, except for the Department of Defence, could only retain half of all savings. Agencies are allowed to retain appropriations for energy expenses that are saved by the energy efficiency measures. The baseline for federal energy savings is updated from FY1985 to FY2003, and a new 20% reduction goal is set for FY2015. These standards increase by 2% each year in order to achieve a 20% increase in efficiency by 2015. By the end of 2014, DOE is to assess progress and set a new goal for FY2025. With these new standards come new benefits. Government facility managers now have the opportunity to reuse the budget dollars they save from increased energy efficiency, instead of losing them.

Federal buildings are required to be metered or sub-metered by 1 October 2012 to help reduce energy costs and promote energy savings. Section 103 also directs all federal buildings to use advanced metering devices that track energy use at least hourly and provide data at least daily by 1 October 2012. Further, the Secretary of Energy is required to prepare guidelines for agency energy managers to facilitate implementation of metering. Each agency is then required to submit an implementation plan to DOE.

The authority for federal facility managers to enter into energy savings performance contracts is extended from 2006 to 2016.

DOE is directed to set revised energy efficiency standards for new federal buildings at a level 30% stricter than industry or international standards.

STATE-RELATED INCENTIVES

Section 123 sets new requirements for state energy conservation goal and plans, including a 25% energy efficiency improvement in 2012 over 1990. In addition, funding for the DOE state energy grant programme was authorised at USD 100 million for FY2006, USD 100 million for 2007, and USD 125 million for 2008.

Section 125 creates a grant programme for energy-efficient renovation and construction of local government buildings. These grants may be used for construction of new buildings that use 30% less energy than comparable public buildings that meet existing conservation standards and for renovations that reduce energy consumption by 30% over the pre-renovation baseline. DOE funding of USD 30 million per year is authorised for FY2006 through FY2010.

Section 127 creates a co-operative programme that links DOE with the states. It is focused on research, development, demonstration and deployment of technologies in which there is a common federal and state energy efficiency, renewable energy and fossil energy interest. Funding has been authorised for FY2006 through FY2010.

Section 128 creates a *Building Energy Efficiency Codes Incentives* grant programme for states that have achieved at least a 90% rate of compliance with the most recent model building energy codes. Funds may be used to implement building energy codes and practices that exceed efficiency requirements of the most recent model building codes. Funding at USD 25 million per year is authorised for FY2006 through FY2010 and such sums as necessary for FY2011 and each fiscal year thereafter.

INFORMATION PROGRAMMES

The act directs the DOE to establish a programme to educate home-owners and small businesses on the benefits of properly conducted maintenance on heating, ventilation, and air-conditioning equipment.

The act also directs DOE to provide grants to non-profit institutions, state and local governments, or universities to establish a geographically dispersed network of *Advanced Energy Technology Transfer Centers*. The centres would encourage the demonstration and commercial application of advanced energy methods and technology through education and outreach to building and industry professionals.

The act states that DOE is required to convene a conference with representatives from industry, education, professional societies, trade associations, and government agencies to design and establish an ongoing *National Public Education Program* focused on energy efficiency and other topics. This conference was implemented by the DOE's Office of Science in January 2007.

DOE is required to conduct an *Energy Efficiency Public Information Initiative*, an advertising and public outreach programme about the need to reduce energy use, the consumer's benefits of reduced use, the relationship to jobs and economic growth, and cost-effective measures to reduce energy use by consumers. Funding at USD 90 million per year is authorised for FY2006 to FY2010 but has not received Congressional appropriations.

OTHER PROVISIONS

Section 110 amends the Uniform Time Act of 1966 to increase the portion of the year that would be subject to *Daylight Saving Time* (DST). Beginning in 2007, the legislation calls for extending the duration of DST in the spring from the first Sunday of April to the second week of March, and in the fall from the last week of October to the first week of November. The legislation extending DST is designed to reduce energy consumption in United States homes and businesses. The legislation also calls for an evaluation of the impact of extended DST on energy consumption in the United States and submission of a report to Congress nine months after the effective date of the extension.

Section 108 requires that federally funded projects involving cement or concrete increase the amount of recovered mineral components (*e.g.* fly ash or blast furnace slag) used in cement. Such use of mineral components is a standard industry practice, and increasing the amount could reduce both the quantity of energy used for cement clinker production and the level of process-related CO_2 emissions.

ENERGY BALANCES AND KEY STATISTICAL DATA

Unit: Mtoe

SUPPLY		1973	1990	2004	2005	2010	2020	2030
TOTAL PRODUCTION		**1455**	**1650**	**1647**	**1631**	**1882**	**2035**	**2202**
Coal[1]		333	539	553	564	613	667	841
Oil		534	433	339	323	403	423	405
Gas		503	419	436	424	504	542	535
Comb. Renewables & Waste[2]		37	62	72	74	96	107	120
Nuclear		23	159	212	211	218	245	247
Hydro		23	23	23	23	26	27	27
Geothermal		2	14	9	9	16	18	21
Solar/Wind/Other		–	0	3	3	6	7	7
TOTAL NET IMPORTS[3]		**289**	**315**	**687**	**709**	**728**	**871**	**1036**
Coal[1]	Exports	31	67	30	32	28	20	17
	Imports	1	2	20	20	22	43	56
	Net Imports	–30	–65	–10	–12	–6	22	38
Oil	Exports	11	39	52	57	68	72	73
	Imports	316	413	693	718	703	800	949
	Bunkers	9	29	24	26	19	20	20
	Net Imports	296	346	617	634	615	709	855
Gas	Exports	2	2	20	17	17	17	22
	Imports	24	35	99	101	135	156	163
	Net Imports	22	33	80	84	118	138	141
Electricity	Exports	0	2	2	2	2	1	1
	Imports	1	2	3	4	3	2	2
	Net Imports	1	0	1	2	1	1	1
TOTAL STOCK CHANGES		**–8**	**–38**	**–6**	**1**	**–**	**–**	**–**
TOTAL SUPPLY (TPES)		**1736**	**1927**	**2329**	**2340**	**2610**	**2905**	**3238**
Coal[1]		311	458	549	556	607	689	879
Oil		824	770	947	953	1018	1132	1260
Gas		515	439	512	509	622	680	676
Comb. Renewables & Waste[2]		37	62	73	74	96	107	120
Nuclear		23	159	212	211	218	245	247
Hydro		23	23	23	23	26	27	27
Geothermal		2	14	9	9	16	18	21
Solar/Wind/Other		–	0	3	3	6	7	7
Electricity Trade[4]		1	0	1	2	1	1	1
Shares (%)								
Coal		*17.9*	*23.8*	*23.6*	*23.7*	*23.2*	*23.7*	*27.1*
Oil		*47.5*	*40.0*	*40.7*	*40.7*	*39.0*	*39.0*	*38.9*
Gas		*29.6*	*22.8*	*22.0*	*21.8*	*23.8*	*23.4*	*20.9*
Comb. Renewables & Waste		*2.2*	*3.2*	*3.1*	*3.2*	*3.7*	*3.7*	*3.7*
Nuclear		*1.3*	*8.3*	*9.1*	*9.0*	*8.4*	*8.4*	*7.6*
Hydro		*1.3*	*1.2*	*1.0*	*1.0*	*1.0*	*0.9*	*0.8*
Geothermal		*0.1*	*0.7*	*0.4*	*0.4*	*0.6*	*0.6*	*0.6*
Solar/Wind/Other		*–*	*–*	*0.1*	*0.1*	*0.2*	*0.2*	*0.2*
Electricity Trade		*0.1*	*–*	*–*	*0.1*	*–*	*–*	*–*

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

Please note: Care should be taken when evaluating consumption by sector since inputs of fuel to autoproducers are included in final consumption for some years and not for others.

Unit: Mtoe

DEMAND

FINAL CONSUMPTION BY SECTOR

	1973	1990	2004	2005	2010	2020	2030
TFC	**1323**	**1307**	**1600**	**1598**	**1732**	**1915**	**2119**
Coal[1]	74	54	34	30	29	28	28
Oil	701	698	866	868	934	1038	1155
Gas	367	303	334	322	356	381	405
Comb. Renewables & Waste[2]	37	23	49	52	64	71	78
Geothermal	–	0	1	1	–	–	–
Solar/Wind/Other	–	–	1	1	2	2	2
Electricity	143	226	311	320	335	384	439
Heat	–	2	3	3	12	11	11
Shares (%)							
Coal	*5.6*	*4.2*	*2.1*	*1.9*	*1.7*	*1.5*	*1.3*
Oil	*53.0*	*53.4*	*54.2*	*54.3*	*53.9*	*54.2*	*54.5*
Gas	*27.8*	*23.2*	*20.9*	*20.2*	*20.6*	*19.9*	*19.1*
Comb. Renewables & Waste	*2.8*	*1.7*	*3.1*	*3.3*	*3.7*	*3.7*	*3.7*
Geothermal	–	–	–	*0.1*	–	–	–
Solar/Wind/Other	–	–	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
Electricity	*10.8*	*17.3*	*19.5*	*20.0*	*19.4*	*20.1*	*20.7*
Heat	–	*0.2*	*0.2*	*0.2*	*0.7*	*0.6*	*0.5*
TOTAL INDUSTRY[5]	**483**	**401**	**461**	**447**	**463**	**472**	**503**
Coal[1]	60	45	31	28	26	26	26
Oil	161	149	183	180	175	175	184
Gas	177	124	135	125	136	139	151
Comb. Renewables & Waste[2]	29	9	30	32	29	32	36
Geothermal	–	–	0	0	–	–	–
Solar/Wind/Other	–	–	–	–	–	–	–
Electricity	56	75	79	79	87	91	97
Heat	–	–	2	3	10	9	9
Shares (%)							
Coal	*12.5*	*11.2*	*6.6*	*6.3*	*5.7*	*5.4*	*5.2*
Oil	*33.4*	*37.1*	*39.7*	*40.3*	*37.8*	*37.1*	*36.6*
Gas	*36.7*	*30.9*	*29.3*	*27.9*	*29.4*	*29.4*	*29.9*
Comb. Renewables & Waste	*5.9*	*2.3*	*6.6*	*7.2*	*6.2*	*6.8*	*7.1*
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	–	–	–	–	–
Electricity	*11.5*	*18.6*	*17.2*	*17.8*	*18.7*	*19.4*	*19.4*
Heat	–	–	*0.5*	*0.6*	*2.1*	*1.9*	*1.8*
TRANSPORT	**420**	**502**	**639**	**648**	**743**	**853**	**968**
TOTAL OTHER SECTORS[6]	**420**	**404**	**499**	**503**	**526**	**589**	**648**
Coal[1]	14	10	3	2	2	2	2
Oil	137	63	65	62	58	59	58
Gas	173	164	185	183	202	220	231
Comb. Renewables & Waste[2]	9	14	12	12	12	12	11
Geothermal	–	0	1	1	–	–	–
Solar/Wind/Other	–	–	1	1	2	2	2
Electricity	87	152	231	240	248	292	340
Heat	–	2	1	1	3	2	2
Shares (%)							
Coal	*3.2*	*2.4*	*0.6*	*0.5*	*0.4*	*0.4*	*0.4*
Oil	*32.6*	*15.6*	*13.0*	*12.4*	*11.0*	*10.0*	*8.9*
Gas	*41.2*	*40.6*	*37.1*	*36.5*	*38.3*	*37.3*	*35.7*
Comb. Renewables & Waste	*2.1*	*3.4*	*2.4*	*2.4*	*2.3*	*2.0*	*1.8*
Geothermal	–	*0.1*	*0.1*	*0.1*	–	–	–
Solar/Wind/Other	–	–	*0.3*	*0.2*	*0.3*	*0.3*	*0.4*
Electricity	*20.8*	*37.5*	*46.4*	*47.7*	*47.1*	*49.5*	*52.5*
Heat	–	*0.5*	*0.1*	*0.1*	*0.5*	*0.4*	*0.4*

Unit: Mtoe

DEMAND

ENERGY TRANSFORMATION AND LOSSES

	1973	1990	2004	2005	2010	2020	2030
ELECTRICITY GENERATION[7]							
INPUT (Mtoe)	**430**	**745**	**944**	**960**	**1090**	**1240**	**1419**
OUTPUT (Mtoe)	**169**	**275**	**357**	**367**	**402**	**462**	**531**
(TWh gross)	1966	3203	4148	4268	4679	5367	6175
Output Shares (%)							
Coal	*46.2*	*53.1*	*50.4*	*50.5*	*49.0*	*49.6*	*57.7*
Oil	*17.1*	*4.1*	*3.4*	*3.3*	*2.4*	*2.3*	*2.1*
Gas	*18.6*	*11.9*	*17.6*	*18.3*	*20.4*	*21.1*	*16.1*
Comb. Renewables & Waste	*0.0*	*2.7*	*1.7*	*1.7*	*2.3*	*2.3*	*2.3*
Nuclear	*4.5*	*19.1*	*19.6*	*19.0*	*17.9*	*17.5*	*15.4*
Hydro	*13.5*	*8.5*	*6.5*	*6.4*	*6.5*	*5.8*	*5.0*
Geothermal	*0.1*	*0.5*	*0.4*	*0.4*	*0.4*	*0.4*	*0.4*
Solar/Wind/Other	*–*	*0.1*	*0.4*	*0.4*	*1.1*	*1.0*	*1.0*
TOTAL LOSSES	**429**	**630**	**716**	**724**	**878**	**990**	**1119**
of which:							
Electricity and Heat Generation[8]	261	467	581	587	665	758	867
Other Transformation	7	14	–7	–7	56	57	54
Own Use and Losses[9]	160	149	141	143	156	175	198
Statistical Differences	**–15**	**–9**	**13**	**18**	**–**	**–**	**–**

INDICATORS

	1973	1990	2004	2005	2010	2020	2030
GDP (billion 2000 USD)	4304.80	7055.00	10651.70	10995.80	12729.12	16995.26	22386.65
Population (millions)	211.94	250.18	293.93	296.68	310.26	337.13	364.94
TPES/GDP[10]	0.40	0.27	0.22	0.21	0.21	0.17	0.14
Energy Production/TPES	0.84	0.86	0.71	0.70	0.72	0.70	0.68
Per Capita TPES[11]	8.19	7.70	7.92	7.89	8.41	8.62	8.87
Oil Supply/GDP[10]	0.19	0.11	0.09	0.09	0.08	0.07	0.06
TFC/GDP10	0.31	0.19	0.15	0.15	0.14	0.11	0.09
Per Capita TFC[11]	6.24	5.22	5.44	5.39	5.58	5.68	5.81
Energy-related CO_2 Emissions (Mt CO_2)[12]	4703.9	4850.5	5791.6	5817.0	6387.1	7154.2	8241.0
CO_2 Emissions from Bunkers (Mt CO_2)	45.2	129.8	127.6	134.2	122.0	143.4	170.2

GROWTH RATES (% per year)

	73–79	79–90	90–04	04–05	05–10	10–20	20–30
TPES	1.3	0.2	1.4	0.5	2.2	1.1	1.1
Coal	2.8	2.0	1.3	1.3	1.8	1.3	2.5
Oil	1.2	–1.2	1.5	0.6	1.3	1.1	1.1
Gas	–1.3	–0.7	1.1	–0.5	4.1	0.9	–0.1
Comb. Renewables & Waste	5.9	1.5	1.1	1.8	5.4	1.1	1.1
Nuclear	20.3	7.7	2.1	–0.3	0.6	1.2	0.1
Hydro	1.1	–0.3	–0.1	0.5	2.2	0.2	0.0
Geothermal	9.0	13.4	–3.5	0.4	12.9	1.3	1.4
Solar/Wind/Other	–	–	16.2	10.2	15.3	1.2	1.1
TFC	0.7	–0.5	1.5	–0.1	1.6	1.0	1.0
Electricity Consumption	3.1	2.5	2.3	2.8	0.9	1.4	1.3
Energy Production	0.8	0.7	–0.0	–1.0	2.9	0.8	0.8
Net Oil Imports	5.1	–1.3	4.2	2.8	–0.6	1.4	1.9
GDP	3.0	2.9	3.0	3.2	3.0	2.9	2.8
Growth in the TPES/GDP Ratio	–1.6	–2.6	–1.6	–2.6	–0.7	–1.8	–1.7
Growth in the TFC/GDP Ratio	–2.2	–3.3	–1.5	–3.2	–1.3	–1.9	–1.7

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

FOOTNOTES TO ENERGY BALANCES AND KEY STATISTICAL DATA

1. Coal includes lignite.
2. 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.
3. Total net imports include combustible renewables and waste and trade of electricity.
4. Total supply of electricity represents net trade. A negative number in the share of TPES indicates that exports are greater than imports.
5. Industry includes non-energy use.
6. Other Sectors includes residential, commercial, public service and agricultural sectors.
7. Inputs to electricity generation include inputs to electricity and CHP plants. Output refers only to electricity generation.
8. 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, 17% for geothermal, from 2002 onwards, and 100% for hydro and photovoltaic.
9. 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.
10. Toe per thousand US dollars at 2000 prices and exchange rates.
11. Toe per person.
12. "Energy-related CO_2 emissions" have been estimated using the IPCC Tier I Sectoral Approach. 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 2005 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.

INTERNATIONAL ENERGY AGENCY "SHARED GOALS"

The 27 member countries* of the International Energy Agency (IEA) seek to create the conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and 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 they 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 hydropower, 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** is central to the achievement of these shared goals. Decision-makers 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 where practicable have regard to the "polluter pays principle".

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 members wish to retain and improve

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, the Slovak Republic (since November 2007), Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States.

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, including industry participation and co-operation with 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.

Co-operation among all energy market participants helps to improve information and understanding, and encourage 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.)

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 subsequently abbreviated, this glossary provides a quick and central reference for many of the abbreviations used:

barrel	42 US gallons, 34.97 imperial gallons, 158.98 litres
bcm	billion cubic metres
bpd	barrels per day
Btu	British thermal units; one Btu = 1.055 joules or 0.000025199 toe
BWR	boiling water reactor
CAFE	Corporate Average Fuel Economy standards for cars and trucks
CBECS	Commercial Building Energy Consumption Survey
CCS	carbon capture and storage
CCTP	Climate Change Technology Program
CO_2	carbon dioxide
DOE	Department of Energy
DOI	Department of Interior
DOT	Department of Transportation
DSM	demand-side managaement
DST	Daylight Saving Time
EC	European Commission
EIA	Energy Information Administration
EIVs	environmental impact volumes
E&P	exploration and production
EPA	Environmental Protection Agency
ERO	Electricity Reliability Organisation
ESCO	energy services company
ETS	EU Emissions Trading Scheme
FERC	Federal Energy Regulatory Commission

GDP	gross domestic product
GHG	greenhouse gas
gpv	gallons per vehicle
GNEP	Global Nuclear Energy Partnership
GW	gigawatt, or one watt $\times 10^9$
GWe	gigawatt of electrical energy
GWh	gigawatt-hour
IEA	International Energy Agency
IOU	investor-owned utilities
IPP	independent power producer
IPPC	Intergovernmental Panel on Climate Change
ISO	independent system operator
kbd	thousand barrels per day
kWh	kilowatt-hour
LNG	liquefied natural gas
mbd	million barrels per day
mpg	miles per gallon
mpv	miles per vehicle
Mt	million tonnes
MTBE	methyl tertiary butyl ether
Mtce	million tonnes of coal equivalent
Mtoe	million tonnes of oil equivalent
MW	megawatt of electricity, or one watt $\times 10^6$
MWh	megawatt-hour = one megawatt $\times$ one hour
NAFTA	North American Free Trade Agreement
NEP	National Energy Policy
NERC	North American Electric Reliability Corporation
NO_x	nitrogen oxides
NRC	Nuclear Regulatory Commission

OASIS	open-access same-time information systems
OCS	outer continental shelf
OECD	Organisation for Economic Co-operation and Development
PEIS	preliminary environmental impact statement
PUC	public utilities commission
PWR	pressurised water reactor
QRU	Qualifying Retail Utility
RECS	Residential Energy Consumption Survey
RPS	renewable portfolio standard
RTO	regional transmission organisation
SPR	strategic petroleum reserve
SUV	sport utility vehicle
tcm	trillion cubic metres
toe	tonne of oil equivalent, 10^7 kilocalories
TSE	truck stop electrification
tSW	tonne of separative work, a defined quantity of enriched uranium
tU	tonne of uranium
TW	terawatt, or one watt $\times 10^{12}$
TWhe	terawatt-hour electric, terawatt x one hour $\times 10^{12}$
UNFCCC	United Nations Framework Convention on Climate Change

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