INTERNATIONAL ENERGY AGENCY

Energy Policies of IEA Countries

The United States 2002 Review

OECD

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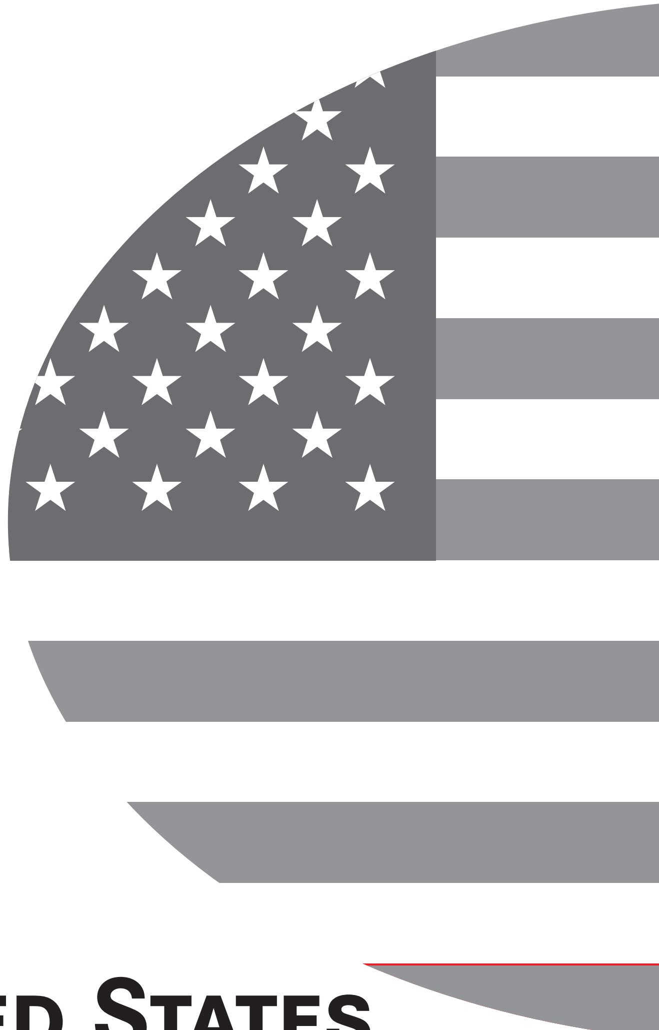

THE UNITED STATES 2002 REVIEW

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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-six* of the OECD's 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 assist in the integration of environmental and energy policies.

** IEA Member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, the Republic of Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States. The European Commission also takes part in the work of the IEA.*

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996), the Republic of Korea (12th December 1996) and Slovakia (28th September 2000). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

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SUMMARY AND RECOMMENDATIONS

SUMMARY

General Energy Policy

The National Energy Policy places increased emphasis on domestic energy production and economic growth. It will influence the formation of energy and energy-environment policy worldwide. US policy debate needs to be widened to include a realistic strategy for addressing the US contribution to global environmental problems.

US energy policy is in transition. Priorities have been redirected by the National Energy Policy to increasing energy production and to supporting economic growth. They will undergo change in response to reactions to the policy and as the Administration seeks to translate general policy guidance into concrete proposals. Many of the proposals will take time to develop and will require congressional approval. What emerges in legislation is likely to be a consensus reflecting stakeholder views that could become the foundation of a longer-term policy. The US government should persevere in the process that the National Energy Policy has started and continue its efforts to ensure that a new and coherent policy emerges.

The new policy approach is likely to influence the formation of energy and energy-environment policy worldwide. The focus on energy security is timely, as is the attention directed to regulatory policies, including environmental regulation, and their impact on economic development. The report comprehensively covers all areas of energy policy, but its greatest impact is likely to be on supply-side measures, particularly measures to encourage domestic energy production. The role of energy demand-side measures is fully acknowledged, but the recommendations that flow from the discussion of these may have less impact than the measures aimed at increasing energy production, notably of fossil fuels. The most important areas on the demand side requiring aggressive action are energy use in transport and energy efficiency in buildings.

Throughout this report, recurring questions arise concerning:

- The weighting that should be given to international energy trade, rather than domestic production, as a means of ensuring energy security.

- The use of such economic instruments as energy pricing, taxation and emissions trading to value the environmental externalities of different fuels and to find market solutions to many policy issues.

- The realism of expecting cost-effective and timely deployment of new technology to protect the environment, and to improve end-use efficiency, in the absence of strong price signals in the energy market.

In some areas, the US policy debate is too narrowly based on current economic benefits and costs. Insufficient weight is given to external environmental costs. Adjusting energy prices to reflect environmental costs is a key means of achieving cost-effective changes in energy end-use and of encouraging the development of new and cleaner energy sources, including renewables. A transition to sustainable development will be made more difficult if environmental costs are not valued by the market.

In almost every policy area, federal-state relations will influence the outcome. Development of the regional energy market, notably between the US, Canada and Mexico, will also be important [1].

Energy and the Environment

The US has withdrawn from the Kyoto Protocol, but the National Energy Policy does not set any target or timetable for achieving reductions in emissions or incentives adequate to deliver them.

The US is the world's largest emitter of greenhouse gases; it is the highest emitter of energy-related carbon dioxide per capita among the OECD countries. By 2020, carbon dioxide emissions from fossil fuel use in the US are projected to be 54% higher than in 1990, despite a reduction in the share of coal in total power generation. The relatively high growth in US carbon dioxide emissions, when compared with other OECD countries, is due to a high growth in demand for services delivered by energy and a more carbon-intensive electricity mix, offset in part by reductions in energy intensity.

The US has withdrawn from the Kyoto Protocol, but is committed to the United Nations Framework Convention on Climate Change that aims to stabilise greenhouse gas concentrations in the longer term. Difficult economic and sectoral issues will be at stake in any US programme on greenhouse gas emissions. These include the wish of the public to keep energy prices low, to exercise free choice in the composition of the automobile fleet, and the pivotal role of coal in securing energy supply. The US government should nevertheless carry forward the debate on greenhouse gas emissions to define its aims and to develop a strategy for achieving them.

The US has played a leading role in developing many advanced energy technologies, often through federal research and development programmes. Its strategic approach to the control of greenhouse gas emissions should include market-based

1. The US, Canada and Mexico are parties to the North American Free Trade Agreement (NAFTA). NAFTA is a comprehensive agreement that came into effect on 1 January 1994, creating the world's largest free trade area. Article 102 of the agreement details the objectives of NAFTA. Among its main objectives is the liberalisation of trade between Canada, Mexico and the US, to stimulate economic growth and give the NAFTA countries equal access to each other's markets.

incentives for the take-up of advanced energy technologies and energy efficiency measures. But complementary policies, including the broader use of economic instruments, will almost certainly be required to achieve worthwhile reductions in greenhouse gas emissions. Because the government is postponing its decision on carbon dioxide, energy-using companies face the risk of having to prematurely retire productive capital stock put in place to comply with the three-pollutants bill when action is taken to reduce carbon dioxide levels. It would be in the interests of both the US and the IEA as a whole to ensure policies are developed in a manner consistent with future participation in an international trading system for greenhouse gases.

US policy is geared towards long-term technological development and international efforts to encourage climate-friendly technology and practices. There is a risk that as international efforts develop in other parts of the world, the US technology industry may not be able to make its full contribution.

Energy Efficiency

Energy efficiency is considered by the National Energy Policy to be an important complement to expanding energy supply, but insufficient to match rising demand.

The National Energy Policy acknowledges the role of energy efficiency. But it considers that efficiency improvement will not suffice to cope with the scale of projected growth in US energy demand. It judges that the population will not tolerate reductions in energy supplies and services nor higher energy prices. This viewpoint limits the scope for proactive promotion of energy efficiency policies and programmes. Important measures are announced in the National Energy Policy, but it is unclear how vigorously they will be pursued. It is equally unclear how inevitable conflicts between improving efficiency for environmental goals on the one hand and meeting consumer demands for low-price energy services on the other, will be resolved.

US policy on energy efficiency lacks sufficient incentives to deliver its full potential. The policy envisages the combined efforts of industry, consumers and governments at all levels, but does not identify the mechanisms by which this would be achieved.

There are important recommendations in the National Energy Policy on energy conservation that could curb the negative environmental effects of energy consumption, and produce benefits for the economy and the security of energy supply. They include more stringent and expanded energy efficiency standards, the promotion of combined heat and power, the extension of the Energy Star labelling scheme and the revision of Corporate Average Fuel Economy (CAFE) standards for automobiles. But little may be achieved in the near term. It will be important to quantify the expected and actual impact of these measures, and to monitor their progress.

The proposal to consider strengthening CAFE standards is an encouraging approach to energy issues in transport. The efficient use of US light-duty vehicle fuel could have a large influence on world oil demand and oil markets. The US gasoline sector accounts for a significant share of world oil demand, and the US market could affect fuel economy performance around the world. Resources should be made available as soon as possible to ensure that the Department of Transportation can issue new CAFE standards by 2004, and then strengthen them progressively. Different CAFE standards for cars and light trucks, which have encouraged the growing use of sport utility vehicles and resulted in a fall in fuel economy, should be addressed as a priority.

Electricity

The US is seeking to improve the operation of the electricity market nationwide. Federal-state co-operation is necessary to harmonise standards and regulations and promote competition, and could work to ensure sufficient investment in generation and transmission. The challenge is to create a small number of regional markets operating under consistent regulatory regimes.

Continued liberalisation of US energy markets could enhance the efficiency of the sector and benefit electricity and gas consumers. US policy should take as its objective the establishment of robust, competitive markets where price mechanisms can operate without undue distortion to provide transparent signals for efficiently timed new capacity to meet growing energy demands. Competitive energy markets should be supported by efficient, consistent and transparent market structures and regulatory arrangements.

The power crisis in California has reversed or delayed progress on market reform in several states. Damaged confidence should be restored to promote reform and to create certainty for new investment. In light of the California experience, it is important that electricity and gas suppliers be free to use financial instruments, for example portfolios of bilateral contracts, to enable them to manage their exposure to market volatility. Decisions on the electricity sector should be taken bearing in mind the large projected increase in energy demand to 2020. The US government estimates that 355 000 MW of new capacity will be needed to meet demand. Benefits from competition should be passed through to end-users, including householders and small businesses, enabling them to participate actively in the free markets where they can exercise effective choice.

The Federal Energy Regulatory Commission’s proposal to establish Regional Transmission Operators appears to be a sensible means of ensuring access to transmission and the functioning of a competitive market at the wholesale level. Progress in market reform is uneven among the states. Progress has been made through consultation and co-operation between regulators. These positive efforts should be complemented by broader discussions on market reform between the federal and state governments with a view to encouraging greater consistency in market arrangements within the new transmission regions.

The California crisis had multiple causes that are now being addressed by market-based means.

The crisis in California's electricity market brought rolling blackouts during the winter of 2000-2001, retail price spikes in San Diego during the summer of 2000, and financial difficulties for the state's two largest utilities, Pacific Gas and Electric, and Southern California Edison. The utilities were compelled to pay market-based wholesale prices for electricity but had to resell at regulated retail rates. Underlying causes of the crisis were:

- Failure to build new generating supply in the face of steadily increasing demand because traditional rate regulation did not provide sufficient profit incentives for new supply. Siting regulations delayed building power plants. With stronger incentives and political pressure, substantial new capacity is now being built.

- Market design flawed by restrictions on the use of long-term contracts, and flaws in spot market operating rules. Utilities and consumers were left extremely vulnerable to short-term price increases at times of high demand. Elsewhere, this problem has been avoided by allowing forward hedging contracts that allow consumers to secure a stable longer-term price. Restrictions on long-term contracts have now been lifted.

- Rising natural gas prices added 3 cents per kWh to the average cost of gas-fired generation between the spring of 1999 and the autumn of 2000. Spot gas price spikes were much higher. Permits to emit nitrogen oxide raised the cost of coal-fired generation by about 4 cents per kWh. Widespread drought in the western states and Canada reduced the amount of hydroelectricity available to the state, raising electricity prices across the board.

Renewables

Renewables could play an important role in US energy policy with direct economic benefits through technology exports.

Objectives for developing renewables should be defined carefully to ensure cost-effectiveness and consistency with other policy goals. As a general rule, market-based incentives are likely to be the most efficient means of delivering those objectives. Renewable portfolio standards could be a neutral way of creating a secure but competitive market for promoting renewables in general.

Oil

Oil exploration is limited on environmental grounds. Refineries are operating at full capacity and new investment is deterred by low profitability. Product standards need to be made more consistent.

The focus in the National Energy Policy on improving domestic oil supplies should be balanced by continuing efforts to diversify supply through trade with politically stable and friendly nations, participation in consumer-producer dialogue, improving the efficiency of energy use in transport and the promotion of alternatives to oil.

There is, nevertheless, considerable scope for expanding domestic supplies, provided there is public confidence that exploration and production can be undertaken in an environmentally acceptable manner. Extensive areas of federal lands have been barred from leasing or drilling by congressionally-imposed restrictions, despite strong industry interest.

The US refining industry is running at nearly 100% of capacity during the peak gasoline consumption season. It is producing record amounts of needed products at other times. No major refineries have been built in the last twenty-five years because of low profitability and heavy environmental regulation. So-called boutique fuels, produced to meet local environmental standards, may be raising the cost of fuels in some regions and reducing the ability of petroleum product markets to respond to supply interruptions or unexpected demand. Consideration should be given to the possible economic benefits and costs of reducing the number of region-specific petroleum product requirements.

Natural Gas

US prospectivity may be too low for exploration incentives to bring about a sufficient supply response.

The National Energy Policy argues that domestic supply must fill the gap in meeting energy demand after efficiency improvements are made. Otherwise, imported supply will grow to a level judged unacceptable by the US government. A supply response to higher prices has been delayed by low prospectivity, despite a high level of exploration. Drilling is currently focused on areas adjacent to existing developments and finds are often shallow and quickly depleted. To meet demand growth, more aggressive drilling in new onshore and offshore areas will be necessary, or larger volumes will have to be imported from Canada, Mexico or as liquefied natural gas. The increase in imports required would be very large and could create network bottlenecks.

Price spikes, already noted with concern in the National Energy Policy, result in part from regional transmission bottlenecks. The federal government needs to work with the Federal Energy Regulatory Commission (FERC) and state regulators to ensure that the planning and regulatory framework creates the right incentives for necessary new investment in transmission capacity and storage.

Coal

Although high domestic demand is forecast, production and exports of coal are falling; despite higher international coal prices, the US is not acting as the swing producer. High domestic consumption could be environmentally sustainable provided advanced clean coal technology is deployed.

US coal production declined for the second consecutive year in 2000. Imports rose and are expected to continue growing. Exports are forecast to remain subdued to 2020. US producers have historically increased coal exports when international prices have risen, effectively capping any rising price trend. This situation has changed in recent years. Fundamental changes in the way the international market operates may be developing.

Policies to control carbon emissions may be perceived as a threat to the coal industry. However, their impact could be managed provided that carbon regimes include opportunity for national and international trading and that incentives exist for the implementation of clean coal technologies, including technologies for carbon sequestration.

Nuclear

The National Energy Policy promotes nuclear energy, but no specific policies are proposed to encourage construction of new plants. Relicensing of existing plants would ensure that nuclear power plays a continuing role. The decision on the Yucca Mountain repository will be important for the future of nuclear power worldwide.

The National Energy Policy promotes nuclear power. New nuclear plants using existing technology would almost certainly be uncompetitive with fossil alternatives at current prices. There are few specific policies to encourage new nuclear plants other than extension of the Price-Anderson Act to limit liability in the event of an accident, and research and development programmes. Relicensing of existing reactors is likely to be more effective than new construction in maintaining a role for nuclear.

Yucca Mountain represents a strategically important development for the nuclear sector in the US. The decision on the project will influence confidence in nuclear power worldwide. A firm decision on its future should be taken as soon as possible. The facility would not start operation until 2010 at the earliest.

Research and Development

The most recent budget allocations have brought research and development expenditures into line with priorities set out in the National Energy Policy. Deployment of new technologies will be difficult in the absence of market incentives to put a value on carbon emissions. Many of the new technologies would reduce levels of carbon emissions, but have higher capital and operating costs than existing technologies.

RECOMMENDATIONS

The Government of the United States should:

General Energy Policy

- ☐ Persevere with the development and implementation of the National Energy Policy to ensure that the eventual outcome is a new and coherent expression of US energy policies, instruments and programmes.

- ☐ Broaden the use of economic instruments to achieve energy policy goals.

- ☐ Develop constructive federal-state dialogue on a wide range of energy policy issues, with a view to bringing a more consistent national approach to many issues where jurisdictional boundaries may be inhibiting progress.

- ☐ Continue the process of energy market liberalisation with federal government leadership.

Environment

- ☐ Acknowledge the influence of US emissions on global greenhouse gas emission levels and climate:
  - Quantify the impact of current energy-environment policies on projected greenhouse gas emissions at the national and global levels.
  - Develop specific targets for the control of US greenhouse gas emissions.

- ☐ Complement current research and development efforts on climate-friendly technologies with a policy framework, including economic instruments, designed to achieve significant reductions in greenhouse gas emissions over a specified period.

- ☐ Take action on carbon dioxide to complement the three-pollutants bill, or announce its intentions on carbon dioxide, so that companies can take carbon dioxide into account when investing in new capital stock to comply with any new environmental goals.

- Develop greenhouse policies consistent with the flexibility mechanisms of the Kyoto Protocol so that US industry has the option of participating in a future international market in emissions.

- Continue to develop and apply market-based policy responses to local pollutants.

Energy Efficiency

- Establish a stronger foundation for energy efficiency programmes by continuing to:
  - Improve the statistical basis for developing policies and programmes.
  - Assess improvements in energy efficiency that are being achieved without government intervention to set benchmarks for evaluating the cost-effectiveness of existing and proposed policies.
  - Improve transparency of information on energy consumption, energy costs, and efficiency-enhancing products for consumers.
  - Give attention to the potential energy security benefits of energy efficiency measures.

- Develop a comprehensive package of measures to achieve quantified targets for efficiency of energy end-use, including:
  - The use of economic instruments wherever possible.
  - Mandatory standards.
  - Information programmes to raise public awareness of the benefits of energy efficiency and conservation strategies.
  - Deployment programmes to ensure appropriate advanced technology enters the market in a timely manner.

- Give priority to enhancing energy efficiency in the transport and building sectors, notably by:
  - Strengthening CAFE standards.
  - Reviewing the range of options available to improve the fuel economy of personal and light-duty vehicles, including the possibility of increased reliance on diesel engines following the introduction in 2006 of low-sulphur diesel.
  - Continuing to work with the states to strengthen building codes.
  - Continuing to provide federal leadership through standards and guidelines on appliances, buildings and systems designed to improve efficiency in buildings.

Electricity

- Establish a formal process to develop overall policy goals for the electricity industry. The states should be encouraged to introduce competition in electricity

markets, including retail competition and customer choice. Conditions for effective competition to be addressed include:
- Encouraging new market entrants.
- Acknowledging the role of spot price spikes in a normally operating competitive market, for example to ensure sufficient investment in peak-load capacity, while protecting final consumers by market means.
- Guarding against undue market influence.
- Taking a regional approach to price-capping to ensure that market power and the value of lost load are addressed appropriately, but interstate trade in electricity is not discouraged.
- Ensuring stranded cost payments are calculated accurately and their reimbursement does not adversely affect the development of competition.
- Including demand response measures in market designs.

☐ Strengthen existing dialogue between regulators to develop consistent, transparent wholesale market structures, rules, and regulatory arrangements within interconnected regions. The aim should be to ensure that a regional approach is taken that reflects the economic boundaries of the markets rather than the jurisdictional boundaries of existing regulatory bodies. Issues to be addressed in this context should include:
- Structural reform of incumbent state-based and government-owned utilities to ensure competitive neutrality and market access.
- Cost-reflective network pricing.
- The potential for competitive delivery of network services and improved market-based reliability arrangements.
- Integrated network planning arrangements and information dissemination on market operations.
- Market governance and institutional arrangements, including clarification of the rights and responsibilities of market participants and governments.
- The capacity of financial derivatives markets to deliver innovative and efficient market management products.

☐ Address regulatory barriers to new investment in generation and transmission:
- Ensure the independent collection, analysis and distribution of information on investment needs for new generating and transmission capacity as a means of avoiding market failure by timely and objective forecasting of capacity needs.
- With the states, streamline licensing arrangements.

Renewables

☐ Consider the use of a federal renewable portfolio standard as an alternative to tax credits on electricity produced from renewable sources.

☐ Develop a standardised national approach to encouraging renewable energy, compatible with the operation of competitive electricity markets. Issues for consideration include net-metering and interconnection standards.

- ☐ Facilitate the development of a commercially-oriented and viable renewables sector:
  - Encourage the development of innovative commercial arrangements such as strategic alliances between different players in the renewables market to strengthen their ability to compete.

Nuclear

- ☐ Assess the extent to which proposals in the National Energy Policy will encourage the construction of new nuclear plants.
- ☐ Assess public opinion on nuclear power and develop information strategies to respond to public concerns.
- ☐ Make a firm decision on the Yucca Mountain repository, bearing in mind the impact the decision will have in the US and worldwide on future investment in nuclear power.

Oil

- ☐ Remove undue obstacles to oil and gas exploration both onshore and offshore, particularly on federal territory.
- ☐ Work with industry to reduce barriers to new investment in refinery capacity.
- ☐ Develop consistent standards for "boutique" fuels.

Natural Gas

- ☐ Maintain the momentum for opening the downstream gas market, giving particular attention to customer choice in the residential sector.
- ☐ Review the outlook for the gas supply and demand balance.
- ☐ Review the adequacy of investment in gas transmission, distribution and storage.

Coal

- ☐ Review policies for the deployment of clean coal technologies, including carbon dioxide sequestration.

Research and Development

- ☐ Give priority to the development of economic incentives for the deployment of advanced technologies.

- ☐ Ensure that the level and distribution of funding for energy research and development matches the expectations for technology to meet environmental and energy policy goals.

2

CONDUCT OF THE REVIEW

REVIEW TEAM

The 2002 International Energy Agency (IEA) in-depth review of US energy policies was undertaken by a team of energy policy specialists drawn from the Member countries of the IEA. The team visited the US 1–5 October 2001 for discussions with government officials, energy suppliers and energy consumers. Published sources and IEA statistical analysis of data provided by the US government supplemented information provided during the visit.

Members of the team were:

Neil Hirst
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Federal Ministry of Economics and Technology
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International Energy Agency

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Desk Officer – United States
Country Studies Division
International Energy Agency

John Cameron managed the review and prepared the report. Richard Baron drafted Chapter 4. Monica Petit and Bertrand Sadin prepared the figures.

The team held discussions with the following:

- American Gas Association
- American Petroleum Institute

- Department of Energy
- Department of State
- Department of Transportation
- Edison Electric Institute
- Elcon (association of large industrial electricity consumers)
- Electric Power Supply Association
- Energy Information Administration
- Environmental Defense
- Environmental Protection Agency
- Federal Energy Regulatory Commission
- Nuclear Energy Institute
- National Energy Plan Co-ordinator
- National Resources Defense Council
- Nuclear Regulatory Commission
- Pennsylvania Public Utility Commission
- PJM Regional Transmission Operator
- PPL (electric utility)
- Senate Energy Committee Staff
- Southern California Edison
- Union of Concerned Scientists
- World Resources Institute

The assistance and co-operation of all participants in the review are gratefully acknowledged.

REVIEW CRITERIA

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

3

GENERAL ENERGY POLICY

OBJECTIVES

The Report of the National Energy Policy Development Group, *National Energy Policy*, was published in May 2001[2]. At the core of the policy are proposals to ensure adequate domestic energy supply and infrastructure. The policy identifies major needs for investment in new power plants, oil refineries, and gas and electric transmission networks.

The National Energy Policy report also includes options for energy conservation, environmental protection, and development of renewable energy. These include, for example, recommendations to double expenditure on conservation programmes for low-income households, extension of appliance efficiency standards and renewable energy tax credits, and new tax incentives for purchase of efficient vehicles, as well as consideration of tightened corporate average fuel economy standards for vehicles.

The National Energy Policy also recommends enhancing collective energy security through global alliances. Measures proposed include diversification of supply sources, and continued co-operation with the OECD and the IEA. The latter is proposed specifically to ensure adequate oil stocks, the development of a more comprehensive and more timely world oil data reporting system, and to implement transparent rules and procedures for energy investment worldwide.

ADMINISTRATION

The Department of Energy has primary responsibility for federal energy policies and programmes. The department's work is carried out by several offices: Energy Efficiency and Renewable Energy; Fossil Energy; Nuclear Energy, Science and Technology; Civilian Radioactive Waste Management; Science; Policy and International Affairs. Data are collected and analysed by the Energy Information Administration, a part of the department headed by an independent administrator.

Responsibilities are shared between the federal government and the state governments which also have the authority to legislate their own energy policies and programmes. State energy policies vary considerably.

Interstate gas and electricity markets (i.e. pipelines and transmission services) are regulated by the Federal Energy Regulatory Commission, which is nominally part of the Department of Energy, but operates independently, with appointed commissioners

2. The full report is published on the US Department of Energy web site at **www.energy.gov**

and professional staff. The states regulate retail rates charged by local gas and electric distribution companies, and the rate of return on electricity generating facilities operated by utilities in franchised service territories.

Other departments and authorities with a major role in energy policy include:

- Department of State, which leads on international energy matters.
- Department of the Interior, which controls the exploration and development of mineral resources on federal land and on the Outer Continental Shelf.
- Department of Justice, which monitors the energy industries for infringement of the anti-trust laws.
- Environmental Protection Agency, which sets environmental standards for the energy sector.
- Department of Transportation, which, among other responsibilities for the sector, sets vehicle fuel economy standards.
- Treasury Department, which is responsible for tax regimes affecting the energy industries.
- Nuclear Regulatory Commission, which is responsible for licensing the construction and operation of nuclear power plants.

ENERGY SUPPLY AND DEMAND

Annex A contains information on energy balances and key statistical data.

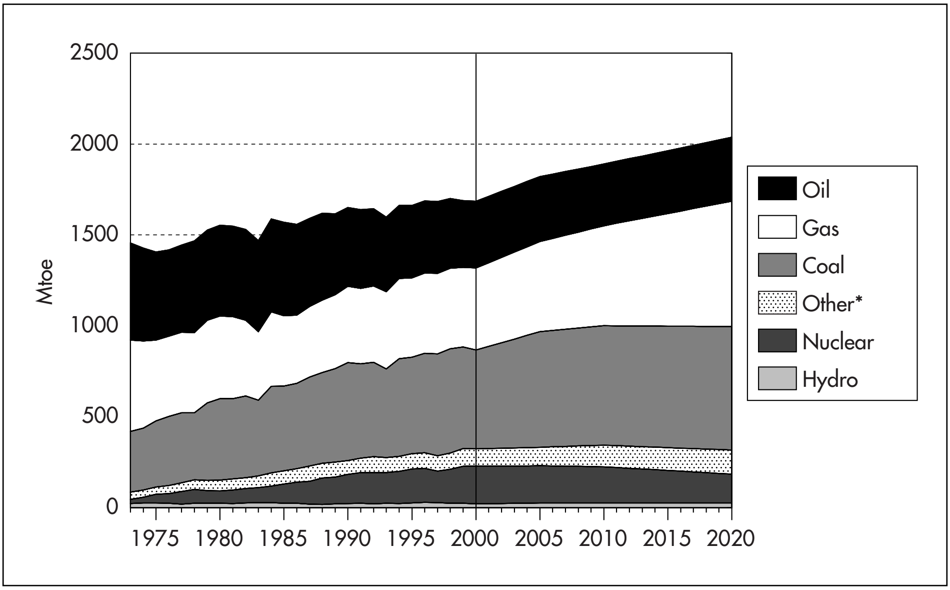
Primary Energy Supply

Energy supply is dominated by fossil fuels. Oil and gas account for about two-thirds of primary energy supply, and coal for most of the remainder. Imports, principally of oil but also gas, account for about one-quarter of supply. Renewables including hydro account for 5.4% of primary energy supply, and 4.3% excluding hydro. Projected growth in primary energy supply shows growth in oil and gas, but a declining share of coal. Renewables remain relatively insignificant.

Final Energy Consumption

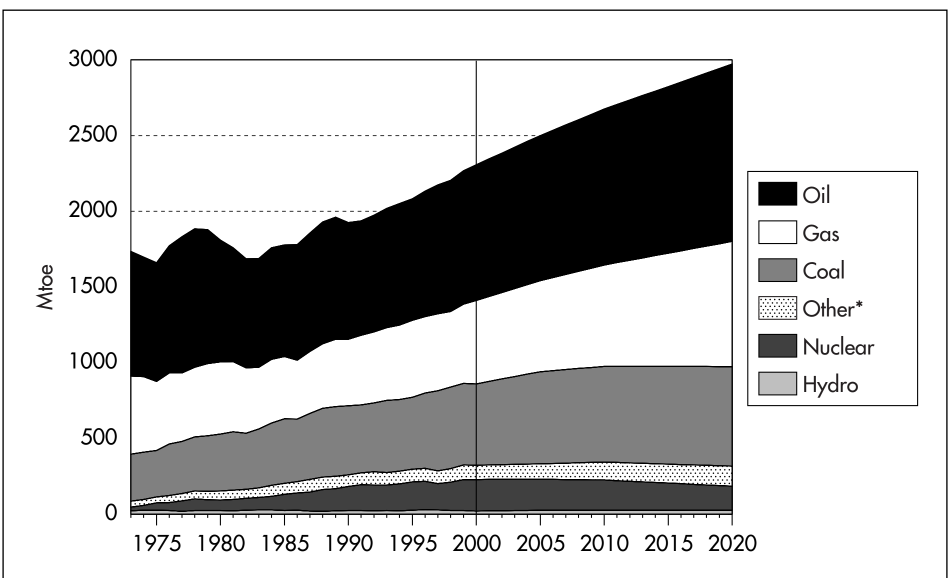
Total final energy consumption was 1 476 Mtoe in 1999, a rise of 3.1% from 1998, slightly lower than the growth in GDP of 3.6%. Growth in consumption recovered sharply in 1999. In 1999, oil accounted for 54.3% of consumption, gas 21.6%,

Figure 1
Energy Production by Source, 1973 to 2020



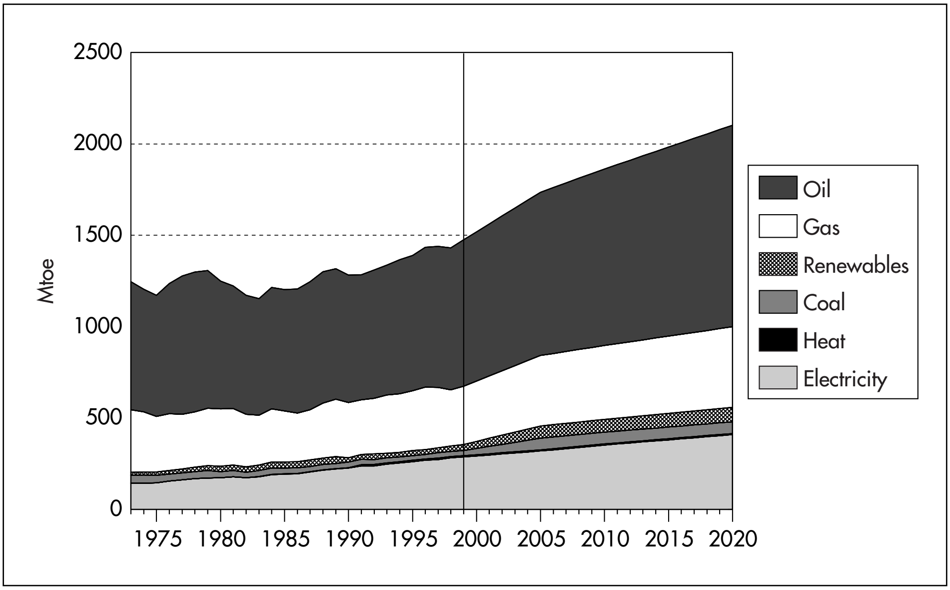
* Includes geothermal, solar, wind, combustible renewables and wastes.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and country submission.

Figure 2
Total Primary Energy Supply, 1973 to 2020



* Includes geothermal, solar, wind, combustible renewables and wastes.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and country submission.

Figure 3
Total Final Consumption by Source, 1973 to 2020



Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and country submission.

electricity 19.5%, and coal 1.9%. Coal accounts for 51.8% of electricity generation, nuclear 19.9%, and gas 15.7%.

Transport is the main energy consumer, accounting for 40.7% of the total in 1999. Transport consumption rose by 3.3% from 1998 and 19.7% from 1990. Industry accounted for 28.7% of energy consumption in 1999. Industry consumption rose by 3.2% from 1998, and by 12.2% from 1990.

OUTLOOK

The Energy Information Administration has made the following assumptions in its Annual Energy Outlook 2001[3].

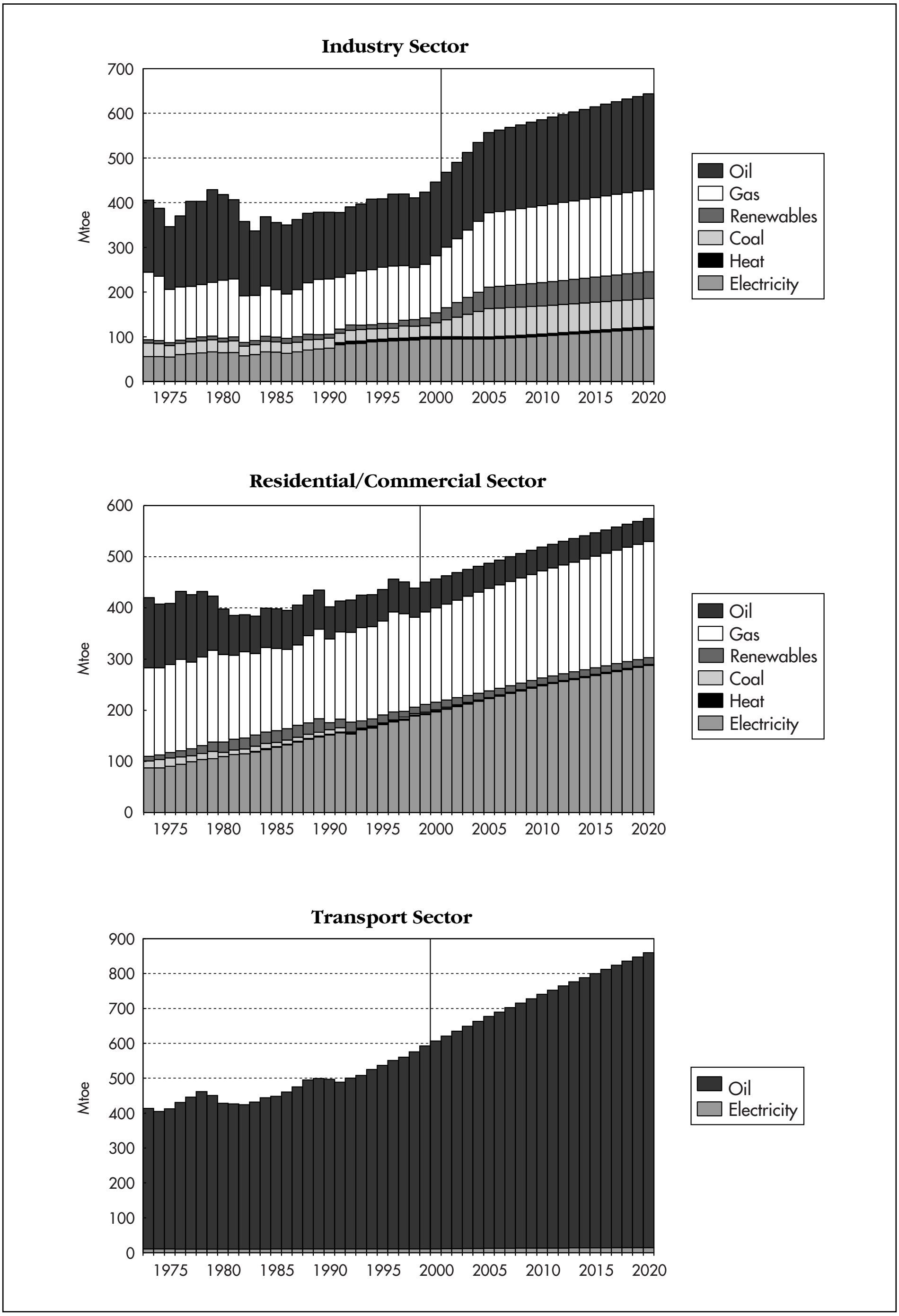
- Real gross domestic product is assumed to grow by 3% per year from 2000 to 2020, while energy intensity of GDP declines by 1.5% per year and carbon dioxide emissions increase 1.4% to 1.5% per year.

- In low and high growth cases, GDP is assumed to grow by 2.4% or 3.4% per year.

3. The full publication, with details about the projections and the assumptions behind them, can be found on the web at **www.eia.doe.gov/oiaf.aeo/**

Figure 4

Final Consumption by Sector and by Source, 1973 to 2020



Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and country submission.

- The world oil price per barrel in 2020, expressed in 2000 dollars, is projected to be US$ 24.68 in the reference case, US$ 17.64 in a low world oil price case, and US$ 30.58 in a high world oil price case, as compared with US$ 17.60 in 1999.

- The 2020 wellhead price of domestic natural gas is projected to be US$ 3.26 per thousand cubic feet in the reference case, US$ 2.94 with low growth, and US$ 3.65 with high growth.

Domestic crude oil production is projected to decline on average by 0.2% per year to 5.6 million barrels per day. Consequently, in the face of rising demand, the share of petroleum demand met by net imports is projected to increase from 51% in 1999 to 63% in 2020. Enhanced incentives for oil production and measures to improve the fuel efficiency of transport could reduce the share met by imports.

Electricity generation is projected to remain dominated by fossil fuels. While the share of coal-fired generation is projected to decline from 51% in 1999 to 45% in 2020, the share of natural gas-fired generation is projected to more than compensate, increasing from 15% to 32%. A key underlying assumption is that electricity industry restructuring favours the less capital-intensive, highly efficient gas-fired generation technologies. Another important underlying assumption is that nuclear plants are retired after 30, 40 or 50 years if operating costs exceed the cost of power from replacement capacity. This assumption results in retirement of 9.7 gigawatts of nuclear capacity by 2020.

As electricity demand continues to grow and some generating capacity is retired, it is projected that there will be substantial needs for new electricity generating capacity, as well as associated transmission and distribution infrastructure. Some 1 300 electric power plants of about 300 MW in size are expected to be required over the next twenty years.

CRITIQUE

The National Energy Policy sets the framework for debate on energy policy, but the outcome will not be determined for some time.

The recently released National Energy Policy presents an important set of policy proposals, focused on energy security. The report comprehensively covers all areas of energy policy, but its greatest impact is likely to be on supply-side measures, particularly measures to encourage domestic energy production. The role of energy demand-side measures is fully acknowledged, but the recommendations that flow from the discussion of these do not have the same concrete focus as the supply-side measures, or are unlikely to have an equivalent quantitative impact. The most important areas on the demand side requiring aggressive action are energy use in transport and buildings.

The National Energy Policy emphasises energy security. The projected growth in US energy consumption outpaces production for the next twenty years, resulting in a growing dependence on imports and posing increasing concerns for energy security. Domestically, the California power crisis has been a wake-up call on the importance of good market design and regulation to ensure reliability of energy supply.

The policy has several concrete objectives for improving energy security. It proposes that the trend to increasing dependence on imported oil be addressed by increasing domestic supply, notably through exploration on federal lands. The policy also considers that nuclear power should be encouraged. Investment in all energy sources is considered necessary, at production, transformation and transportation levels. But the policy does not give much weight to the role energy efficiency could play in improving energy security. Energy security may also be enhanced by improving energy trade and by reducing international political tensions.

Energy-environment issues also receive prominent attention in the National Energy Policy. The US is committed to reduce carbon emissions because it is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC). Because the US has withdrawn from further participation in the Kyoto Protocol, its commitment to reduce carbon emissions is not quantified and has no time limit. Many of the proposed measures could have an impact on carbon emissions, often in association with reductions in other pollutants, but in the absence of quantified targets, carbon emissions will inevitably increase with economic growth in the foreseeable future. There is some scope for the emergence of a unilateral US approach to carbon emissions, which could lead to a degree of convergence of US policy and the policies of adherents to the Kyoto approach.

At this stage, the National Energy Policy is best seen as a set of proposals by the Bush Administration. In the US system of government, significant changes can be expected during Congress's consideration of the policy report. There are also important energy-environment proposals already under consideration in Congress, not originating from the present Administration, which are not reflected fully in the policy report. These have the potential of impacting significantly on the balance of policies that emerge in legislation. The present balance of the parties (Executive – Republican, Senate – Democrat majority, Congress – Republican majority) lends considerable uncertainty to the final outcome. Congressional elections, due during 2002, could be an important influence.

The National Energy Policy proposals will undergo change in response to reactions to the policy, and to the ability of the Administration to translate the recommendations into legislation. What emerges in legislation is likely to be a consensus reflecting stakeholder views that could become the foundation of a longer-term policy. The US government should persevere in the process that the National Energy Policy has started and continue its efforts to ensure that a new and coherent national policy strategy emerges.

The focus of energy policy will continue to be on the development of new technology and the operation of free markets. But it is not clear what will stimulate deployment of new technologies.

In all areas of energy policy, advanced technology is central to the government's response. All areas of the Department of Energy have technology development and deployment as core activities. Nuclear energy is strongly favoured in the policy as a means of securing energy supply and reducing greenhouse gas emissions. Renewable energy development is considered important, but insufficient to meet US needs. Advanced fuels and engine designs are seen as means of improving efficiency of energy use, and of reducing emissions, in transport. Advanced clean coal technologies are seen as the means of combining substantial growth in coal use with environmental objectives.

Development of new technologies is supported by high levels of funding and by government research institutions. High expectations are held for the deployment of new technologies. For example, the present fleet of advanced coal-fired power plants is expected to be replaced with advanced technologies around 2030. However, it is not clear what will motivate generators to move to new technologies in the absence of market signals reflecting the value of avoided carbon emissions, unless costs are brought down to equal those of existing technologies. A similar challenge exists in other areas where advanced technology is expected to play a key role.

Liberalisation of energy markets is also a consistent theme of US energy policy maintained in the National Energy Policy. The crisis in electricity supply in California has retarded, in some cases reversed, progress. The causes of the problems in California are discussed in full later in the report. It is clear that while market design and regulation both showed some faults, the problems encountered can be overcome and important lessons learned from the experience.

In almost every policy area, but particularly in market reform, federal-state relations will influence the outcome. As in other federations, the federal government has only limited jurisdiction to bring about market reform. Regulatory bodies have played an important role in discussing and promoting change. While this process is commendable, it would be desirable for the Department of Energy to promote market reform directly, using co-operative means that avoid jurisdictional conflicts. Reform is uneven across the states, and a national approach is called for.

US energy policy has critically important international repercussions, both as a role model for other countries, and because of the influence of the US economy in all spheres of the international economy.

The US has historically played a critically important role in international energy policy. Its actions triggered the formation of the International Energy Agency in 1974[4]. It has

4. Pilgrims Society Speech (Henry Kissinger, US Secretary of State), December 1973; Washington Energy Conference, February 1974.

since been a leader in designing some of the fundamental building-blocks of current approaches to energy policy. These include, for example, the central role of free markets in energy, international trade in energy as a means of securing energy supply diversity and security of supply, and the use of economic instruments in responding to climate change.

The new policy approach is likely to influence the formation of energy and energy-environment policy worldwide. The focus on energy security is a timely adjustment, as is the discussion of the impact of regulatory policies, including environmental regulations, on economic development. The National Energy Policy's proposals for federal policy intervention and leadership in a vast and diverse country are also important means of countering the influence of low energy prices on consumption, and of co-ordinating policies. Nonetheless, throughout this report, recurring questions arise concerning:

■ The appropriate weighting that should be given to energy trade, rather than domestic production, as a means of ensuring energy security.

■ The use of economic instruments, notably energy pricing, taxation and emissions trading, to place a value on externalities and bring market solutions to many policy issues.

■ The realism of expecting cost-effective and timely deployment of new technology to protect the environment and to improve end-use efficiency, in the absence of strong price signals in the energy market.

Underlying the last two points of concern is the focus of the National Energy Policy on current economic benefits and costs. Insufficient weight is given to environmental costs. This is a key reason for encouraging renewables, and for adjusting energy prices to reflect all costs as a means of achieving cost-effective changes in energy end-use. A transition to a true sustainable development policy will be made more difficult if externalities are not valued by market mechanisms.

RECOMMENDATIONS

The Government of the United States should:

☐ Persevere with the development and implementation of the National Energy Policy to ensure that the eventual outcome is a new and coherent expression of US energy policies, instruments and programmes.

☐ Broaden the use of economic instruments to achieve energy policy goals.

- ☐ Develop constructive federal-state dialogue on a wide range of energy policy issues, with a view to bringing a more consistent national approach to many issues where jurisdictional boundaries may be inhibiting progress.

- ☐ Continue the process of energy market liberalisation with federal government leadership.

4

ENERGY AND THE ENVIRONMENT

In the US as in other countries, the energy sector affects the environment through the local effects of energy exploration, production and distribution, and the release of local and global pollutants. The federal government sets a number of standards and requirements to limit the environmental impacts of energy-using activities, including energy efficiency standards and emission caps. Decisions at federal level are sometimes supplemented by state policies. States set fuel standards for automobiles for environmental reasons and can raise taxes on fuels. In the last few years, individual states have also taken measures to reduce their greenhouse gas emissions.

THE NATIONAL ENERGY POLICY

The National Energy Policy includes a number of recommendations meant to reduce the environmental impacts of energy use additional to environmental efforts to date. The government estimates that measures taken to date have avoided emissions of 242 Mt of carbon dioxide in 2000 (2.7% of total emissions) compared to what they would have been otherwise. Recommendations with beneficial environmental implications include:

- **Energy conservation:** extension of the Energy Star labelling programme, possibly higher energy efficiency standards, extension of education programmes on energy efficiency; review of current funding and performance of past programmes, encouraging the use of combined heat and power.

- **Non-fossil fuel sources:** promotion of renewables through tax credits, possible access to federal land to increase renewable energy production, review of the accomplishments of research efforts on renewable energy, possible public-private partnerships, promotion of nuclear energy.

- **Local and regional pollution:** legislation to reduce emissions of nitrogen oxides, sulphur dioxide and mercury from power generation. The so-called three-pollutants bill is to combine emission objectives with tradable emission allowances, as is currently the case for sulphur dioxide under the Clean Air Act Amendment of 1990 and for nitrogen oxides in some states.

- **Transportation:** review Corporate Average Fuel Economy (CAFE) standards; tax credit for the purchase of hybrid or fuel-cell vehicles; research on fuel cells, intelligent transportation systems and systems to mitigate traffic congestion; programme to reduce emissions and fuel consumption.

- **Research and development on clean energy technologies:** National Climate Change Technology Initiative to evaluate technology research; to enhance private-public partnerships; to recommend demonstration projects of advanced clean technologies; to improve the measurement and monitoring of greenhouse gas emissions; and to offer guidance to strengthen basic research. The US also participates in the Climate Technology Initiative created at the first UNFCCC Conference of the Parties in 1995, which was designed to accelerate clean technology deployment. As part of the research and development programme (see Chapter 10) the Clean Coal Power Initiative seeks to demonstrate emerging technologies in coal-based power and accelerate their deployment. One of the long-term goals of this effort is to demonstrate a suite of technologies to sequester carbon dioxide at a cost of less than US$ 10 per tonne of carbon – amounting to a 1 to 3% increase in power costs. If successful and widely used, such technology would allow burning of fossil fuels to continue without adding carbon dioxide to the atmosphere, at acceptable cost.

- **Promotion of clean energy technologies abroad:** a Clean Energy Technology Exports working group was established to facilitate private-sector efforts to provide clean energy technologies to world markets.

The National Energy Policy has prompted debate on the environmental implications of increasing domestic exploration and energy supply, including oil and gas exploration in the Arctic National Wildlife Refuge.

LOCAL POLLUTANTS

The Clean Air Act Amendment of 1990 introduced the Acid Rain Program to reduce emissions of sulphur dioxide and nitrogen oxides. The resulting US sulphur dioxide allowances trading system has been advanced as a model for an international emissions trading system for greenhouse gases.

Sulphur Dioxide

The Clean Air Act requires electric utilities to reduce emissions of sulphur dioxide to ten million tonnes below their 1980 level in two phases, before and after 2000. Allowances to emit sulphur dioxide are issued to cover actual emissions. Surplus allowances may be bought, sold or traded. Units are free to trade allowances among themselves; and anybody outside the system can also buy, sell or trade allowances. The programmme is administered by the Environmental Protection Agency. The price of allowances is made public by brokerage firms. The Environmental Protection Agency annually auctions 3% of the total allowances.

Phase I covered 263 generating units at 110 mostly coal-based electricity utilities. At the end of Phase I in 1999, emissions were 29% lower than their required total. Units are allowed to "bank" unused allowances, for sale or use at a future date. A large quantity of banked units has been carried over into Phase II. All units under Phase I were in compliance with their objectives. In 2000, non-compliance would have triggered a financial penalty of US$ 2 682 per tonne emitted above the allowances level, and would have lowered the following year's allocation by the same quantity. Two-thirds of all transactions in allowances were between units within the same utility.

Phase II, starting in 2000, tightened emission objectives and extended coverage to smaller and cleaner units (coal, oil and natural gas), and all new utility units. The overall cap during Phase II is 8.95 million tonnes of sulphur dioxide. The price is now around US$ 200 per tonne, much lower than expected. Much of the reduction in cost can be attributed to the availability of low-sulphur coal from Wyoming's Powder River Basin, made cheaper by the deregulation of the railroad sector. As a result, targets were achieved for some units without expensive scrubbing equipment.

Nitrogen Oxides

The Clean Air Act requires a two million tonne reduction in emissions of nitrogen oxides, focusing on coal-fired power generation boilers. Total emissions are capped. The reduction objective was set based on the availability of abatement technology, but the use of that technology is not mandated. Generators may average the emissions of two or more units and can apply for a less stringent emission rate, if they have used the recommended technology but still do not meet the objective. For units covered in the first phase, 1999 emission rates were already 43% below 1990 levels or 18% below the compliance rate. Total emissions were 32% below 1990 levels.

Some regions have established trading programmes such as the NO_x Budget Program of the Ozone Transport Commission in the North-East, and the Regional Clean Air Incentives Market (RECLAIM) programme in southern California. The NO_x Budget Program seeks to reduce summertime NO_x emissions, which cause ozone formation, in the North-East US[5]. The goal is to reduce region-wide emissions as a part of each state's effort to attain the national ambient air quality standard for ground level ozone. Reductions are to take place in two phases, the first phase beginning on 1 May 1999 and the second phase on 1 May 2003. The programme caps summertime emissions at 219 000 tonnes in 1999 and 143 000 tonnes in 2003, less than one-third the 1990 baseline emission level of 490 000 tonnes.

RECLAIM set caps on emissions ranging from 60 000 tonnes in 1994 to 20 000 tonnes in 2003. The system covers about 360 facilities, including power plants. Emission objectives were met in the period 1994 to 1999. Prices started growing significantly in 1997-1998 as emissions approached the cap and in 2000 were ten times higher than in 1999. Emission limits were exceeded in 2000. In light of this problem, and its contribution to an increase in electricity prices in California, prices

5. States participating in the Ozone Transport Commission NOx Budget are Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Maryland, Delaware, the northern counties of Virginia, and the District of Columbia.

were stabilised by excluding power plants of more than 50 MW of capacity until 2003 as a means of lowering demand. Instead, power plants must install pollution control equipment and pay into a fund to reduce emissions in other activities (diesel trucks and equipment at the ports).

States can petition the Environmental Protection Agency to take action to mitigate significant transport of emissions of nitrogen oxides, and states can introduce trading systems. In May 1999, the Federal NO_x Budget Trading Program was established as a model for use by the states.

MTBE (methyl tertiary butyl ether)

MTBE and other oxygenates help reduce NO_x, volatile organic compounds, carbon monoxide and benzene emissions and are used in reformulated gasoline used in high-pollution areas, as required by the federal government. However, MTBE has been found to contaminate drinking water because of storage tanks leakage. One alternative to MTBE is ethanol, but it is a costly alternative for some states, as it must be shipped from Midwest refineries. The oil industry argues that the situation should be clarified at federal level to reduce the number of different fuels marketed in the US.

GREENHOUSE GAS EMISSIONS TRENDS

The US is the world's largest emitter of greenhouse gases. In 1999, 6.7 billion tonnes of carbon dioxide equivalent were emitted, 11.7% above the 1990 level. Like many other IEA Member countries, the US has not met the aim of the United Nations Framework Convention on Climate Change to return greenhouse gas emissions to their 1990 levels by the end of the decade. Energy extraction, production and use account for the majority of such emissions (85.4%), with carbon dioxide from fuel combustion contributing most. The US share in global energy-related carbon dioxide emissions rose from 23% to 24% between 1990 and 1999.

Carbon dioxide emissions from fuel combustion rose by 15.2% between 1990 and 1999, compared with a 10.3% increase in the OECD and an 8.9% increase in the world. Per capita emissions show a similar trend, with a 5.5% increase in the US, a 3.1% increase in the OECD and a 4.2% reduction in global per capita emissions. Faster growth in GDP in the US than in the rest of the world is the most important driver in these trends. Carbon dioxide emissions per unit of GDP have declined faster in the US than in the OECD, also as a result of exceptional growth in GDP of 32% over nine years. This decline owes more to structural changes – the shift of economic activity from one sector to another sector – than to a reduction in the amount of energy used within specific sectors[6]. The US economy is more carbon-

6. Murtishaw S, Schipper L (2001): "Disaggregated Analysis of U.S. Energy Consumption in the 1990s - Evidence of the Effect of the Internet on Efficiency and Structural Change", in *Energy Policy*, forthcoming.

Table 1
Energy Sector Contribution to US Greenhouse Gas Emissions
(% of total greenhouse gases)

	1990	*1999*
Carbon dioxide	80.2	81
Methane	4.1	3.2
Nitrous oxide	1.1	1.2
Total share of energy-related emissions	85.43	85.41
Total energy-related emissions (Mt CO_2 equivalent)	5 158.5	5 762
Total GHG emissions (Mt CO_2 equivalent)	6 038.2	6 746

Source: Environmental Protection Agency, *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-1999*, EPA 236-R-01-001, April 2001.

intensive than most of other IEA Member countries. It has the highest level of energy-related carbon dioxide emission per capita among the OECD countries.

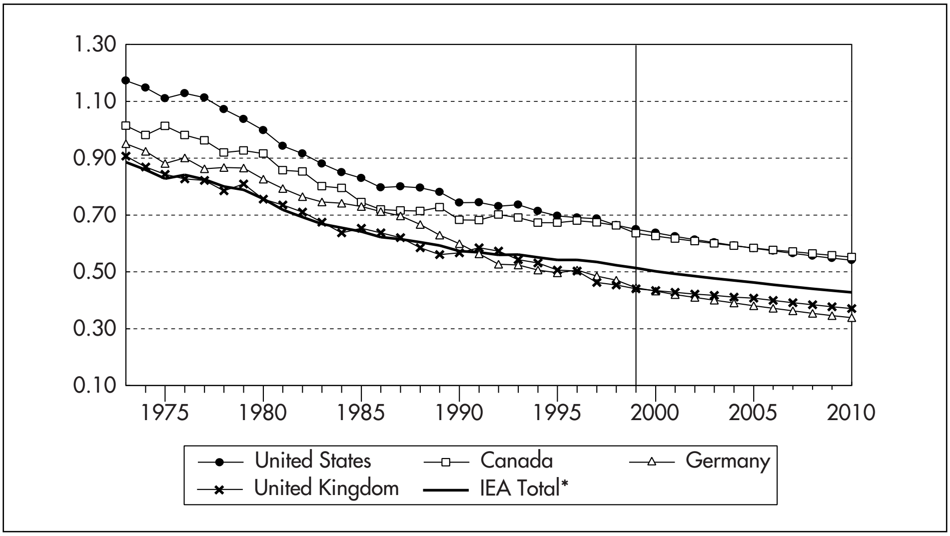
Electricity contributed 62% to the gross increase in emissions; and transport contributed 35%. Electricity generation will remain fossil-fuel-intensive and dominated by coal, which accounts for more than 50% of total generation. Natural gas is projected to account for a growing share. Nuclear, hydro and new renewable energy sources are unlikely to alter this picture significantly in the medium term without additional policy interventions. The fastest growing renewable source, wind, is experiencing unprecedented growth (8% per year since 1990, with a 32% increase in installed capacity between 1998 and 1999 alone), but amounts to only 0.1% of overall electricity supply at present.

Road transport emissions have risen by 24% since 1990, adding 5.6% to the 1990 emission level. The average fuel economy of cars and light trucks reached a twenty-year low in 1999 of 23.8 miles per gallon, or 9.9 litres per 100 km, compared with 25 miles per gallon in 1985. The combination of a low fuel economy with a growing number of vehicles, relatively low gasoline prices, and slightly increasing travel – including in road freight – explains the growth in oil consumption and related carbon dioxide emissions.

Direct carbon dioxide emissions from manufacturing and construction have declined by 10% since 1990. However, electricity use in industry rose by 27% over the same period, shifting part of industry's direct emissions to the power sector.

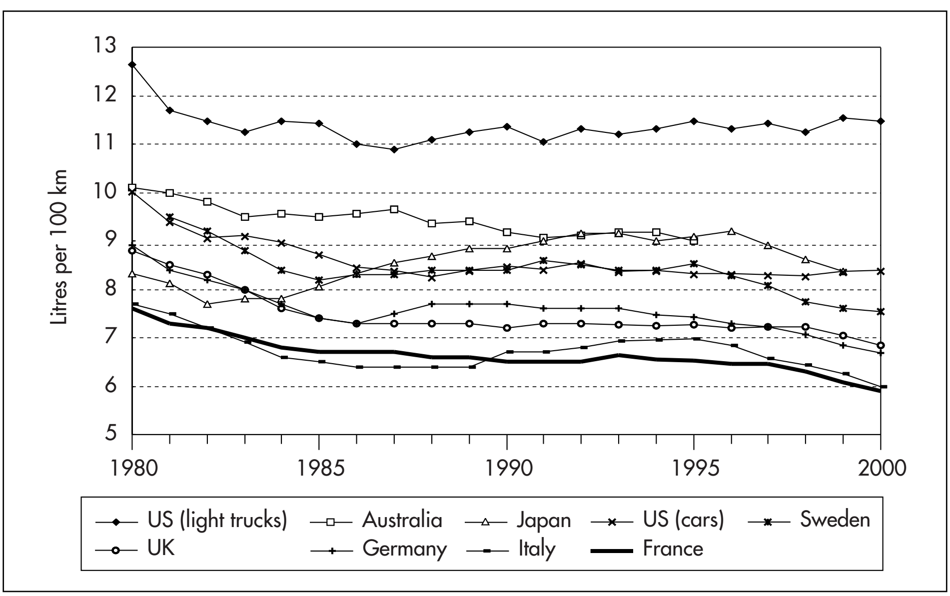
The contribution of each fossil fuel to energy-related carbon dioxide emissions has remained fairly stable over the last decade: coal, oil and gas currently account for 38%, 40% and 22% respectively.

Figure 5
Energy-related Carbon Dioxide Emissions per GDP in the United States and in Other Selected IEA Countries, 1973 to 2010
(CO_2 Emissions/GDP using 1995 prices and purchasing power parities)



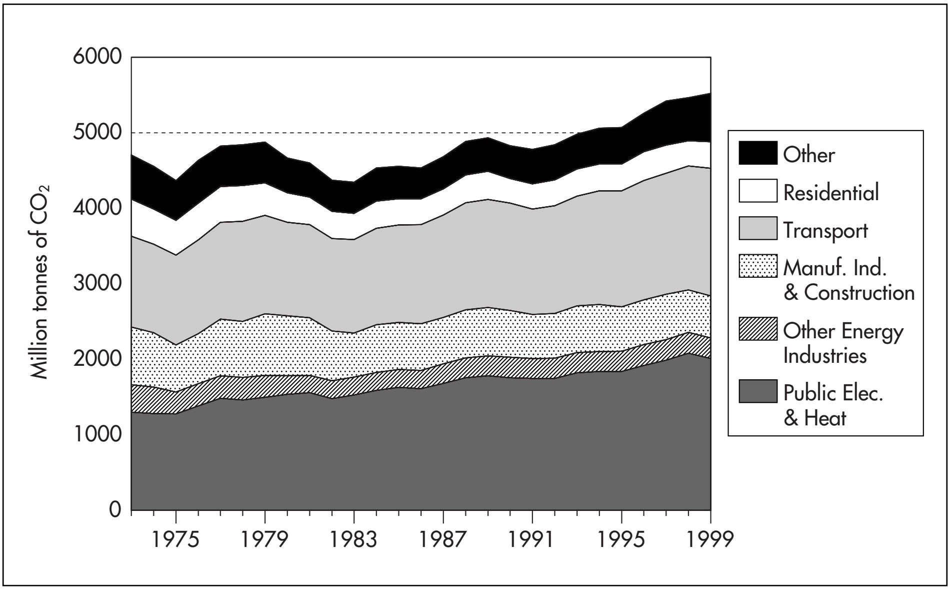
* Excluding Korea and Norway from 2000 to 2010.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001; *National Accounts of OECD Countries*, OECD Paris, 2001; and country submissions.

Figure 6
New Car Fuel Economy in Selected IEA Countries, 1980 to 2000



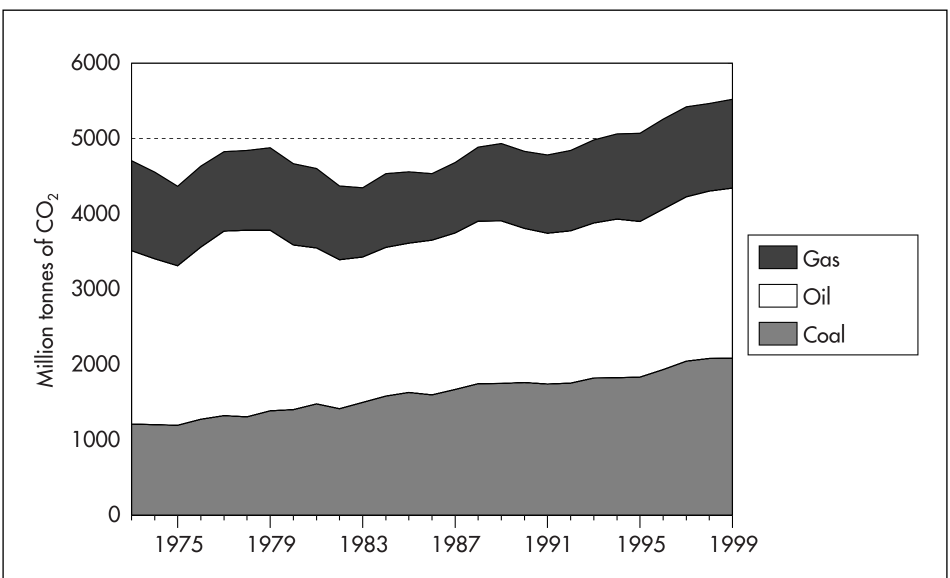
Source: *Saving Oil and Reducing CO_2 Emissions in Transport*, IEA/OECD Paris, 2001.

Figure 7
Carbon Dioxide Emissions by Sector*, 1973 to 1999



* Estimated using the IPPC Sectoral Approach.
Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2001.

Figure 8
Carbon Dioxide Emissions by Fuel*, 1973 to 1999



* Estimated using the IPPC (Inter-governmental Panel on Climate Change) Sectoral Approach.
Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2001.

In summary, the relatively high growth in US carbon dioxide emissions, when compared with other OECD countries, can be attributed to:

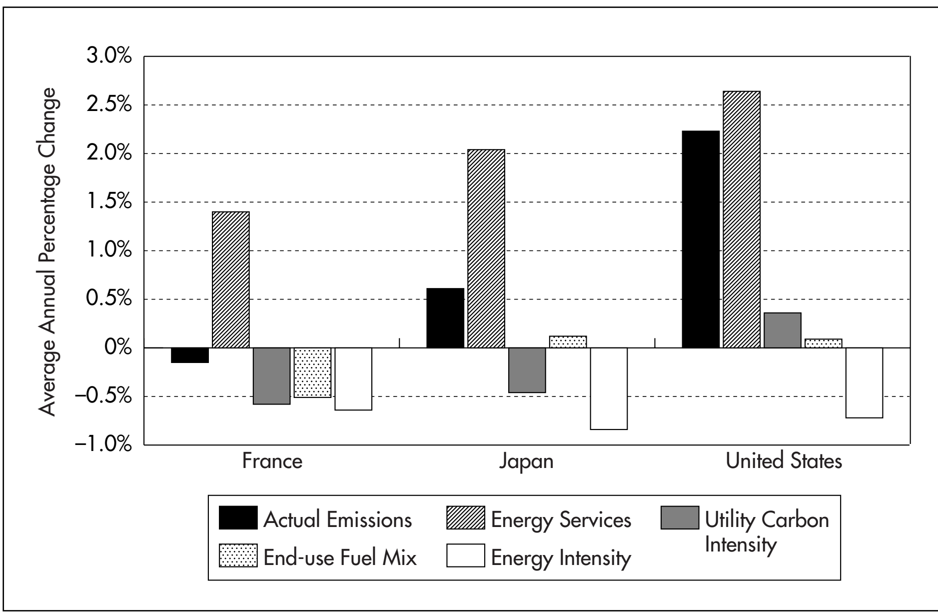
- A high growth in energy services (demand for transport, heating and cooling, industrial production, most of which is reflected in high GDP growth).

- A more carbon-intensive electricity mix, offset, in part, by a reduction in the energy intensity of all activities.

The Energy Information Administration projects that under current policy, carbon dioxide emissions from fossil fuels in 2020 will be 54% higher than in 1990, in spite of a reduction in the share of coal in total power generation from 52% in 2000 to 44% in 2020.

Figure 9

Changes in Carbon Dioxide Emissions in Selected IEA Countries, 1990 to 1998



Source: *Energy Indicators and Sustainable Development*, IEA/OECD Paris, 2001.

CRITIQUE

The US is undertaking a significant technology development effort, but will need to take concrete policy action to fulfil the goal of the United Nations Framework Convention on Climate Change.

The US has withdrawn from the Kyoto Protocol but it remains committed to the United Nations Framework Convention on Climate Change and the goal to stabilise concentrations of greenhouse gases. Policy intervention is needed to meet this long-term goal. International efforts will achieve little to stabilise the global climate if US emissions continue to increase.

The basic science is still questioned. A government-commissioned review of the scientific knowledge of climate change by the US National Academy of Sciences confirmed that "... there is general agreement that the observed warming is real ... Whether it is consistent with the change that would be expected in response to human activities is dependent upon what assumptions one makes ..." The US Energy Information Administration considers from this statement that the National Academy of Sciences reached no conclusion about warming induced by human activities[7]. Nevertheless, a Cabinet-level review of US climate change policy in 2001 identified main areas for research, both on climate science and technology developments to secure long-term reductions in greenhouse gases, resulting in the National Climate Change Technology Initiative. The approach is geared towards long-term technological development and international efforts to encourage climate-friendly technology and practices.

US policy is focused on technology development and on a range of conservation measures, rather than market measures such as energy pricing and taxes, and carbon dioxide cap-and-trade programmes being developed in other IEA countries. There is no target or timetable to reduce the country's greenhouse gas emissions.

Current projections show rapidly rising energy-related carbon dioxide emissions in the US, driven by growth in demand for electricity and transportation. Federal programmes have successfully developed many climate-friendly technologies and practices in these areas. But funding for the Department of Energy's research development budget may have peaked and it is doubtful that widespread application of new technologies will take place fast enough to place the country on a lower emission path in the near future. Other measures would be required. The possibility of a revision of the CAFE standard is welcome in this regard. Similarly, new and extended energy efficiency standards for appliances should also be encouraged, as they have probably had a marked impact on certain residential and commercial end-uses in the past.

The National Energy Policy stresses the importance of nuclear and renewable sources and seeks to promote more energy efficiency. All three could reduce carbon dioxide emissions. But the policy also aims to increase supply of coal, oil and gas. Carbon dioxide emissions from fossil fuels can be offset by clean coal technologies, but only sequestration, capture and storage are likely to have sufficient impact on emissions and all are at an early stage of development. According to the Energy Information Administration's 2020 projections, even a stringent carbon dioxide constraint would not trigger the deployment of capture and storage technologies by 2020. Fossil fuel use in power generation would still contribute to

7. Comments on draft of this report. The Office of Science in the Department of Energy made a similar comment.

the build-up of greenhouse gases in the atmosphere[8, 9]. Energy-related carbon dioxide emissions are therefore unlikely to depart radically from their current trend without new measures.

A market-based approach to reduce energy-related emissions other than carbon dioxide is commendable but postponing action on carbon dioxide may increase the cost for the power sector in the longer term.

The US has several innovative policy approaches to reduce emissions related to the production and use of fossil fuels. Cap-and-trade programmes have been implemented for sulphur dioxide at the federal level, and for other emissions at a regional or state level. The federal government is now introducing a proposal for a three-pollutants bill to reduce emissions of sulphur dioxide, nitrogen oxides and mercury by 2008.

The three-pollutants bill, if passed, would require industry to invest in equipment to comply with standards set for sulphur dioxide, nitrogen oxides and mercury. But the US is also committed to reducing greenhouse gas emissions under the United Nations Framework Convention on Climate Change (UNFCCC). Although no decisions have been announced on carbon dioxide, the US commitment under the UNFCCC requires action at some unspecified date, and consequently further investment by industry. Because the government is postponing its decision on carbon dioxide, energy-using companies face the risk of having to prematurely retire productive capital stock put in place to comply with the three-pollutants bill when action is taken in the future to reduce carbon dioxide levels. It may be more cost-effective to legislate now on carbon dioxide as well as sulphur dioxide, nitrogen oxides and mercury, or at least to foreshadow future requirements on carbon dioxide, so that companies can take carbon dioxide into account when investing in new capital stock.

Analysis by the Energy Information Administration confirms that the power sector's approach to reducing any one pollutant would depend very much on whether and how other pollutants, including carbon dioxide, are addressed. A clear and early signal on the government's approach to carbon dioxide emissions would greatly minimise regulatory risk for the power sector and other stakeholders. A number of voluntary initiatives by US industry indicate that government action to reduce emissions is expected at some point.

The Energy Information Administration has found that average electricity prices could increase by up to 3% to 4% (assuming mercury emissions were capped), but

8. Energy Information Administration, Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants: Sulfur Dioxide, Nitrogen Oxides, Carbon Dioxide, and Mercury and a Renewable Portfolio Standard, SR/OIAF/2001-03, July 2001.
9. The research goal is for a cost of sequestration of US$ 10 per tonne of carbon; the Energy Information Administration study projects carbon dioxide allowance prices as high as US$ 150 per tonne of carbon, but no penetration of sequestration technology by 2020.

sulphur dioxide and nitrogen oxide emissions could be reduced by 75%, and mercury emissions by 90%, compared with 1997 levels. Capping these three pollutants would not significantly affect the overall fuel mix, as "end-of-pipe" technologies would be the primary solution to reduce emissions.

Adding a domestic cap on carbon dioxide emissions from the power sector would have more radical effects. Natural gas would become the fuel of choice instead of coal. Electricity prices would grow by about 6% in the period 2010 to 2020. If an obligation to produce 20% of all electricity with renewable energy by 2020 were required by a portfolio standard, final electricity prices would rise more slowly. Renewable energy could potentially substitute for natural gas and lower both gas and gas-based electricity prices. In spite of a high price of carbon dioxide allowances, the analysis does not consider carbon sequestration likely although this option seems to be the cornerstone of the government's long-term strategy to mitigate carbon dioxide from power generation.

International co-operation and market-based instruments to reduce greenhouse gas emissions could bring down the cost of action in the US.

For the electricity industry, a unilateral domestic approach to reducing greenhouse gas emissions may be more costly than participation in the Kyoto Protocol. The latter allows international transactions and a wider coverage of the domestic trading regime beyond a single sector and a single greenhouse gas (carbon dioxide). These options would lower the cost of reductions in the US power sector. An international trading system could be arranged regionally. For example, the New England states and eastern Canada provinces have announced the objective of a 10% reduction in greenhouse gas emissions. The North American Free Trade Agreement could also offer a framework for international co-operation on climate change policy, including through some form of emissions trading. Ideally, the US would, as far as possible, develop its policies in a manner consistent with participants in the Kyoto Protocol so that an international trading system might emerge, perhaps as a voluntary action by companies seeking to minimise the costs of complying with domestic legislation.

RECOMMENDATIONS

The Government of the United States should:

- ☐ Acknowledge the influence of US emissions on global greenhouse gas emission levels and climate:
  - Quantify the impact of current energy-environment policies on projected greenhouse gas emissions at the national and global levels.

- Develop specific targets for the control of US greenhouse gas emissions.

- ☐ Complement current research and development efforts on climate-friendly technologies with a policy framework, including economic instruments, designed to achieve significant reductions in greenhouse gas emissions over a specified period.

- ☐ Take action on carbon dioxide to complement the three-pollutants bill, or announce its intentions on carbon dioxide, so that companies can take carbon dioxide into account when investing in new capital stock to comply with any new environmental goals.

- ☐ Develop greenhouse policies consistent with the flexibility mechanisms of the Kyoto Protocol so that US industry has the option of participating in a future international market in emissions.

- ☐ Continue to develop and apply market-based policy responses to local pollutants.

ENERGY EFFICIENCY

ENERGY DEMAND TRENDS

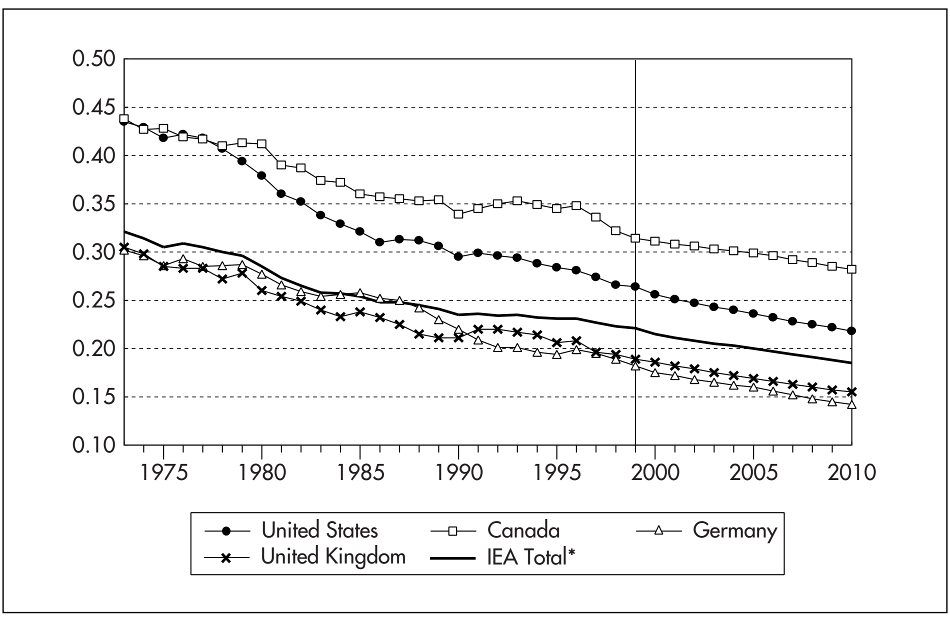
In 1999, the US consumed 1 476 Mtoe of energy, of which 85.6% was obtained from coal, petroleum and natural gas. Most of the coal is consumed in the electric utility sector to generate electricity for use in the building and industrial sectors. Most of the petroleum is consumed in the transport sector. Relatively equal amounts of natural gas are consumed in the building and industrial sectors, and a smaller amount is consumed by electric utilities to generate electricity that is sold to the end-use sectors.

Industrial Sector

The industrial sector accounted for 29% of national energy consumption in 1999. Oil accounted for the largest portion. Manufacturing employs roughly 19 million people, produces more than 90% of the economy's materials, and accounted for nearly 30% of US economic growth in the last decade.

Figure 10

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

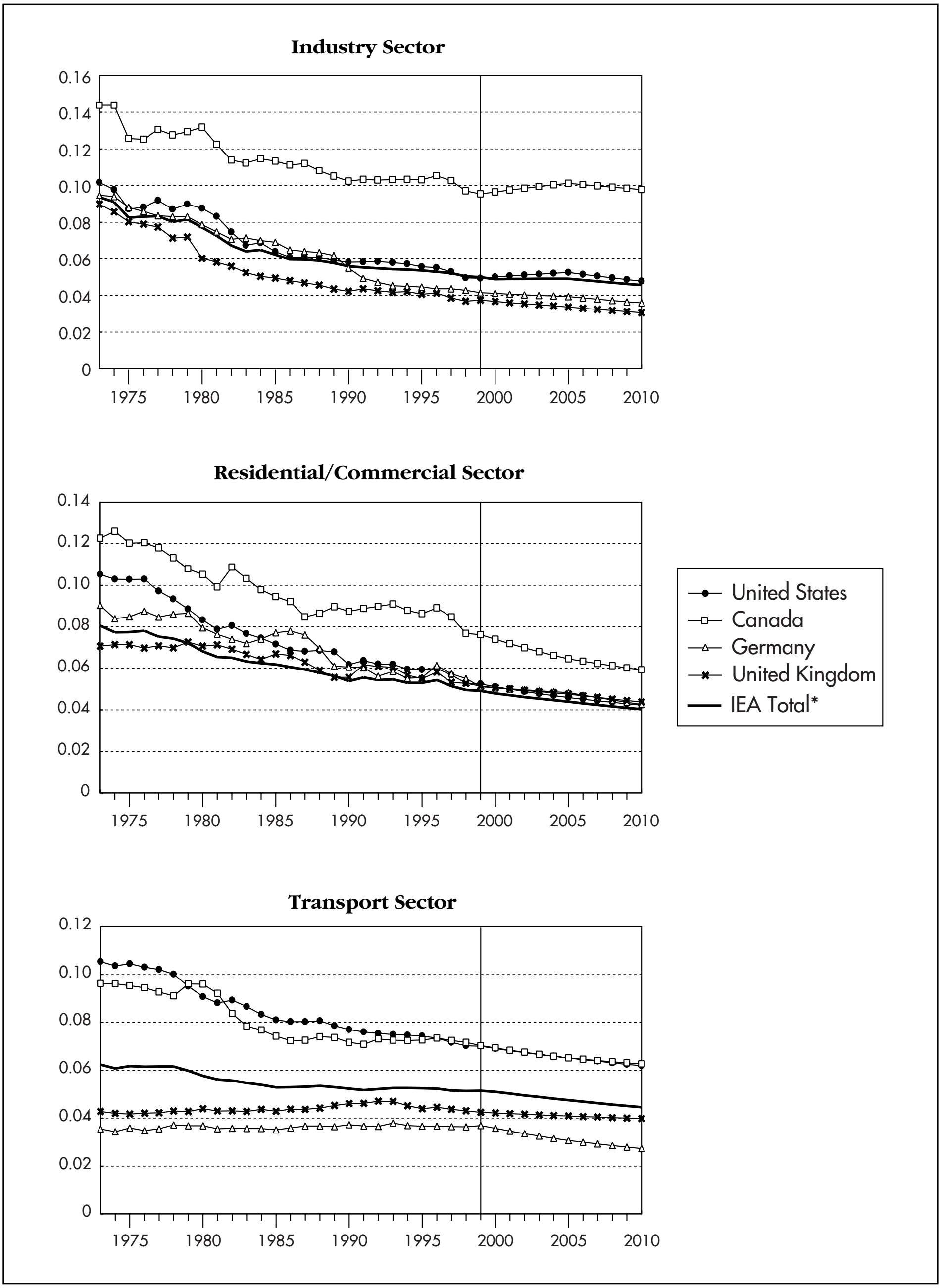


* Excluding Korea and Norway from 2000 to 2010.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001; *National Accounts of OECD Countries*, OECD Paris, 2001; and country submissions.

Figure 11

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



* Excluding Korea and Norway from 2000 to 2010.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001; *National Accounts of OECD Countries*, OECD Paris, 2001; and country submissions.

Substantial reductions in the amount of energy used per unit of industrial output occurred from 1972 to the mid-1980s. Over two-thirds of these reductions are attributable to efficiency improvements and the remainder to a continuing shift away from energy-intensive industries. Industrial energy-intensity increased from 1985 to 1991 because of increased output of energy-intensive products, growing electricity use and declining real energy prices. Industrial energy intensity declined significantly during the 1990s. Industrial output rose by 50% while industrial energy use increased by only 12%.

Industrial energy use is concentrated in a relatively small number of industries, mainly the major materials processing and extraction industries. Nine of these industries alone account for about two-thirds of industrial energy consumption: petroleum refining, chemicals, forest products, agriculture, steel, mining, aluminum, metal-casting, and glass industries. Energy use and waste disposal are important fractions of their operating costs and end-product costs.

Transport

The transport sector accounted for 40.7% of total final consumption of energy in 1999. Petroleum accounts for 97% of the fuel consumed in this sector. The sector accounts for roughly two-thirds of all US petroleum consumption. Combustion of transportation fuel accounts for about half of the air pollutants that contribute to the formation of ground-level ozone and urban smog, and about one-third of US emissions of carbon dioxide.

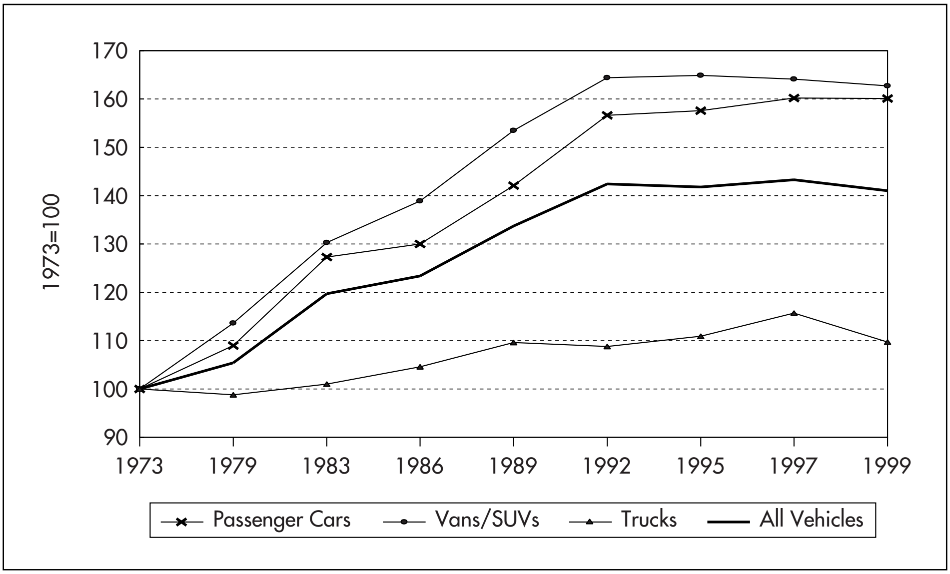
Highway vehicles account for 76% of the total energy required for transportation, aircraft for 9%, watercraft for 5%, off-highway vehicles for 3%, and rail for 2%. Since 1990, energy used by cars and light trucks, primarily for passengers, has increased at a rate of 1.8% annually, to eight million barrels per day in 1999. Energy used by trucks and buses to carry freight and commercial passengers increased at the rate of 2.4% annually, to two million barrels per day in 1999.

In 1994, the last year for which complete survey data are available, nearly 85 million US households owned or had access to at least one vehicle. In that year, the 157 million household vehicles travelled some 1.8 trillion miles and consumed 91 billion US gallons (344.5 billion litres) of petrol. All of these figures have continued to increase with population growth.

Fuel economy for all types of vehicles, including passenger vehicles, light trucks (vans and sport utility vehicles known as SUVs), and trucks, has plateaued for about the last decade. In the case of the fleets of passenger vehicles and light trucks, this reflects the facts that Corporate Average Fuel Economy (CAFE) standards for new vehicles have not been tightened since the early 1980s and that US petrol prices do not encourage efficiency improvements.

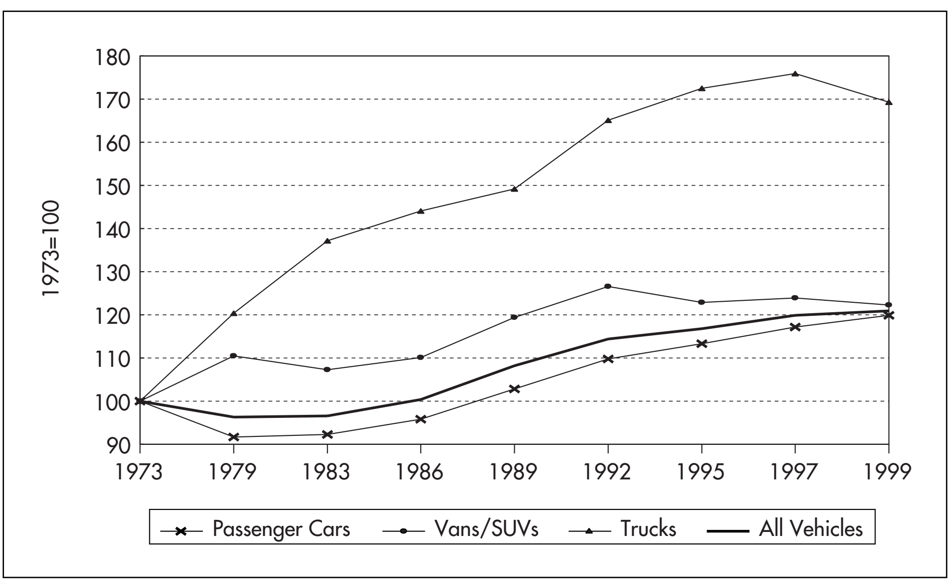
The CAFE standards were a major factor behind the improvement in average passenger car fuel economy from 13.4 miles per gallon (mpg, 5.6 litres per 100 km) in 1973 to

Figure 12
Trends in Vehicle Fuel Economy, 1973 to 1999
(miles per gallon or mpg)



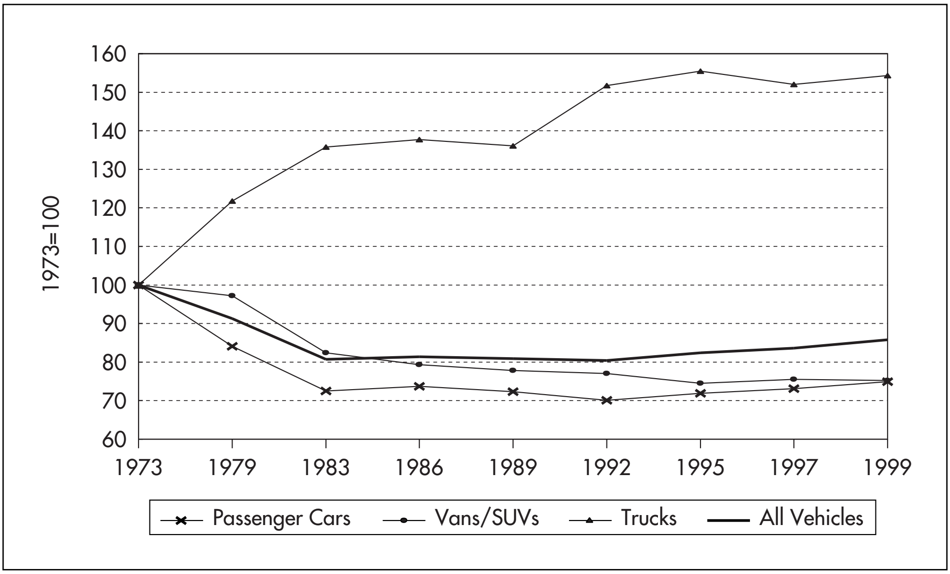
Source: Country submission.

Figure 13
Trends in Vehicle Mileage, 1973 to 1999
(miles per vehicle or mpv)



Source: Country submission.

Figure 14
Trends in Vehicle Fuel Consumption, 1973 to 1999
(gallons per vehicle or gpv)



Source: Country submission.

21 mpg (8.7 litres per 100 km) in 1992 and a high of 21.5 mpg (8.9 litres per 100 km) in 1997. Distance driven per vehicle and fuel consumption per vehicle (which move in tandem since fuel economy is flat) have continued to increase modestly for passenger vehicles at around 1% per year in the last decade, while they have decreased slightly for light trucks and increased slightly for other trucks. However, the average fuel economy for *new* automobiles and light trucks declined from 25 mpg (10.4 litres per 100 km) in 1985 to a twenty-year low of 23.8 mpg (9.9 litres per 100 km) in 1999 – primarily because of a growing fraction of light trucks and SUVs.

Buildings

Homes and commercial buildings consumed about 30% of US energy in 1999. They use more than two-thirds of all the electricity generated. The growth in the economy, as well as the rising population, is leading to more, larger and better equipped homes, resulting in increasing energy consumption in this sector.

In 1997, energy consumption per household averaged 2.55 toe. Household energy is consumed in four primary applications: space heating (51%), appliances (26.5%, up dramatically from 23.4% in 1993 because of greater penetration of computers and other conveniences), water heating (18.7%), and air-conditioning (4.1%, down from 4.5% in 1993, despite demand growth, because of more efficient air-conditioning units). Natural gas was the primary source of energy for space and water heating, providing the main source of heat in fifty-three million households (more than half the total) while electricity was the main heating source in twenty-nine million households. Electricity was essentially the only source of energy used for air-conditioning.

During the 1970s and much of the 1980s, the residential sector saved proportionately more energy than any other sector as energy use per household was cut by more than a third. Residential energy use per household declined rapidly immediately following the second oil price shock in 1979, from 3.5 toe in 1978, to 3.2 toe in 1979, to 2.6 toe in 1982. It has since fluctuated, declining further in 1990, rebounding slightly in 1993, and declining again to 2.55 toe in 1997, the last year for which data are complete. Efficiency improvements continue, but they have been more than offset by increases in the number of households, amount of living space per capita, and penetration of major energy-using equipment.

Most indicators of commercial energy efficiency improved substantially following the 1979 oil price shock, but the indicators are more mixed after the mid-1980s. Recently, as shown in Table 2, reductions in energy consumption appear to have been more marked when measured per employee than when measured per square foot, implying that more employees are occupying less space. In the 1992 survey, as shown in Table 3, new commercial buildings (built from 1990 to 1992 inclusive) appeared to be substantially more fuel-efficient than the average commercial buildings in place. In the 1995 survey, however, new commercial buildings (built from 1993 to 1995) appeared to be somewhat less efficient than the average buildings in place, perhaps reflecting where the buildings are located and higher energy use for air-conditioning, for example.

Energy Consumption by Sector

Overall, a general trend of declining demand can be seen in the four years following the second oil price shock in 1979, followed by fairly steady growth in demand since 1983.

Table 2

Commercial Sector Energy Consumption – Per Square Foot, Per Employee

(thousand Btu)

Year	*Per Square Foot*	*Per Employee*
1979	115.0	85.0
1983	98.2	65.7
1986	86.6	68.6
1989	91.6	81.9
1992	80.9	77.1
1995	90.5	69.3

Btu: British thermal unit.

Note: 1 kBtu = 0.000025199 toe.

Source: Department of Energy.

Table 3

Commercial Sector Energy Consumption – All Buildings, New Buildings

(thousand Btu consumed per square foot)

End-use	*All Buildings*		*New Buildings*	
	1992	*1995*	*1990-92*	*1993-95*
Space heating	28.2	29.0	20.3	24.3
Cooling	6.8	6.0	6.8	7.9
Ventilation	2.5	2.8	3.6	3.2
Water heating	12.6	13.8	7.9	11.7
Lighting	17.1	20.4	17.9	22.7
Cooking	3.3	3.7	2.1	3.3
Refrigeration	2.0	3.1	1.1	7.4
Office equipment	3.0	5.7	4.9	4.9
Other	5.3	6.1	4.7	6.8
All end-uses	80.9	90.5	69.3	92.2

Note: 1 kBtu = 0.000025199 toe.

Source: Department of Energy.

ENERGY EFFICIENCY AND CONSERVATION POLICY

The National Energy Policy outlines the federal government role as:

- Disseminating timely and accurate information regarding the energy use of consumers' purchases.
- Setting standards for more energy-efficient products.
- Encouraging industry to develop efficient products.
- Maintaining programmes like the Energy Star programme.
- Researching technologies that improve efficiency and conservation.

The President has directed the Secretary of Energy to improve the energy intensity of the US economy through the combined efforts of industry, consumers, and federal, state, and local governments.

Industry

The Office of Industrial Technologies seeks to reduce projected annual industrial energy consumption by 10 quadrillion Btus by 2020. Major elements of the approach are as follows:

- Focus on energy-intensive and environmentally sensitive industries: nine energy-intensive industries are being targeted to reduce energy consumption per unit of output by 25% from 1990 levels.

- Creating industry visions: industries are encouraged to define their long-term goals, identify their most critical needs for the future, and enter into public-private partnerships to share the costs and risks of research.

- Developing a strategic path for research, development and demonstration: based on its vision, each industry develops one or more technology roadmaps. The published roadmaps[10] help align public and private research investments to goals in common.

- Investing co-operatively in strategic research, development and demonstration projects: costs are shared in projects that address an industry's priority needs and significantly reduce energy use or improve environmental performance.

- Establishing partnerships with industry: partnerships within industry and between industry and government have proven to be the most effective approach for solving complex technological challenges that affect whole industries.

- Leveraging investment: partnerships are encouraged to network with other government agencies and industrial organisations to tap their technological and financial resources.

- Involving the states: the State Energy Program encourages state-level implementation of roadmaps and participation in the national process.

Transport

The Office of Transportation Technologies supports the development and use of advanced vehicle technologies and fuels which reduce demand for petroleum, decrease emissions of criteria air pollutants, reduce emissions of greenhouse gases, and enable the transportation industry to sustain a strong, competitive position in domestic and world markets.

The National Energy Policy recommends:

- Establishing new Corporate Average Fuel Economy (CAFE) standards and consideration of other, market-based approaches to increasing the national average fuel economy of new motor vehicles.

10. The roadmaps for each partner industry are available on the web site, **www.oit.doe.gov**

- Review and promotion of congestion mitigation technologies.

- A tax credit for fuel-efficient vehicles, and a temporary, efficiency-based income tax credit for purchase of new hybrid fuel-cell vehicles between 2002 and 2007.

Support is already given to Intelligent Transportation Systems, such as traveller information/navigation systems, freeway management, and electronic toll collection; fuel-cell-powered buses; a new clean fuel formula grant programme for buses; and programmes that reduce emissions and fuel consumption from long-haul trucks.

Four complementary programmes promote the use of alternative fuels:

- The Department of Energy's Clean Cities programme seeks to achieve 100% use of alternative fuel vehicles in proven niche markets, such as taxis, airport shuttles, transit buses, school buses, delivery fleets, and welfare and work shuttles. Competitive grants are used to fund infrastructure development projects.

- The Testing and Evaluation programme provides reliable information on the performance of alternative fuel and hybrid fuel-cell vehicles. The programme is integrated with the expansion of the federal fleet of alternative fuel vehicles, which now numbers more than 45 000. The current focus of the programme is to test the performance of medium- and heavy-duty hybrid-electric vehicles.

- The Replace Fuels Program analyses the implementation of alternative fuels programmes and makes recommendations for additional programmes and policies needed to meet federal goals.

- The Advanced Vehicle Competitions bring together government, industry and university participants to demonstrate the use of advanced power plants, alternative and reformulated fuels, and advanced lightweight and propulsion materials technologies. The current focus is on advanced large SUVs and trucks.

At the state level, California has adopted a low-emission vehicle programme that establishes stricter emission standards that are required under the Clean Air Act. The California programme includes the mandated sale of "zero-emission" vehicles in sufficient numbers to represent 10% of total sales in the state by 2003, with manufacturers voluntarily introducing such vehicles earlier.

The Ozone Transport Region, composed of thirteen states in the North-East which represent 25% of the US light-duty vehicle market, has also adopted the California low-emission vehicle programme, with individual states given the option of adopting the California mandate for zero-emission vehicles. New York and Massachusetts have adopted the zero-emission vehicle sales mandate. As a possible alternative to the production of zero-emission vehicles, American vehicle manufacturers have offered to produce low-emission vehicles throughout the country.

Residential/Commercial Sector

The fragmentation of the construction and building operation and maintenance industries poses a particular challenge to improving the energy efficiency of this sector. The Office of Building Technology, State and Community Programs, administers a research, development and deployment programme in partnership with industry and state and local governments to meet this challenge.

The National Energy Policy recommends a balanced use of market transformation, standards, education, and assistance to low-income families to advance energy efficiency in the building sector. The policy recommends:

- Expanding the Energy Star programme beyond office buildings to include schools, retail buildings, health care facilities, and homes.

- Extending the Energy Star labelling programme to additional products, appliances, and services.

- Strengthening public education programmes related to energy efficiency.

- Improving the energy efficiency of appliances by supporting the appliance standards programme for covered products, and by setting higher standards where technologically feasible and economically justified.

- Expanding the scope of appliance standards, setting standards for additional appliances where technologically feasible and economically justified.

- Developing educational programmes related to energy development and use.

- Mitigating the impact of high energy costs on low-income consumers by increasing funding for the Weatherization Assistance Program and the Low Income Home Energy Assistance Program.

The Office of Buildings Research and Standards develops, implements and co-ordinates research and development to improve the energy efficiency of building components. These components are integrated into building energy systems through system design and regulatory activities. The programme addresses both the building envelope (walls, windows, roofs) and equipment (heating and cooling equipment, lighting, etc.) and their integration into optimal "whole building" designs. The office develops building design computer software and other tools to allow architects and others to apply this integrated design approach to individual buildings. The office develops voluntary building energy codes, mandatory codes for federal buildings, and minimum appliance efficiency standards. The office also develops test procedures for documenting energy use for appliance labels, the appliance standards programme, the Energy Star programme and related deployment strategies.

The Office of Building Technology Assistance accelerates the adoption of energy efficiency and renewable energy technologies by addressing barriers inhibiting investment in these technologies. There are four major programmes:

- The Weatherization Assistance Program provides cost-effective services to low-income families who otherwise could not afford the investment, giving priority to households with elderly members, persons with disabilities, and children.

- A companion programme, called Weatherization *Plus,* greatly increases the number of families served and the energy saved through a cost-sharing approach with the states.

- The Community Energy Program provides federal energy efficiency assistance for community leaders and covers land-use planning, water and wastewater treatment in addition to building construction and retrofit projects.

- The Energy Star programme provides a trademark name to the home appliances and home designs that are highly efficient and cost-effective.

Efficiency Standards

The National Appliance Energy Conservation Act of 1987 set efficiency standards and established schedules for mandatory review of standards for each covered product, and strengthened the federal pre-emption of states in appliance standards matters. Residential products covered include refrigerators and freezers, room air-conditioners, central air-conditioners, clothes washers and dryers, and several other appliances. Some of these standards set minimum energy efficiency levels, while others are prescriptive (for example, clothes washers were required to have a cold-rinse option). The Energy Policy Act of 1992 established minimum standards for commercial and industrial equipment, including commercial heating and air-conditioning equipment, water heaters, and electric motors.

Efficiency standards are maintained by the Department of Energy for most major residential appliances and much commercial and industrial equipment. In 2000, the department published amended standards for commercial and industrial fluorescent lamps that essentially require the use of electronic ballasts. These standards will begin to go into effect in 2005. In 2001, the department published amended standards for clothes washers, residential water heaters and commercial heating, air-conditioning and water heating equipment. The clothes washer standards will require a 22% reduction in energy use by 2004 and a 35% reduction by 2007. The residential water heater standards go into effect in 2004 and will require a 4% improvement in the energy efficiency of electric water heaters and an 8% improvement in gas water heaters. The standards for the commercial products cover eighteen product categories of commercial air-conditioners, heat pumps, furnaces, water heaters and hot water storage tanks. These standards become effective in 2003 and 2004.

Federal Energy Management Program

The federal government is the largest single energy consumer. In 1999, the federal government consumed nearly 1.1% of all the energy consumed in the US. The Federal Energy Management Program aims to reduce the cost and environmental impact of government energy consumption by promoting energy efficiency, water conservation, and the use of renewable energy, and by managing utility costs in federal buildings, facilities and operations. Heads of executive departments and agencies have been directed to conserve energy use. Agencies located in regions where electricity shortages are possible were directed to conserve especially during periods of peak demand.

Between 1985 and 1999, the government achieved a site-based reduction in energy intensity of 21.1% (energy consumption per square foot). The programme goals for 2005 and 2010 are a 30% and 35% efficiency improvement in federal buildings from the 1985 baseline.

Power Energy Efficiency and Conservation

The electric power sector is the largest direct consumer of energy in the US, using 36% of all primary energy consumed annually in 1996.

The National Energy Policy recommends:

- Research and development on transmission reliability, including distributed energy resources, which moves power generation closer to its end-use.

- Measures to advance the use of combined heat and power projects, including encouraging developments at brownfields sites, guidance to encourage the development of well-designed combined heat and power units, and flexibility in environmental permitting.

- Shorter depreciation life for combined heat and power projects or to provide investment tax credits.

The Distributed Energy Resources programme is developing affordable distributed energy resources. The programme seeks to match the thermal, electrical and mechanical power technologies to the requirements of commercial, residential, utility, and industrial customers. Barriers include a lack of interconnection standards, building and fire codes, and siting and permitting rules.

CRITIQUE

Energy efficiency is considered by the National Energy Policy to be an important alternative to expanding energy supply, but insufficient to cope with rising energy demand.

The National Energy Policy acknowledges the role of energy efficiency but considers that efficiency improvement is not a sufficient response to cope with the scale of projected growth in US energy demand as a result of economic growth. The policy judges that the population will not tolerate reductions in energy services nor higher energy prices.

This viewpoint limits the scope for proactive promotion of energy efficiency policies and programmes. Important measures are announced in the National Energy Policy, but a question arises as to how vigorously they will be pursued and how inevitable conflicts between the objectives of improving efficiency for environmental goals on the one hand, and meeting consumer demands for low-price energy services on the other, will be ultimately resolved.

The policy on energy efficiency lacks concrete formulation at present. The policy envisages the combined efforts of industry, consumers and governments at all levels, but does not identify the mechanisms by which this would be achieved. There are important recommendations in the National Energy Policy on energy conservation, which may lower the negative impacts on the environment of energy consumption, and have benefits for the economy and the security of energy supply. These include the promotion of combined heat and power, the extension of the Energy Star labelling scheme and the revision of Corporate Average Fuel Economy (CAFE) standards for automobiles. But little may be achieved in the near term. It will be important to quantify the expected and actual impact of the conservation measures proposed in the National Energy Policy, and to monitor progress.

Maintaining high-quality energy statistics is a fundamental requirement for sound policy formulation.

Since 1998, the Energy Information Administration's consumption survey area has undergone several major changes in its efforts to maintain or improve data quality while running a cost-effective information programme. Many of the changes have been made in response to budget pressure. For example, in 1999 the Commercial Buildings Energy Consumption Survey was conducted using computer-assisted telephone interviewing rather than personal interviews, as a cost-saving procedure. The sample size for the 1998 Manufacturing Energy Consumption Survey was reduced. In 1997, the Residential Transportation Energy Consumption Survey was discontinued because of budget constraints.

Surveys of this nature are clearly fundamental for the formulation of sound policy and programmes. It will be important to maintain, and possibly increase, funding in recognition of the important role played by end-use efficiency policies.

Many areas of efficiency policy require the co-operation of the states. Improving energy efficiency in buildings shows the difficulties involved.

The Department of Energy provides support for state adoption of building codes and standards. This is important since residential and commercial buildings account for about 17% of US energy use. New buildings using available, cost-effective technologies can consume up to 40% less energy than conventional buildings. But building codes are often too complex for those who must use and enforce them, including builders, designers and building code officials. Most state and local jurisdictions lack the resources to support building energy codes, and most home-buyers assume their new homes are efficient regardless of the level of energy code or its enforcement.

The Energy Policy Act of 1992 mandates that states certify their energy codes have been updated to meet or exceed minimum levels of efficiency. To help states update their codes and ensure that they are enforced, the federal government is working with state and local governments, home-builders and material suppliers to improve energy code compliance. Financial assistance, technical assistance, and code adoption and support products are provided. Overall, it is anticipated that state implementation of updated building codes and standards will lead to energy savings of over 2% of projected building energy use by 2010.

Thirty-four states meet Energy Policy Act requirements for residential energy codes. Work with the states is continuing to encourage the adoption of the next generation of the building industry's consensus standard for commercial buildings.

Apart from standards, there is a federal effort to accelerate the voluntary adoption of highly efficient building products, appliances and systems that can significantly reduce utility bills. To accelerate development and adoption of these technologies, partnerships are being developed with lead builders, equipment manufacturers, retailers, utilities, material suppliers and designers to disseminate information about the technologies and demonstrate the savings they can yield. Federal guidelines are being prepared for selecting qualifying products and systems.

Stronger CAFE standards will have important energy security benefits by reducing oil consumption, as well as economic and environmental benefits.

The primary drivers of oil demand have been the level of economic activity and the associated demand for passenger and freight transport. Oil demand was driven down substantially in the 1970s and 1980s through displacement of oil in the power sector by coal and nuclear plants, as well as by CAFE standards for vehicles. Very little power is produced from oil today, and the fuel economy standards have not been altered significantly for two decades. Oil demand may be expected to continue increasing in line with economic growth, unless the fuel economy standards are made more stringent or consumers and businesses buy more fuel-efficient vehicles.

The growing share of light trucks and sport utility vehicles, which face a less stringent CAFE standard than other passenger vehicles, has led to a decline in average automotive fuel efficiency, contributing to demand growth for gasoline. The fuel economy standards are administered by the National Highway Traffic Safety Administration of the Department of Transportation, which will review their adequacy following a recommendation in the National Energy Policy. At the time of writing, resources had not been made available for this purpose.

In addition to strengthened CAFE standards, attention might also be directed to reviewing other options available to improve the fuel economy of personal and light-duty vehicles, including the possibility of increased reliance on diesel engine technology following the introduction in 2006 of low-sulphur diesel.

RECOMMENDATIONS

The Government of the United States should:

- Establish a stronger foundation for energy efficiency programmes by continuing to:
  - Improve the statistical basis for developing policies and programmes.
  - Assess improvements in energy efficiency that are being achieved without government intervention to set benchmarks for evaluating the cost-effectiveness of existing and proposed policies.
  - Improve transparency of information on energy consumption, energy costs, and efficiency-enhancing products for consumers.
  - Give attention to the potential energy security benefits of energy efficiency measures.

- Develop a comprehensive package of measures to achieve quantified targets for efficiency of energy end-use, including:
  - The use of economic instruments wherever possible.
  - Mandatory standards.
  - Information programmes to raise public awareness of the benefits of energy efficiency and conservation strategies.
  - Deployment programmes to ensure appropriate advanced technology enters the market in a timely manner.

- Give priority to enhancing energy efficiency in the transport and building sectors, notably by:
  - Strengthening CAFE standards.
  - Reviewing the range of options available to improve the fuel economy of personal and light-duty vehicles, including the possibility of increased reliance on diesel engines following the introduction in 2006 of low-sulphur diesel.
  - Continuing to work with the states to strengthen building codes.
  - Continuing to provide federal leadership through standards and guidelines on products, buildings and systems designed to improve efficiency in buildings.

6

ELECTRICITY

INDUSTRY STRUCTURE

The US has over 5 000 electricity entities made up of utilities owned by private investors, governments (usually municipal, but sometimes federal), or co-operatives (usually in rural areas), and a growing number of independent power producers with interests in generation only[11].

About 60% of the investor-owned utilities are traditional, integrated generation-transmission-distribution companies involved in all aspects of the industry, from producing electricity to retailing. Nearly 30% of the investor-owned utilities have no transmission facilities. Among public utilities which are not federal or co-operative, i.e. state and municipal utilities, two-thirds own distribution only while about one-fifth have both generating and distribution facilities. Over three-quarters of all co-operative utilities own only distribution facilities. Non-utilities are strictly generators.

Table 4
Structure of the US Electricity Industry

Type of Entity	*Total*	*Generation, Transmission,*	*Generation, Transmission*	*Generation, Distribution*	*Transmission, Distribution*	*Generation only*	*Transmission only*	*Distribution only*
Investor-owned Utility	239	140	10	25	6	11	7	34
Publicly-owned Utility	2 009	132	36	403	58	12	8	1 358
Federal Utility	9	3	3	2	1	0	0	1
Co-operative Utility	912	20	40	23	74	1	19	735
Non-utility Generator	1 930	0	0	0	0	1 930	0	0

Source: Department of Energy.

In 1998, investor-owned utilities accounted for about two-thirds of generating capacity and generation and three-quarters of retail sales. Independent power producers controlled one-eighth of total generating capacity and undertook over

11. Definitions of different electricity entities are not precise. Utilities are usually large integrated organisations combining generation, transmission, distribution, including retail supply, but many are not involved in transmission, while some are not generators. Non-utilities are electricity generators only and sell electricity to the utilities. Non-utilities are often described as independent power producers or merchant generators.

four-fifths of the incremental additions to generating capacity. They accounted for few retail sales because most of the power they generate is passed through transmission and distribution facilities owned by utilities. By 1999, non-utility generators accounted for 15% of generation and 21% of generating capacity.

Table 5
Shares of Sales, Generation and Capacity

Type of Entity	*Total*	*Share of Retail Sales (%)*	*Share of Generation (%)*	*Share of Capacity (%)*	*Share of 1998 New Capacity (%)*
Investor-owned Utility	239	74.9	68.1	66.1	11
Publicly-owned Utility	2 009	15	9.1	10.7	3.8
Federal Utility	9	1.5	7.6	8.2	0.1
Co-operative Utility	912	8.6	4	3.1	3.5
Non-utility Generator	193	0	11.2	11.9	81.6

Source: Department of Energy.

Investor-owned utilities accounted for nearly 55% of total wholesale market purchases. They obtained 23% of their electricity from non-utility generators (typically independent power producers), while other types of utilities did not.

Table 6
Wholesale Market Sales to Utilities by Other Utilities and Non-utility Generators
(billion kWh)

Type of Utility	*Purchases from Utilities*	*Purchases from Non-utilities*	*Total*	*Share of Purchases (%)*
Investor-owned	808	247	1 055	54.7
Publicly-owned	426	7	433	22
Federal	12	2	14	0.75
Co-operative	424	3	427	22.1

Source: Department of Energy.

ELECTRICITY TRADE

Net imports of electricity accounted for just 1.2% of overall US retail electricity sales in 1998. In certain regions, however, imports were more important, accounting for up to 6.5% of retail sales.

Gross imports have been steady over the last few years, amounting to 42.9 billion kilowatt-hours in 1995, 43.5 billion kWh in 1996, 43 billion kWh in 1997 and 39.5 billion kWh in 1998. Gross exports, however, have increased, from 3.6 billion kWh in 1995 and 3.3 billion kWh in 1996 to 9 billion kWh in 1997 and 12.7 billion kWh in 1998. The increase has been mostly in the western grid and the Ohio Valley, but also in Minnesota, Iowa, Nebraska, North and South Dakota, New York and New England.

Canada accounted for 99% of gross imports in 1998. Electricity flows from Canada vary from year to year with rainfall and hence Canada's available hydropower. Construction of international transmission lines with either Canada or Mexico requires a permit from the federal government, but there is no regulation or restriction of trade over such lines once they are in place.

MARKET TRENDS

Generating Mix for Electric Utilities

Total capacity run by utilities has been declining at an accelerating pace, with a noticeable drop-off in 1999 caused by divestiture and sale of generating units to non-utility power producers. Total capacity fell by 9.5% in the period 1995 to 1999 and by 6.9% in the year 1998-99 alone.

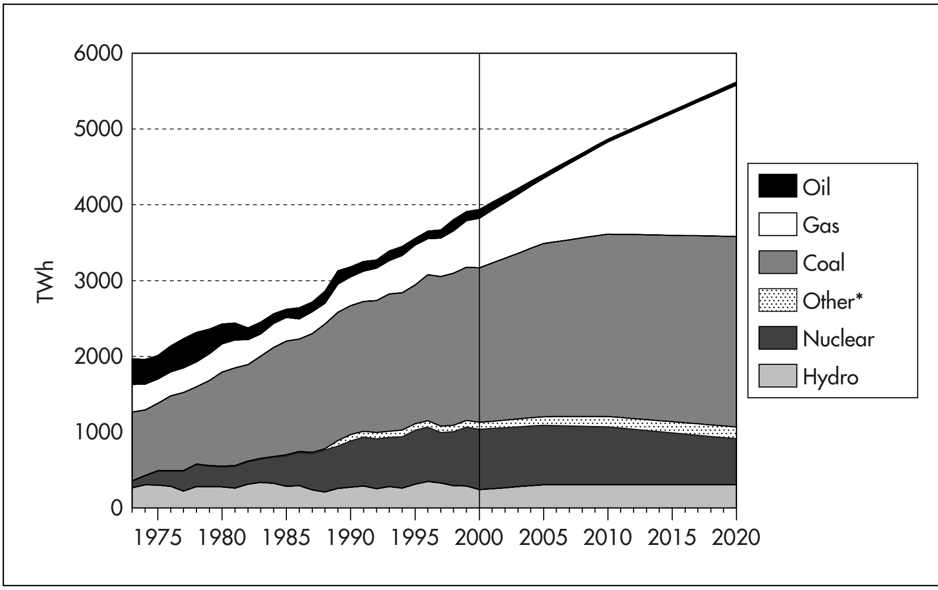
Baseload coal and nuclear plants have substantially higher shares of generation than of capacity. Gas- and oil-fired peaking plants have much lower shares of generation than of capacity. The nuclear share of generation has increased despite a decline in utility-owned capacity because of a more intensive utilisation of plants, which have been operating at very high capacity factors. Overall, generation by utilities grew by 6% in the period 1995 to 1999. Growth in nuclear generation in this period was 7.7%, offsetting a 6.9% fall in coal-fired generation and a 3.6% fall in gas-fired generation.

Generating Mix for Non-utility Generators

Total capacity run by non-utility generators has been increasing rapidly as a result of independent construction and the trend to divestiture. It increased by 138% in the period 1995 to 1999, with 71% of the increase occurring in 1999 alone. About a quarter of all utility generating capacity had been divested or was in the process of being divested as of mid-2001.

Most non-hydro renewable power is generated by non-utility producers that operate substantial biomass, waste, geothermal and wind capacity. New renewables accounted for about 10% of non-utility capacity in 1999. Nuclear generating capacity was acquired by non-utility entities for the first time in that year.

Figure 15
Electricity Generation by Source, 1973 to 2020



* Includes geothermal, solar, wind, combustible renewables and wastes.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and country submission.

Generation from coal increased by 115% in the period 1995 to 1999, with 84% of the increase in 1999. Generation from natural gas also increased substantially, by 50% in the same period, with 24% of the increase in 1999.

Renewable generation from hydro, geothermal, and wind power all increased by roughly half in 1999, while biomass and solar power generation were stable over the period. New renewables now account for about 15% of all non-utility generation.

Generating Mix for the Electricity Industry

For the electricity industry as a whole, including both utilities and non-utility generators, total generating capacity increased by an average of 1% per year between 1995 and 1999. Most of the increase (2.8% out of a total 3.9%) occurred between 1998 and 1999. Of the total generating capacity, the non-utility share grew from 9% in 1995 to 20.7% in 1999.

A modest increase in natural gas-fired capacity occurred to 1999, assuming the dual-capable petroleum-gas units were mostly used to burn gas. Major increases in gas-fired capacity in 2000 (about 22 GW) and 2001 (about 25 GW) are not reflected in Table 7.

Table 7
Generating Capacity, 1995 and 1999

Fuel	*Generating Capacity (MW)*		*Share of Capacity (%)*		*Growth in Share (%)*
	1995	*1999*	*1995*	*1999*	*1995-99*
Coal	311 481	326 281	40.1	40.4	4.8
Petroleum	67 786	53 772	8.7	6.7	–20.7
Natural Gas	170 460	167 825	22	20.8	–1.5
Petroleum/Gas*	10 479	40 508	1.3	5	286.6
Nuclear	99 515	96 572	12.8	12	–3
Waste Heat	. .	4 808	. .	0.6	. .
Renewable					
Hydro	78 673	80 118	10.1	9.9	1.8
Geothermal	3 042	2 971	0.4	0.4	–2.3
Biomass/Waste	10 882	11 446	1.4	1.4	5.2
Wind	1 731	2 251	0.22	0.28	30
Solar	358	387	0.05	0.05	8.1
Pumped Storage	21 387	18 945	2.8	3	–11.4
Multifuel/Other	574	798	0.07	0.08	39
Total	**776 368**	**806 682**	**100**	**100**	**3.9**

. . : not available.

* capable of being fired by oil or gas.

Source: Department of Energy.

Total generation increased by an average of 2.6% per annum between 1995 and 1999, with a slightly quicker pace (3%) in 1999. Of the total generation, the non-utility share grew from 11.2% in 1995 to 11.6% in 1998 and to 15.2% in 1999.

By 1999, electricity production was roughly 51% from coal, 20% from nuclear power, 16% from natural gas, 11% from renewables, and 3% from oil.

Capacity Factors

Industry capacity factors have increased, which may be a sign of increased efficiencies induced by growing competition in electricity markets, as well as declining reserve margins of generating capacity over peak demand.

Non-hydro renewable power plants appear to be operated at higher capacity factors by non-utility generators than by utilities. But overall, capacity factors have been declining for non-utility generators as those for utilities have been increasing. This may be due to the growing non-utility share of generation from natural gas and

Table 8
Electricity Generation, 1995 and 1999

Fuel	*Generation (GWh)*		*Generation Share (%)*		*Generation Growth (%)*
	1995	*1999*	*1995*	*1999*	*1995-99*
Coal	1 713 148	1 897 181	50.8	50.7	10.7
Petroleum	89 877	117 583	2.7	3.1	30.8
Natural Gas	503 939	592 106	15	15.8	17.5
Nuclear	673 402	734 383	20	19.6	9.1
Renewable					
Hydroelectric	311 152	321 662	9.2	8.6	3.4
Geothermal	14 657	17 279	0.4	0.5	17.9
Biomass/Waste	59 163	59 303	1.8	1.6	0.2
Wind	3 196	4 533	0.09	0.12	41.8
Solar	828	873	0.02	0.02	5.4
Pumped Storage	2 725	5 982	0.1	0.2	119.5
Other	3 792	4 088	0.1	0.1	7.8
Total	**3 370 429**	**3 743 009**	**100**	**100**	**11.1**

Note: Numbers may differ slightly from those shown in Annex A.
Source: Department of Energy.

renewable facilities, which tend to have lower capacity factors than baseload coal and nuclear facilities.

Capacity factors for oil-fired and natural gas-fuelled plants are shown for utilities only as statistics for non-utility generators include dual-capable oil and gas facilities for which the breakdown between oil and gas generation is not readily available.

Consumption

Figure 16 illustrates the steady growth in electricity consumption in all sectors. Growth in electricity consumption has historically matched growth in GDP. The link is less obvious in recent years. In 1998 and 1999, electricity consumption grew by 2.8% and 1.7% respectively, while GDP grew by 3.1% and 3.6%.

Prices

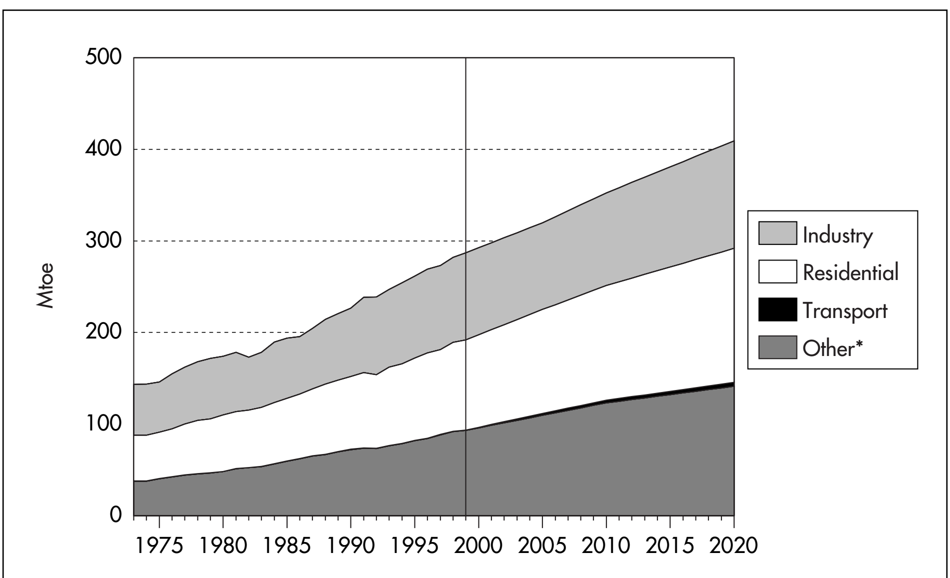
Electricity prices for industry and households are low relative to other IEA countries. Although tax is not included in the figures, the change in price allowing for tax would be small. Prices shown in Figures 17 and 18 fluctuate, in part because of exchange rate variations.

Table 9
Electricity Generation Capacity Factors (%)

Fuel	*Utilities*		*Non-utilities*		*Industry*	
	1995	*1999*	*1995*	*1999*	*1995*	*1999*
Coal	62.8	72.6	63.2	30.5	62.8	66.4
Petroleum	10.8	20.2	–	–	–	–
Natural Gas	24.6	28.6	–	–	–	–
Nuclear	77.2	87.1	–	69.2	77.2	86.8
Renewable						
Hydro	44.9	46.27	49.6	41.4	45.1	45.8
Geothermal	31	71	87.4	65.9	55	66.4
Biomass/Waste	33.2	47.1	63.7	59.7	62.1	59.1
Wind	15.7	9.1	21.1	23.2	21.1	23
Solar	11.4	6.8	26.6	26	26.4	25.8
Total	**48.4**	**56.7**	**61.1**	**38.8**	**49.6**	**53**

– : not applicable.
Source: Department of Energy.

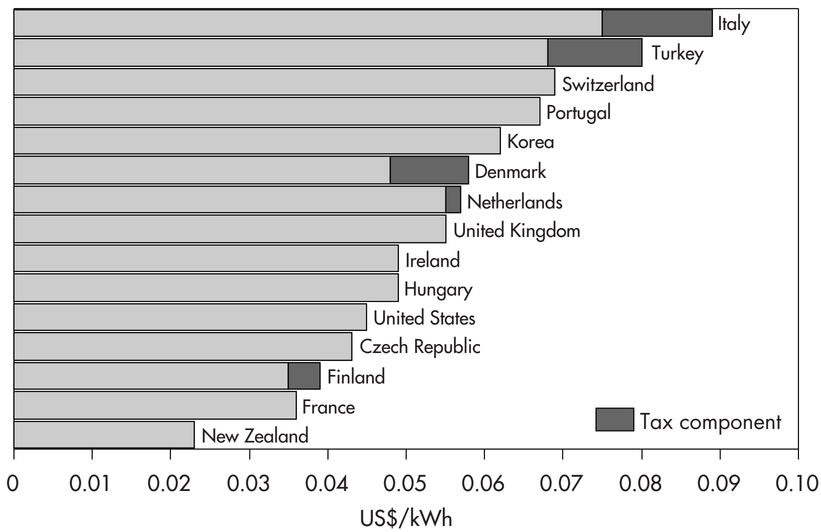
Figure 16
Final Consumption of Electricity by Sector, 1973 to 2020



* Includes commercial, public service and agricultural sectors.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and country submission.

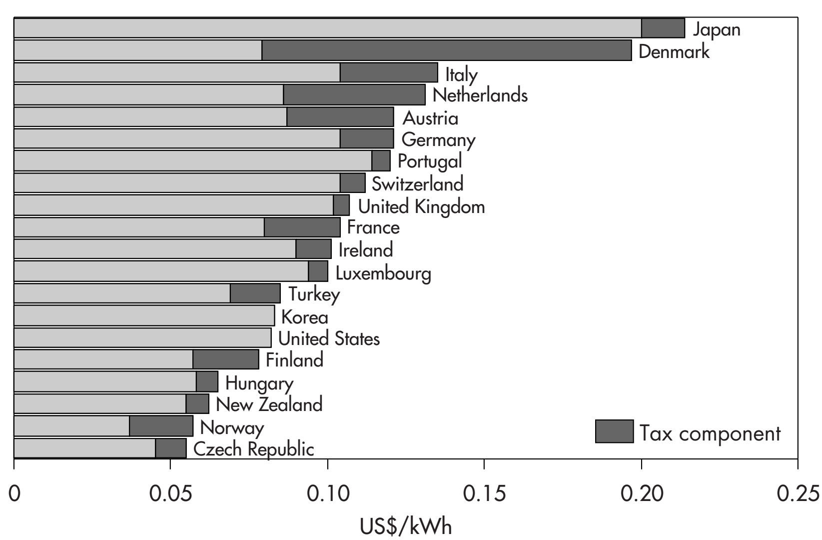
Figure 17
Electricity Prices in IEA Countries, 2000

Industry Sector



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

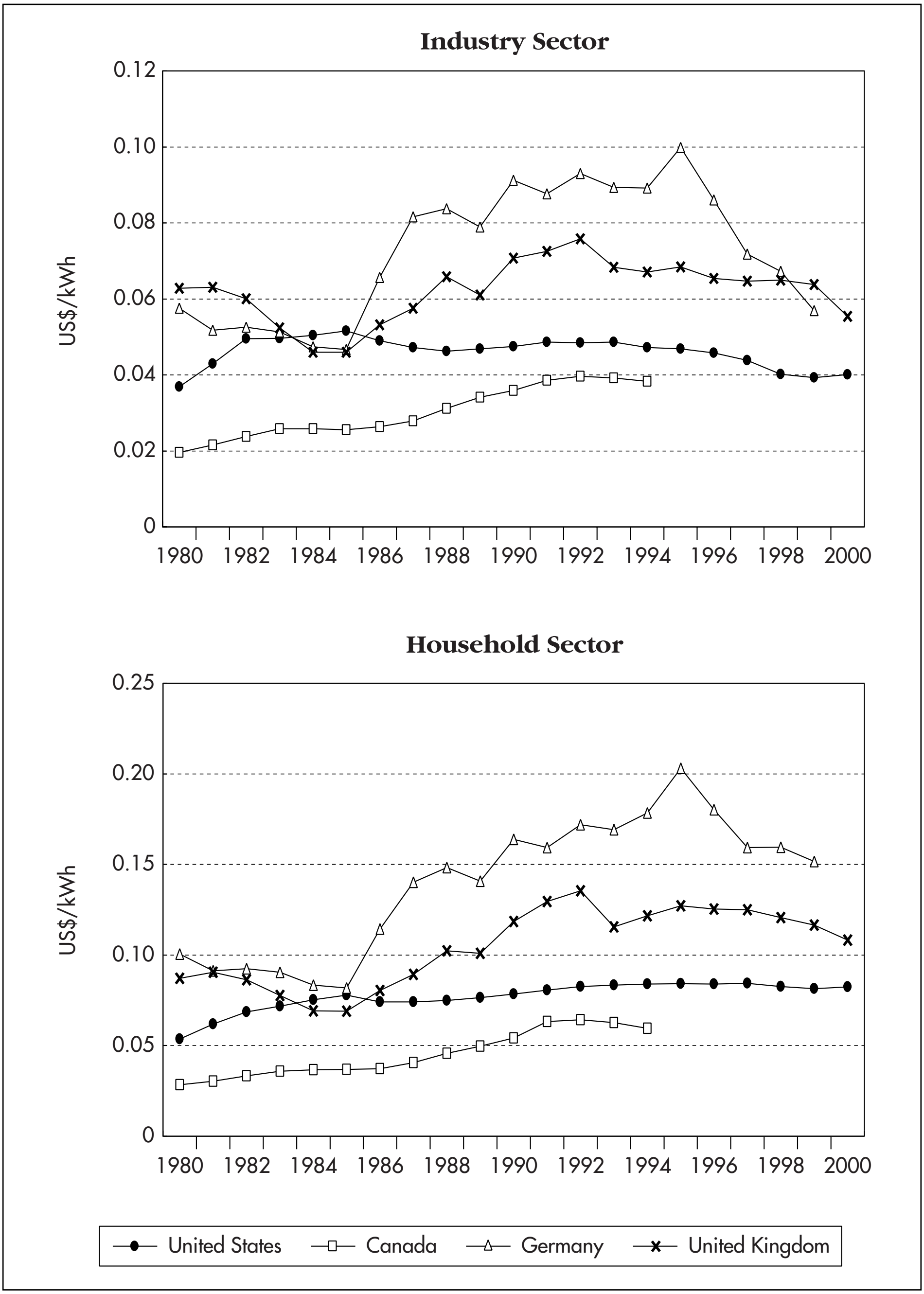
Household Sector



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

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2001.

Figure 18
Electricity Prices in the United States and in Other Selected IEA Countries, 1980 to 2000



Note: Price excluding tax for the United States.
Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2001.

CALIFORNIA

In the summer of 2000, San Diego Gas and Electric became the first incumbent utility in California to pay off its stranded costs from revenues provided under the transitional price cap. Hence, its retail electricity prices were fully deregulated. Owing to the nature of the wholesale market, with separate day-ahead and real-time markets in which participation was mandatory, tight supplies led to enormous wholesale price hikes. Hedging was not possible because long-term contracts were not permitted. The average August price on the California Power Exchange for purchases in San Diego increased roughly fourfold, from 3.8 cents per kWh in 1999 to 15.3 cents per kWh in 2000, even though peak demand was similar in both years. These prices were passed along to retail customers.

Price spikes were not due entirely to flaws in market design. Higher gas prices, limited hydroelectricity because of drought, and higher nitrogen oxides permit prices, all of which would have existed regardless of market design, accounted for about 30% of the price increase.

In the winter of 2000-01, Pacific Gas and Electric, and Southern California Edison were faced with a credit crisis because they were forced to pay high wholesale spot prices for power that they then had to resell at interim capped retail prices. Southern California Edison announced that it would be unable to make certain debt repayments, and the bond ratings of both utilities were downgraded to junk status. Uncollected charges had placed the utilities some US$ 14 billion in debt by April 2001. California entered negotiations with the utilities to help them avoid bankruptcy. Southern California Edison accepted a deal in which the state would assume its debt from unrecovered charges, the utility would relinquish its transmission assets, and the state would issue bonds to pay off the debt. Pacific Gas and Electric declared bankruptcy anyway, hoping for a better deal from the courts.

An analysis of these events is contained in the critique to this chapter.

REGULATION

Federal Energy Regulatory Commission

The Federal Energy Regulatory Commission (FERC) oversees wholesale electric rates and service standards, and the transmission of electricity in interstate commerce. Sales of electricity for resale (sales between public utilities or by a public utility to a municipality or a co-operative), transmission and interchanges comprise a little over a quarter of total US investor-owned electric utility sales. Retail electric sales (sales to end-use customers such as home-owners and businesses) are generally regulated by state public utility commissions. FERC:

- Ensures that wholesale and transmission rates charged by utilities are just and reasonable and not unduly discriminatory or preferential.

- Reviews utility pooling and co-ordination agreements.

- Oversees the issuance of certain stock and debt securities, assumption of obligations and liabilities, and mergers.

- Reviews the holding of officer and director positions between top officials in utilities and major firms supplying electrical equipment to the power companies and underwriting securities.

- Reviews rates set by the federal power marketing administrations, such as the Bonneville Power Administration, makes determinations as to exempt wholesale generator status under the Energy Policy Act 1992, and certifies qualifying small power production and co-generation facilities.

FERC also regulates federal hydropower projects and some non-federal hydroelectric power projects.

Recent Developments in Regulation

Under the Federal Power Act and the Energy Policy Act of 1992, FERC has promoted non-discriminatory transmission pricing and access. Under amendments to the legislation, FERC can in some circumstances require a utility to provide transmission services upon application by any wholesale generator.

In 1996, FERC issued Orders 888 and 889 to substantially restructure wholesale electricity markets. Order 888 is an open-access restructuring rule that:

- Requires transmission utilities under FERC jurisdiction to file non-discriminatory open-access transmission tariffs that offer service to third parties on a comparable basis to the utilities' own uses of their transmission facilities.

- Issues guidelines for independent system operators (ISO) that would be subject to FERC jurisdiction, though it does not require utilities to relinquish control of their transmission systems to an ISO.

- Requires functional unbundling of utilities' transmission business from their power marketing business.

Order 889 established Open-Access Same-time Information Systems (OASIS) on which utilities must post real-time information about their transmission networks. It also prescribed what procedures utilities must follow when responding to requests for transmission services and proposed standards for information posted on OASIS to ensure uniformity. The rule also required utilities to separate wholesale power marketing from transmission operations, and to obtain transmission information for wholesale transactions from OASIS as their competitors do.

Despite progress made under Orders 888 and 889, several significant obstacles to competition in electric power markets remained:

- There are complaints that transmission owners continued to discriminate against independent power companies. Discriminatory behaviour is growing harder to monitor as the number of market participants increases.

- Functional unbundling has not produced sufficient separation between the transmission system operation and power marketing activities of power utilities to fully guard against discriminatory behaviour (in favour of utility generating facilities and to the disadvantage of non-utility generators).

- While six ISOs were formed, of which five are operating, regionalisation of the grid through ISO formation has been incomplete.

- Congestion of transmission lines has increased, impeding competitive power flows, while real-time procedures for relieving congestion are often unfair and inefficient, with little consideration of the value of alternative power flows.

- "Pancaking" tariffs (transmission customers pay a separate access charge every time power crosses a transmission ownership boundary) raise overall transmission costs and reduce the geographic area of competition.

- Responsibilities for transmission grid expansion to reduce congestion are unclear.

FERC issued Order 2000 in December 2000 to encourage the voluntary formation of Regional Transmission Organizations (RTOs). The basic objective was eventually to transfer control of the transmission system from vertically-integrated utilities to a limited number of RTOs. With access to the transmission grids controlled by independent RTOs, there would no longer be an economic incentive to discriminate between competing suppliers (dealing with the first and second obstacles to competition described above). In addition, regional entities would be better positioned than local utilities to incorporate system-wide congestion costs into transmission prices, eliminate pancaking of transmission tariffs across utility boundaries, and plan for cost-effective transmission expansion (responding to the remaining obstacles to competition described above).

Order 2000 required that an RTO be independent of market participants, have operational authority for all transmission facilities under its control, have exclusive authority for maintaining the short-term reliability of the transmission grid under its control, and be regional in scope encompassing one contiguous geographical area, a highly interconnected portion of the grid, existing regional transmission entities, and existing control areas. Every public utility that owns, operates or controls interstate transmission facilities was required to file by 15 October 2000 a proposal to participate in an RTO that would be operational by 15 December 2001, a description of efforts to participate in an RTO, or an explanation of how the Independent System Operator (ISO) under which it operates would function as an

RTO. Each RTO was to elaborate a system for congestion management by 15 December 2002, as well as systems for parallel path flow co-ordination and for transmission planning and expansion by 15 December 2004.

In July 2000, persuaded that voluntary formation of RTOs under Order 2000 was proceeding too slowly, FERC issued a set of directives declaring its intention that four RTOs be established covering the North-East, South-East, Midwest, and West[12]. The North-East RTO is to encompass the existing ISO New England (formerly the New England Power Pool), NYISO (formerly the New York Power Pool), and PJM (formerly the Pennsylvania-Jersey-Maryland control area), with PJM's system to be the platform upon which the RTO is based. In the South, where the fewest states have deregulated power supply and little progress has been made towards grid regionalisation, the RTO building-blocks are less developed.

In September 2001, the Chairman of FERC made several proposals to encourage standardisation of market design and strenghten support for the RTOs:

- All utilities under FERC jurisdiction would be given until 15 December 2001 either to elect to join an approved RTO or lose permission to charge market-based rates.
- No mergers would be approved by FERC that involve entities that do not become part of an operational RTO.
- Transmission tariffs will be reviewed where a utility elects not to join an RTO.

In November 2001, FERC announced price controls on power companies whose size permits them to control electricity prices in their home markets. If a generating company's capacity exceeds the difference between the total capacity accessing the market and the peak capacity for that market, FERC considers that the applicant has market power and may be subject to price controls. In these instances, FERC may decide that the generators must charge cost-based, rather than market-based, prices. FERC's action is, in part, designed to encourage large companies to join RTOs. Companies covered by an RTO would be permitted to charge market prices.

CRITIQUE

Market Trends

Competition has encouraged construction of independent generation.

Competition has had a number of important effects on the structure of the US electricity supply industry. The steady shift towards non-utility producers has resulted from the

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12. Texas, which is generally outside FERC jurisdiction, would effectively constitute a fifth RTO.

construction of generating plants by non-utility firms and divestiture by the utilities. According to a survey by investment banking firm Goldman Sachs, 85 gigawatts of new independent generation facilities were planned or under construction in the US in mid-2000. These include more than 30 gigawatts in the North-East, more than 20 gigawatts in the West, and about 10 gigawatts each in the South-East, South-West, and Midwest. Such facilities, if all completed, would provide an increment of over 10% of generating capacity of the 1998 level.

Divestiture by large utilities has also been encouraged. By 2010, about half of all generating capacity will be divested.

In recent years, another major factor in the shift towards non-utility production has been the divestiture of generating units owned by large utilities. By early 2001, 51 investor-owned utilities, or over 25% of the investor-owned utilities owning generating capacity, had divested generating units or were in the process of doing so. About 156 gigawatts are being divested, representing 29% of investor-owned utilities' generating capacity. Of the amount being divested, 37% has been sold, 18% is about to be sold to an identified buyer, 20% is for sale without a buyer yet identified, and 25% is transferred or about to be transferred to an unregulated subsidiary. The expectation is that about half of all generating capacity will be divested by 2010. This, in addition to the substantial amount of power being built by non-utility generators, should substantially broaden the scope for effective competition in the US electric power sector.

But remaining investor-owned utilities have consolidated and their share of capacity is increasing.

Counteracting the competitive effects of divestiture has been the rapid consolidation of investor-owned utilities into large, multi-state regional holding companies such as Southern Company, Duke Power, Constellation and Entergy. The number of investor-owned utilities has been declining, and the scale of a typical investor-owned utility has been increasing. From 1992 to April 2000, 35 mergers or acquisitions had been completed between investor-owned utilities or between investor-owned utilities and independent power producers, and another 12 mergers were pending approval by stockholders or by state or federal regulators. In 1992, 70 electric holding companies owned 78% of total generating capacity in investor-owned utilities, but at the end of 2000, there were only 53 electric holding companies owning 86% of total capacity in investor-owned in utilities. The share of generating capacity held by the ten largest utilities increased from 36% in 1992 to 51% at the end of 2000, while the share held by the 20 largest utilities grew from 58% to 72%.

Valuation of stranded costs has been addressed by the market.

The last review drew attention to the issue of stranded costs, including the manner in which they are estimated and recovered. The federal government has very little influence on stranded cost recovery of generation facilities, which is determined by the states. The extensive divestiture of generating facilities in the course of state restructuring programmes has often yielded higher prices for the facilities than originally anticipated. For many generating plants, the current market value, reflecting inflation and market changes over the years since the plants entered into service, is well in excess of the substantially depreciated book value. Sale of such plants has substantially reduced outstanding stranded costs for many utilities while also providing a reliable indicator of market value and stranded costs for generating units that have not been divested.

Incentives for investing in new generating and transmission capacity may not be adequate.

The adequacy of transmission and generating capability is causing some concern in the US. In the regulated regime, these activities were undertaken by vertically-integrated utilities that were assured of recovering investments. Demand for power grew by nearly 22% during the period 1991 to 2000, while capacity increased by about 11%. Consequently, capacity margins have fallen. Nationwide, capacity margins for summer 2001 were estimated to be 14.7% compared with 18.9% during summer 1996. Lower capacity margins do not necessarily imply lower reliability, but the trend will need to be kept under review. If announced projects are completed as planned and electricity demand follows recent trends, the reserve margins should recover and several markets may even experience excess capacity.

Adding new transmission capacity requires overcoming different problems. There is a need to address difficulties in obtaining permits for new lines and uncertain future rates of return on investments.

Progress with Electricity Market Reform

The experience of California has adversely affected progress in market reform[13].

FERC has broad authority to regulate interstate aspects of the electricity market, notably wholesale (business-to-business) transactions. The states have authority to regulate retail rates charged to consumers. Under this authority, about half the 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 in the hope of bringing rates down. By July 2000, twenty-four states and the District of Columbia had enacted legislation or passed regulatory orders to liberalise their electric power industries, with sixteen providing for retail choice by the start of 2000, and the other nine providing for retail choice by the start of 2001.

13. The IEA is preparing a report on electricity sector investment and security issues, which will include an analysis of experience in California. The report should be published in 2002.

Another two states had legislation or regulatory orders pending, while sixteen were carrying out legislative or regulatory investigations. All but eight states have seen activity of some kind towards electricity market liberalisation.

Widespread public attention has been attracted to electricity market developments in California (discussed in detail below). One of the impacts of experience in California has been to delay progress with market reform, or even to put into reverse action already taken. Six states (Nevada, Oklahoma, New Mexico, Arkansas, West Virgina and Oregon) have delayed or stopped retail competition, two (Montana and New Hampshire) have extended the periods during which utilities must offer default or provider of last resort service to retail customers to help protect them from high wholesale prices, and two others (Connecticut and Rhode Island) have formally begun reviewing their restructuring legislation. Many other states that were in various stages of considering the adoption of comprehensive restructuring programmes have slowed or abandoned these efforts for now, often explicitly referring to concern over California's experience.

Market reform should be sustained following fundamental principles.

FERC has taken a proactive position on market design by proposing changes in a rule-making context rather than through decisions on contested formats. This is an important development that could accelerate market reform more methodically and predictably. In principle, the RTO model is an appropriate means of encouraging the emergence of strong regional markets where there are already strong interconnections and similar regulatory structures. RTOs should provide a strong foundation for further reforms. A number of key issues that might be addressed by FERC and state regulators acting together are summarised in the recommendations. These are suggested as issues that, like the development of regional markets, are seen as fundamental components underlying a truly competitive electricity market.

Pragmatically, the success of the RTO concept and of other FERC-inspired reforms will be the extent to which state regulators and stakeholders are committed to a consistent set of reforms to be introduced in an orderly manner. FERC has acknowledged that a rift with state regulators was opened by the abruptness of the FERC July 2000 orders. More formal consultative and policy development mechanisms might be established to contribute to the success of reform efforts.

California

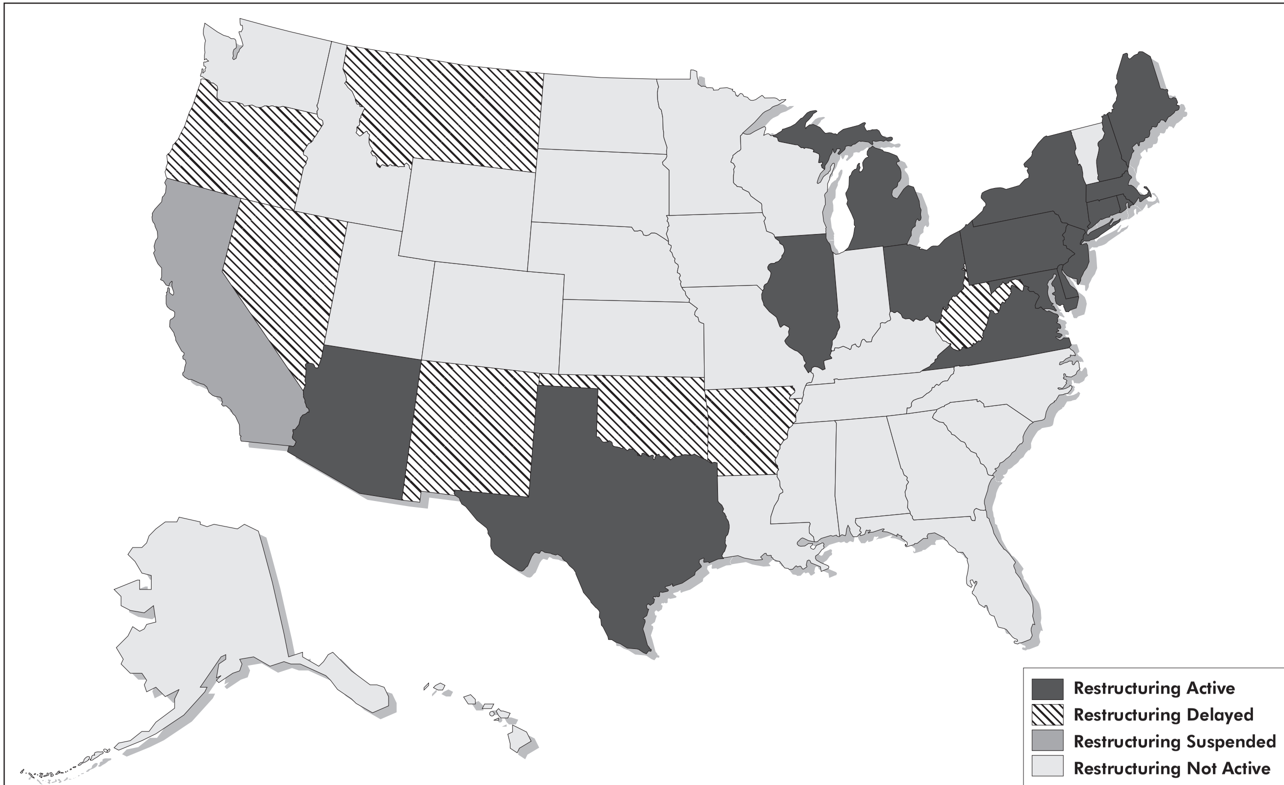
Failure to build new generating capacity coincided with reduced availability of imports.

California was one of the earliest states to deregulate electricity supply because it is one of the states with the highest electricity rates. In 1996, the average revenue per kilowatt-hour was 9.48 cents, giving California the tenth-highest rates in the fifty states. The reasons for these high historical prices include high-cost nuclear plants and mandated purchases for costly co-generation and renewable facilities under the Public Utilities Regulatory Policies Act.

Figure 19

Status of State Electricity Industry Restructuring

(November 2001)



Source: Energy Information Administration.

Very little new generating capacity has been built in the last decade in California or the rest of the Western System Coordination Council to which California belongs. In the four years from 1996 to 1999, only 672 megawatts of generating capacity were added – less than a 2% increase in generating capacity – while peak demand grew by 12%. The situation was worsened by the frequent need to take plants out of service for maintenance and repairs because 55% of the state's generating facilities are more than 30 years old.

California has long been a net importer of power, and a similar level of electricity imports was assumed available in 2000. However, low levels of precipitation reduced available generation from hydroelectric facilities in the region. In addition, market rules discouraged imports to the state, and exports from the state increased owing to more attractive prices elsewhere.

While California has six gigawatts of transmission going North and nine gigawatts going East, this is modest compared with the peak load of forty-five gigawatts in the service area of the Independent System Operator. New transmission lines are difficult to build because of lengthy siting processes.

An ambitious but flawed deregulatory design.

California's legislature designed a system under which all generation would become fully deregulated, all customers would have a choice of suppliers, and transmission and distribution networks would remain regulated monopolies. Over a four-year transition period from 1998 to 2002, rates for small captive customers were capped at 10% below the rates that had prevailed previously. The gap between capped customer rates and wholesale power costs, which were substantially lower at the outset and presumed to remain so over the four-year period, were earmarked to repay incumbent utilities' stranded assets that had been built with regulatory approval under the traditional system. However, flaws in the deregulatory design, combined with high gas prices, restrictions on hydroelectricity supply due to drought, and regulations on nitrogen oxides, upset this plan.

Market rules prohibited long-term bilateral contracts for power purchases. In addition, the rules allowed only 20% of power to be purchased under long-term contracts for larger commercial and industrial customers. This forced the bulk of transactions on to the power exchange, where market power combined with poorly designed market rules led to high prices.

The market power of any one power producer was limited through a programme of divestiture. The three largest utilities divested over 20 gigawatts of generating capacity, out of 55 gigawatts in the state (Pacific Gas and Electric – 7.4 gigawatts; Southern California Edison – 10.6 gigawatts; San Diego Gas and Electric – 2.1 gigawatts). But almost all the capacity is still owned by five firms (AES, Reliant, Duke, Southern and Dynergy). California regulators estimated that while the power exchange operated, power plants owned by these five generators determined prices 80% of the time.

The power exchange operated a day-ahead and hour-ahead market, while the ISO administered a real-time balancing market intended primarily to cover small discrepancies in forecast versus actual load. But market rules gave both buyers and sellers incentives to operate in the real-time market as opposed to the day-ahead and hour-ahead markets. Since the bid price received by the power exchange for the last unit required to meet demand in any particular hour set the price for all power sold on the power exchange in that hour, generating firms may have been able to keep prices high by withholding units from service at times of high demand, when they could often realise higher prices in the real-time market operated by the ISO. With more and more trading shifted to the real-time market, the ISO was forced to buy large amounts of power on an hour-by-hour basis in order to keep the system running, giving electricity generators a significant advantage in setting prices. These problems arose from the particular design of the California pool and are satisfactorily addressed in other electricity pools.

The ISO in California may not have been sufficiently independent. It is not a public agency, as in other states, but an organisation run by stakeholders, including the generators whose output it schedules. There are other examples, such as PJM discussed below, where the ISO is industry-owned and problems of independence do not arise because of strict governance rules.

High market prices for natural gas and pollution permits exacerbated California's power crisis.

Average market gas prices increased from US$ 2.50 to US$ 4 per million Btu between 1998 and 2000, adding an average of US$ 12 per MWh to costs. Spot market prices for gas during the winter of 2000-2001 frequently topped US$ 20 per million Btu and spiked as high as twice that level, which would have added US$ 160 to US$ 320 per MWh or 16 to 32 cents per kWh to the spot price of electricity if gas plants were at the margin. California gas prices have since moderated substantially.

Because of a reduction in available allowances for emissions of nitrogen oxides in July 2000, the cost of permits per pound increased from US$ 6 in June to US$ 36 in July and US$ 45 in September, adding about US$ 30 to US$ 40 per MWh (three to four cents per kWh) to the cost of electricity generated in coal-fired power plants. The price of permits peaked in December 2000 and is expected to decline over the next few years as pollution controls are installed.

Responses to California's power crisis: regulated prices for small consumers, but market-based prices for larger consumers; state power purchases to ensure utilities are profitable; bilateral electricity sales; demand metering; accelerated site approvals for new plants.

In San Diego, state regulators responded to the price spikes of summer 2000 by setting a cap on wholesale power prices which was then reflected in retail prices. The wholesale caps no longer apply. For small consumers, a retail cap of 6.5 cents per kWh was set. This retail cap does not apply to large consumers, who still face high rates. In most of the rest of the state, regulated retail prices have been retained for all customers, but have been increasing. As small customers representing 60% of residential demand have been exempted from additional increases, the average rate hike for other customers is 4.5 cents per kWh or about 46%. Non-exempt residential customers pay an average of 22 cents per kWh. High prices are intended to encourage conservation and investment in new supply.

In April 2001 FERC established a benchmark price for wholesale electricity sold in California on days when emergency power shortages are declared. The benchmark price is equal to the cost of power from the highest-cost generating unit in service. All generators bidding at or below the benchmark price receive that price. Generators exceeding the benchmark have to justify their prices or face possible refunds. In June, the benchmark system was extended to all hours and the entire West. The benchmark should be an incentive for new investment, while requiring justification for prices above the benchmark should discourage market manipulation.

The government sought bids for long-term contracts for power at a price that would enable the utilities to operate at a profit despite retail price caps. Bids were received for roughly half of California's power needs at an average cost of 6.9 cents per kWh, far below the level of recent price spikes but well above current prices.

To reduce pricing pressure in the day-ahead and real-time markets, the California Public Utility Commission gave approval for utilities to enter into bilateral contracts outside the power exchange, including forward hedging contracts. (Individual non-captive customers, i.e. large industrial and commercial firms, were already able to contract bilaterally outside the power exchange.) With use of the exchange no longer mandatory, a sharp drop in business occurred and it went out of service in early 2001.

To improve the ability of customers to adjust their demand in response to higher prices, San Diego Gas and Electric aimed to install real-time meters for all 22 000 customers with loads above 20 kilowatts, who are collectively responsible for 46% of peak demand. Another 200 000 of the utility's 1.2 million customers will receive real-time meters by June 2002. The state has a US$ 35 million programme to install time-of-use and real-time meters for customers with loads over 200 kW, which aims to reduce peak consumption by 500 MW in 2001 and 1 500 MW over time.

To reduce the time required to build new power plants, the governor has ordered an acceleration of the siting process by requiring all state agencies involved in plant licensing to comment within 100 days on any application for a new plant.

In anticipation of attractive wholesale market prices, power suppliers have responded with plans for many new generating plants.

The California ISO reports in its *2001 Summer Assessment* that on top of some two gigawatts of new capacity entering service during the summer of 2001, about five gigawatts are forecast to enter service in 2002, 10 gigawatts in 2003, 11 gigawatts in 2004 and four gigawatts in 2005 – some 54 generation projects with 30 gigawatts of capacity in all. In the neighbouring states of Arizona, Colorado, Nevada and New Mexico, at least another 17 gigawatts of capacity have been announced, or are planned or under construction. In California and the surrounding region, therefore, a total of roughly 47 gigawatts of new capacity is in the pipeline. The supply situation will remain tight for the next two or three years, but once announced new plants are built, market prices for power should moderate.

In other states, such as Pennsylvania, New Jersey and Maryland, abundant generation and transmission capacity, customer choice and long-term contracts have probably helped avoid California-style problems.

Like California, Pennsylvania has historically had high electricity rates. In 1996, Pennsylvania had the eleventh-highest rates in the US. Yet unlike California, Pennsylvania has had no severe price spikes for consumers or credit crunch for producers.

Why should this be so? The answer seems to lie partly in abundant generating and transmission capacity. The Pennsylvania-Jersey-Maryland (PJM) power pool has East-West transmission constraints that periodically segment the state into two distinct markets, as happens between North and South in California. But this segmentation appears to be less frequent in Pennsylvania's case. Within each portion of the PJM pool, there is ample transmission capacity to allow numerous generating plants to compete for customers. Generation is abundant since PJM rules require retail service providers to secure a reserve margin of generating capacity over customer load.

Another part of the answer may lie in customer choice of suppliers. The "fallback" rates for customers that remained with their traditional utilities were higher in Pennsylvania than in California; so there was an incentive for them to switch to competing suppliers. Today, 52 competitive suppliers are licensed to sell their generation in the state. About 8% of all residential electricity customers in the state have switched suppliers. In the service area of the Pennsylvania Electric Company, in the south-eastern part of the state, 15% of residential customers, 30% of commercial customers, and 62% of industrial customers have switched suppliers.

Perhaps most importantly, there was no restriction on long-term contracts. Bilateral contracts for power take the form of financial hedges (contracts for differences) in which an intermediary purchases power from the pool at fluctuating prices and resells it to a purchaser at a fixed long-term price, thereby assuming the risk of price fluctuations and sparing the purchaser that risk. Suppliers and their customers are far less exposed to the spot market.

RECOMMENDATIONS

The Government of the United States should:

- ☐ Establish a formal process to develop overall policy goals for the electricity industry. The states should be encouraged to introduce competition in electricity markets, including retail competition and customer choice. Conditions for effective competition to be addressed include:

- Encouraging new market entrants.
- Acknowledging the role of spot price spikes in a normally operating competitive market, for example to ensure sufficient investment in peak-load capacity, while protecting final consumers by market means.
- Guarding against undue market influence.
- Taking a regional approach to price-capping to ensure that market power and the value of lost load are addressed appropriately, but interstate trade in electricity is not discouraged.
- Ensuring stranded cost payments are calculated accurately and their reimbursement does not adversely affect the development of competition.
- Including demand response measures in market designs.

☐ Strengthen existing dialogue between regulators to develop consistent, transparent wholesale market structures, rules, and regulatory arrangements within interconnected regions. The aim should be to ensure that a regional approach is taken that reflects the economic boundaries of the markets rather than the jurisdictional boundaries of existing regulatory bodies. Issues to be addressed in this context should include:

- Structural reform of incumbent state-based and government-owned utilities to ensure competitive neutrality and market access.
- Cost-reflective network pricing.
- The potential for competitive delivery of network services and improved market-based reliability arrangements.
- Integrated network planning arrangements and information dissemination on market operations.
- Market governance and institutional arrangements, including clarification of the rights and responsibilities of market participants and governments.
- The capacity of financial derivatives markets to deliver innovative and efficient market management products.

☐ Address regulatory barriers to new investment in generation and transmission:

- Ensure the independent collection, analysis and distribution of information on investment needs for new generating and transmission capacity as a means of avoiding market failure by timely and objective forecasting of capacity needs.
- With the states, streamline licensing arrangements.

7

RENEWABLE AND NON-CONVENTIONAL FUELS

POLICIES TO PROMOTE RENEWABLES

The current contribution of renewable energy is relatively small – only 5.4%, three-quarters of which is hydro – but it is among the fastest-growing energy sources in the US. The contribution to total energy supply of renewables other than hydro grew by over 27% during the 1990s.

The National Energy Policy recommends:

- Re-evaluating access limitations to federal lands in order to increase renewable energy production, such as biomass, wind, geothermal, and solar.
- Increasing funding for research and development of renewable energy resources by US$ 39.2 million in the 2002 budget.
- Reviewing current funding and historic performance of renewable energy and alternative energy research and development programmes with a view to proposing funding of those research and development programmes that are performance-based and are modelled as public-private partnerships.
- Making tax credits available for new landfill methane projects.
- Reducing delays in geothermal lease processing.
- Developing a new renewable energy partnership programme to help companies more easily buy renewable energy, as well as receive recognition for the environmental benefits of their purchase, and help consumers by promoting consumer choice programmes that increase their knowledge about the environmental benefits of purchasing renewable energy.
- Extending and expanding tax credits for electricity produced using renewable technology, such as wind and biomass[14].
- Providing a new 15% tax credit for residential solar energy property, up to a maximum credit of US$ 2 000.

14. The president's budget request extends the present 1.7 cents per kWh tax credit for electricity produced from wind and biomass; expands eligible biomass sources to include forest-related sources, agricultural sources, and certain urban sources; and allows a credit for electricity produced from biomass co-fired with coal.

- Using an estimated US$ 1.2 billion of bid bonuses from the leasing areas of the Arctic National Wildlife Refuge for funding research into alternative and renewable energy resources.

- Continuing the ethanol excise tax exemption.

- Developing next-generation technology, including hydrogen and fusion.

- Developing an education campaign that communicates the benefits of alternative forms of energy, including hydrogen and fusion.

- Focusing research and development efforts on integrating current programmes on hydrogen, fuel cells, and distributed energy.

- Developing legislation to provide a temporary income tax credit available for the purchase of new hybrid or fuel-cell vehicles.

Financial Incentives

Renewable energy systems receive a combination of financial incentives from the federal and state governments and utilities.

The Federal Business Investment Tax Credit allows commercial entities a tax credit of up to 10% of investments or purchase and installation of solar property when filing annual tax returns. The credit covers the equipment that uses solar energy to generate electricity or to heat, cool, or provide hot water.

The Federal Renewable Production Tax Credit provides an incentive to generate electricity using closed loop biomass and wind resources. Private entities subject to taxation (corporations, small businesses and home-owners) that generate electricity from wind and biomass systems are eligible for the credit for the electricity they sell to an unrelated party. It was set at 1.5 cents per kWh, and has been adjusted annually for inflation to its present level of 1.7 cents per kWh. The tax credit expired on 31 December 2001, but is expected to be continued and extended.

Public, non-taxpaying power facilities can apply for an incentive payment of up to 1.7 cents per kWh for electricity produced from solar, wind, and some biomass and geothermal energy systems.

The Modified Accelerated Cost Recovery System in the US Internal Revenue Code allows businesses to recover a portion of their investments in solar, wind and geothermal property through accelerated depreciation deduction schedules.

Many states offer incentives for renewable energy technologies. These include income tax credits, property tax exemptions, state sales tax exemptions, loan programmes, special grant programmes, industry recruitment incentives, accelerated depreciation allowances and net-metering provisions. At least fourteen states have system benefit charges (a charge on electricity bills) to help fund research and promotion of renewables. At least ten states have portfolio standards requiring minimum levels of generation from renewable sources. More than thirty states have net-metering laws requiring utilities to purchase surplus generation from renewable sources. Retail green power products are offered in six states.

Some US utilities offer financial incentives for the use of renewable energy technologies, ranging from leasing programmes (for example, solar systems are leased to the utility's customers), rebates, low- or no-interest loans, and grant programmes. The Public Utilities Regulatory Policy Act, 1978 requires utilities to purchase electricity produced from renewable energy resources by non-utility power producers. Such producers are required to meet the utility's capacity, quality, and safety requirements. The rates and metering methods are largely utility-specific. More than one-third of US electricity customers have green power options, and more than 300 000 customers nationally are purchasing green power. About 500 000 additional customers are purchasing power of which 1% or 2% is generated by renewable sources.

Wind

Wind Powering America is a commitment to dramatically increase the use of wind energy in the US. The goals are to provide at least 5% of the nation's electricity with wind by 2020, install more than 5 000 megawatts by 2005 and more than 10 000 megawatts by 2010, double the number of states that have more than 20 megawatts of wind capacity to sixteen by 2005 and triple the number to twenty-four by 2010, and increase wind's contribution to federal electricity use by 5% by 2010. The 2005 capacity target is expected to be met by 2002 and eight or nine gigawatts will be in place by 2005.

The Utility Wind Resource Assessment Program provides assistance to utilities with interest in developing wind energy, by evaluating the wind resources in their service area. The Utility Wind Turbine Performance Verification Program accelerates the commercialisation of wind power. The programme's goal is to reduce the risk of testing and evaluating advanced wind technologies for utility use. Costs are shared with utilities to build and operate wind power plants of at least 6 MW capacity, using the latest technology.

Solar

The Solar Energy programme seeks to improve the performance and reduce the cost of solar technologies.

The National Photovoltaic systems programme works in partnership with industry, universities and national laboratories to expand US leadership in photovoltaic research by identifying promising options for research and development, and to achieve the following specific goals by 2004:

- Establish large-scale production capability in several thin-film technologies and increase commercial module efficiencies from the current 7% to 12%.

- Improve manufacturing technologies to achieve direct module manufacturing costs of less than US$ 1.25 per peak watt, a 50% reduction from the current average cost of US$ 2.50.

- Achieve a greater than 25-year lifetime for photovoltaic systems by improving the reliability and lifetime of components and reducing recurring costs by 50%.

- Attain a near-term goal of 1 000 MW cumulative of US sales (domestic and export) and 30 000 MW by 2020, i.e. an industry growth rate of 25% a year.

The Concentrated Solar Power programme seeks to lead a national effort in developing clean, competitive and reliable power options using concentrated sunlight. Working with industry, the programme has the following goals:

- By 2004, provide multiple Native American sites with an off-grid option for remote power applications.

- By 2005, achieve a reliability target of 4 000 hours of unattended operation for dish/engine systems, which is essential for market entry.

- By 2006, develop an option for residential-sized distributed power applications, capable of providing 1-5 kW dish converter systems.

The Solar Buildings Technology programme seeks to develop solar technologies that are reliable, easy to install, and cost-effective. The goals of the programme are:

- To develop low-cost solar technology that can provide the hot water, space heating, and a portion of the cooling needed for domestic residential and commercial buildings.

- By 2010, to ensure successful implementation of the Million Solar Roofs initiative by installing 500 000 solar water heating systems.

- To support the development of zero net energy buildings by optimally integrating solar thermal energy technologies with solar electric technology and very energy-efficient buildings.

Geothermal

The Geothermal Program works in partnership with US industry to establish geothermal energy as an economically competitive contributor to the US energy supply. "GeoPowering the West" seeks to accelerate the use of geothermal energy in western states. Activities focus on overcoming the technical, institutional and environmental barriers to geothermal development with the following specific goals:

- By 2006, double the number of states with geothermal electric power facilities to eight.
- By 2007, reduce the levellised cost of generating geothermal power to 3 to 5 cents per kWh, as compared with 5 to 8 cents in 2000.
- By 2010, supply the electric power or heat energy needs of five million homes and businesses in the US.

Biomass

The Bioenergy Initiative supports the BioPower Program and the BioFuels Program. The BioPower Program generates electric power and heat from plant-based resources such as energy crops, agricultural residues, wood and wood residues. The goal of the BioPower Program is to increase the installed capacity of new biomass power capacity in the US by 3 000 MW to a total of 10 000 MW by 2010. The BioFuels Program supports research, development and demonstration of technologies that produce and convert cellulosic biomass materials to liquid transportation fuels, focusing on the production of ethanol. A goal of the BioFuels Program is to increase domestic cellulosic ethanol production by 2.2 billion gallons in 2010 from zero in 2000.

Hydrogen

The key elements of the programme include the transitional use of natural gas as the feedstock for production of hydrogen while renewable resource technology is under development, the introduction of proton exchange membrane fuel cells for co-generation systems integrated with natural gas reformers, the development of codes and standards to ensure the safest technologies are produced and ready for market penetration, and the use of domestic resources to produce hydrogen as a future energy carrier. The hydrogen programme has the following goals to be achieved by 2010:

- Hydrogen production costs of US$ 12-15 per million Btu for pressurised hydrogen produced in quantity from natural gas and biomass.
- Safe, low-cost, hydrogen storage technology for vehicles that are able to achieve a range of 350 miles.
- Hydrogen fuel-cell systems that will reduce carbon emissions by 1.3 million tonnes of carbon equivalent, and 13.7 MMTCE by 2020.

Hydropower

The goal of the Hydropower Program is to develop by 2010 commercially viable turbine designs that reduce fish mortality to 2% or less compared with an estimated 30% mortality in 2000.

CRITIQUE

Renewables could play an important role in US energy policy with direct economic benefits through technology exports. Objectives should be defined carefully to ensure cost-effectiveness and consistency with other policy goals.

Policy on renewables is closely related to policies on energy efficiency and the electricity supply industry, where the technologies will be largely applied, and to policy on research and development. Policies to promote development and use of "new" renewables (that is, other than large-scale hydro) should be designed to meet objectives for the sectors where the technology is to be deployed. These include reducing greenhouse gas emissions by replacing coal and gas in electricity generation and petroleum products in transport, replacing investment in transmission through distributed generation based on renewables, and increasing energy security by adding to capacity to produce domestically-sourced energy. At present, renewables are likely to be more expensive sources of energy than conventional sources. Cost-effectiveness is therefore an issue; development of renewables should be considered as one of several means for meeting these objectives. Consideration of cost should take into account cost trends and potential competitiveness in the longer term and external benefits such as environmental impact.

Setting clear objectives for development of renewables should also be consistent with policy objectives for the sectors where it is intended to use renewables. This is particularly true for the electricity supply industry where the market is being liberalised. Discrimination in favour of some generation sources must take into account the impact on competition. Policies should be designed to ensure that discrimination is for a transitional period only and that costs are kept to a minimum. Open competition between all generation technologies should be the ultimate goal. Hence, policies should ensure that the most competitive technologies emerge after a period of development. Generators using renewable technologies should be encouraged to develop the same aggressively competitive approach as that by suppliers using conventional technologies.

The US is in a strong position to be a world leader in developing renewable energy technologies. Energy policy is focused on developing a wide range of new technologies. The energy market is very large and should provide opportunities for large-scale demonstration projects not possible in many other countries. Exporting proven renewable technologies could provide very large economic returns.

Initiatives on renewables focus on tax credits to promote particular technologies.

The National Energy Policy proposes a number of tax credits to promote particular renewable energy supply technologies. These include credits to boost sales of hybrid petrol-electric, fuel-cell-powered, and electric cars; household solar panels; electricity generation technologies, and biomass energy sources (i.e. energy crops, notably ethanol). Support for combined heat and power sources is also proposed. Tax credits have been very effective in promoting wind power in the US. Tax credits could continue to play a role, particularly in encouraging demonstration uses of new technologies. Their quantitative and longer-term impact will depend on the underlying technical quality and economic value of the technologies themselves.

The principles for a broader and more neutral policy framework exist; they should be developed further. The key elements include renewable portfolio standards for the electricity supply industry and federal-state co-operation.

Tax credits and funding linked to development of Arctic oil resources need to be placed in the context of a broader policy framework designed to encourage development of renewables over the longer term. Pricing to reflect externalities is an efficient and effective way of encouraging wide-ranging reform of the economy that would also benefit renewables. In the absence of this approach, policies should be directed to ensuring that the most cost-effective forms of renewable energy are developed.

Renewable portfolio standards are one means, already under active discussion in the US, which could be a neutral way of ensuring a minimum take-up of the most cost-effective renewable technologies. By quarantining a part of the market for renewables, a portfolio standard ensures a secure but competitive environment for developing renewables that promotes renewables over the long term at no direct cost to the budget. Combined with programmes to encourage a market-oriented approach by technology manufacturers and others in the market, the path would be set for developing truly competitive, environment-friendly technologies. There will nevertheless be a higher cost. A protected market may not necessarily lead to the development of genuine commercial viability. Organisational as well as technological innovation is necessary to encourage the emergence of a commercially-oriented approach to renewables.

As in other areas of US energy policy, the federal government's role is limited constitutionally. Federal-state co-operation will be an important element in the success of any policy for promoting renewables.

RECOMMENDATIONS

The Government of the United States should:

- ☐ Consider the use of a federal renewable portfolio standard as an alternative to tax credits on electricity produced from renewable sources.

- ☐ Develop a standardised national approach to encouraging renewable energy, compatible with the operation of competitive electricity markets. Issues for consideration include net-metering and interconnection standards.

- ☐ Facilitate the development of a commercially-oriented and viable renewables sector:
  - Encourage the development of innovative commercial arrangements such as strategic alliances between different players in the renewables market to strengthen their ability to compete.

8

NUCLEAR

POLICY

The National Energy Policy recommends:

- Facilitating efforts by utilities to expand nuclear energy generation in the US.
- Relicensing existing nuclear plants that meet or exceed safety standards.
- Licensing new advanced-technology nuclear reactors meeting safety and environmental requirements.
- Assessing the potential of nuclear energy to improve air quality.
- Increasing resources as necessary for nuclear safety enforcement in light of the potential increase in generation.
- Using the best science to provide a deep geological repository for nuclear waste.
- Supporting legislation clarifying that qualified funds set aside by plant owners for eventual decommissioning will not be taxed as part of the transaction.
- Supporting legislation to extend the Price-Anderson Act.
- Developing certain proliferation-resistant nuclear technologies.

OPERATING PLANTS

At the end of 2001, 104 nuclear units having a net capacity of 97.5 GWe were connected to the grid. Of these, 103 plants were operating in the year and supplied 748 TWhe, or 20% of US electricity needs. There are 69 pressurised water reactors and 35 boiling water reactors.

Nuclear plant performance has progressively improved over the past twenty years, but wide variations exist between plants. The mean capacity factor in 2000 was 88.7%. Some plants have been uprated.

NEW PLANTS

The last plant to have been completed was ordered in 1973. No new plants are currently being constructed. Under certain conditions, such as a planned sequential construction of similar reactors, new nuclear plants are considered by the industry to be cost-competitive. New designs (known as Generation III plus) might also be competitive.

PLANT LICENSING

Nuclear plants are licensed by the Nuclear Regulatory Commission, an independent government agency. Since most existing nuclear plants were completed during the 1970s and licensed for forty years, their licences expire between 2010 and 2020. Licence extensions are thus a major potential source of "new" generating capacity for 2010-40. Plant life extensions have been granted recently for six units on three sites to allow operation for a further twenty years. Other applications are pending. Most US plants are expected to be relicensed and to operate for a further twenty years generating 15 000 TWhe of electricity, equivalent to meeting four years of current electricity demand.

INDUSTRY CONSOLIDATION

Increasing market pressures in the US have resulted in formation of strategic alliances and mergers of nuclear power plant owners and operators in order to improve business efficiency. As a result of consolidation in the sector, some nuclear plants have been sold. Eighteen reactors have changed owners, including some sales to foreign interests. US legislation limits the involvement of non-US companies to a non-controlling interest in nuclear power plants. New legislation is planned to remove this restriction, which limits competition and market access.

FRONT-END NUCLEAR FUEL CYCLE

In 2000, production of indigenous uranium from mining was 1 456 tU compared with consumption in US reactors of 22 200 tU. The shortfall is met by imports, including uranium released from military use (primarily from Russia), and stocks. The world uranium market is currently depressed by the large quantities of material available and supplies are not at risk.

In 2000, the US had the capacity to produce 12 700 tU of uranium hexafluoride compared with consumption of 23 200 tU in that year. Uranium hexafluoride is produced by chemical conversion from mined uranium oxide as the first step in nuclear fuel production. Supplies on the world market are sufficient to make up the shortfall.

A large surplus capacity of enrichment services exists domestically (18 700 tSW compared with consumption of 10 600 tSW in 2000) in plants owned and operated by the United States Enrichment Corporation (USEC Inc.), a private-sector company owned until 1997 by the Department of Energy. The technology and plant deployed are old and energy-intensive; consideration is being given to their replacement. Until November 2001, USEC was the sole agent for the supply of enriched uranium produced by blending of former Russian military highly enriched uranium.

Domestic fuel fabrication services are sufficient to meet the needs of domestic plants. In 2000, there was a capacity of 3 900 tU per year compared with consumption of 2 100 tU. Competition exists in this sector of the services chain, but is limited by the requirements of fuel for particular plant designs.

RADIOACTIVE WASTES

Low-level radioactive wastes resulting from decommissioning and from continuing plant operations are generally disposed of in shallow facilities in various states.

About 44 000 tU of irradiated nuclear fuel are stored in the US pending the availability of an approved and licensed geological repository. In general, this highly radioactive irradiated fuel is kept in storage pools at the plant site.

The Department of Energy was unable to take title to the waste by the statutory deadline of 31 January 1998 set by the Nuclear Waste Policy Act. Several nuclear utilities responded by improving the efficiency of on-site pond storage and adding on-site dry storage facilities. The Nuclear Regulatory Commission has ruled that dry storage is safe for at least 100 years. Most utilities have decided to pursue litigation against the department for its failure to take title to the spent fuel by the statutory deadline.

The final disposal of irradiated fuel is planned to take place in a deep geological repository that would be approved for storage periods of several thousand years. The currently favoured site is Yucca Mountain in Nevada. The Office of Civilian Radioactive Waste Management in the Department of Energy has responsibility for the project.

Since 1987, progress has been made in assessing the suitability of the Yucca Mountain site for a radiocative waste repository. Site characterisation is nearing completion. In 2001, a report was issued that described the results of scientific and engineering studies completed to date, the waste forms to be disposed of, the flexible repository and waste package designs to accommodate these waste forms, and the results of recent repository performance assessments. Also in 2001, a second report updated the assessment of potential environmental impacts

If the Secretary of Energy recommends the site, and the President recommends it to Congress, the Governor and legislature of Nevada may submit a notice of disapproval to Congress, which will then be required to decide whether to override

Nevada's objection. If the site is designated, a licence application will be submitted to the Nuclear Regulatory Commission for authorisation to construct a repository. If authorised, surface and underground facilities would be built to commence operating in 2010.

Expenditure on the Yucca Mountain programme has been US$ 5 660 million to date. The balance remaining in the Nuclear Waste Fund stands at US$ 9 966 million, which, together with payments made by operators at the rate of $US 0.001 per kWhe on future generation, is expected to be sufficient to meet the total costs of disposing of the waste.

NUCLEAR PLANT DECOMMISSIONING

Funds required to meet the costs of plant decommissioning are accrued over the operating life of each plant and overseen by the Nuclear Regulatory Commission and the local Public Utility Commission. The total sum required is not accumulated until the plant reaches the end of its planned and licensed life. Early closure would result in a shortfall of funds and life extension would result in an excess. Decommissioning funds cover only the costs of site decontamination and activities that lead to licence termination. They do not include the cost of demolition and restoring the site to a "greenfield" condition, such as the removal of non-radioactive structures and restoration, spent fuel storage and associated management, and post-closure activities. Funds for spent fuel storage and management are raised separately.

CONTINGENT THIRD PARTY NUCLEAR LIABILITY

The Price-Anderson Act defines and limits nuclear liability to US$ 9.4 billion in the event of a nuclear accident. The act expires in August 2002 and its renewal is currently being considered by the Congress. The US is not a party to any international nuclear liability regime.

PUBLIC ACCEPTANCE

A survey conducted for the industry's Nuclear Energy Institute in July 2001 found that recent increased public support for nuclear power has held at high levels. Almost two-thirds of US adults support building new nuclear power plants, and there is near public consensus on renewing federal licences of existing nuclear power plants that meet federal safety standards.

The survey shows a marked change in public opinion. In October 1999, only 42% of US adults supported construction of new nuclear plants *in the future*. Support rose to 50% in January 2001, and to 66% in March 2001, before falling slightly to 63%

in July 2001. The trend is uniform throughout the nation. Even in the West, where support was only 33% in October 1999, support was 63% in July 2001.

In areas where companies already operate nuclear plants, 71% of adults support additional plants being built on existing sites *if a new power plant were required to supply electricity*. Licence renewals were supported by 85% of US adults in July 2001, compared with 79% in October 1999.

An ABC News poll[15] asked if construction of nuclear power plants *at this time* would be supported. In 1990, support for this proposition was only 22% and in June 2001, only 42% (compared with 63% in the industry survey). A CBS/*New York Times* poll in June 2001 asked more neutrally "Would you approve or disapprove of building more nuclear plants to generate electricity?". The results were 51% approved, 42% disapproved. Those who approved show a rise of 10 percentage points from 1991.

CRITIQUE

Will new nuclear plants be built? Any incentive policies should be based on market-based measures to encourage development of all forms of carbon-free power generation technology.

The National Energy Policy promotes the nuclear option. The Vice President and the Secretary of Energy have both advocated nuclear power. However, the few major specific policies that have been announced may not be sufficient to encourage nuclear energy investment.

Nuclear power is a proven carbon-free source of power technically ideal for large-scale baseload power generation. It is unlikely that new plants built to currently available designs would be competitive with gas- or coal-fired plants in the US. It is therefore difficult to see under what circumstances new plants will be built under present market conditions, unless policies are introduced to reflect the carbon value of fossil-fuelled generation.

The industry has responded to the challenge by developing new designs that may be economically attractive. The proposal by the industry for a planned sequential construction of several plants of similar design is an imaginative response to help overcome the economic challenge to new nuclear, but is unlikely to be taken up in practice.

The greenhouse benefits of nuclear power generally present a strong case for the government to introduce market-based policies to encourage the development of

15. The ABC and CBS/*New York Times* polls are quoted in the Nuclear Energy Institute report to illustrate the importance of the question asked. The commentary also observes that the level of support is closely related to concerns about future electricity production and energy scarcity generally.

many power generation technologies. The introduction of incentives for nuclear alone could be undesirable in the competitive electricity market.

Other ways in which the government could assist the growth of the industry include:

- Regulatory reforms, although considerable caution is necessary to ensure that safety is not prejudiced. The Nuclear Regulatory Commission appears to have accepted the challenge to improve its procedures to reduce unnecessary regulatory burden and lower licensee capital and personnel resource expenditures required to implement the commission's regulations.

- Research and development (see Chapter 10). The Generation III plus and Generation IV plants that are under development may offer lower-cost technology that could help promote the industry.

- Support for nuclear education. Several major programmes are in place for this purpose and undergraduate interest in nuclear programmes is undertstood to be rising.

Even if new technology does offer lower-cost options and public acceptance of new nuclear investment is positive, nuclear power will continue to require long-term investment and high up-front capital costs. In a competitive, deregulated market, the risk of long construction lead times, high capital costs and long lifetimes will all act to discourage investment in nuclear power. Governments are yet to develop acceptable policies to overcome these disadvantages without intervening unreasonably in the market in favour of one fuel. These issues are relevant in several countries and are not specific to the US.

The decision on Yucca Mountain will have worldwide implications for the future of nuclear power.

No operational repository for long-term disposal of high-level radioactive waste exists anywhere in the world. Thus, as well as having critical importance for the US nuclear energy sector, the Yucca Mountain project has a broader strategic place in the evolution of nuclear technology. An early and firm decision on the future of the project would be desirable, subject to acceptance by the nuclear safety authorities. If the Yucca Mountain site is not developed, there will be an urgent need to identify and develop another site to respond to doubts about the general viability of any high-level nuclear waste repository.

Public opinion will probably continue to be a major influence on the outlook for nuclear.

Industry surveys suggest that US public opinion is not an impediment to the future development of the industry. This result stands in contrast to experience in other nuclear countries, where public opinion is proving to be a major obstacle for policy-makers planning the future role of nuclear power.

In light of the government's wish to promote nuclear power, it would be desirable for the government to make independent assessments of public attitudes, and to respond objectively to any findings suggesting that the public is concerned about the use of nuclear power.

Arrangements for meeting decommissioning costs are challenged by the changing electricity market.

In the present market circumstances of plants being transferred from a regulated to a fully competitive environment, the processes for assuring that plant operators have the financial capacity to meet their long-term obligations, many of which arise long after the production of electricity ceases, should be maintained under active review.

When US nuclear plants were built, the electric utility industry functioned as a monopoly, with rates closely regulated by the state Public Utility Commissions and the Federal Energy Regulatory Commission. Utilities and their rate commissions factored the cost of decommissioning into the utility rate structures. With the electric utility industry increasingly deregulated, concerns could arise as to whether licensees are setting aside sufficient funds to decommission their nuclear reactors. In 1999, the Nuclear Regulatory Commission amended its regulations on financial assurance requirements for decommissioning of nuclear power plants. The amended regulations require licensees to report on the status of their decommissioning funds every two years.

RECOMMENDATIONS

The Government of the United States should:

☐ Assess the extent to which proposals in the National Energy Policy will encourage the construction of new nuclear plants.

☐ Assess public opinion on nuclear power and develop information strategies to respond to public concerns.

☐ Make a firm decision on the Yucca Mountain repository, bearing in mind the impact the decision will have in the US and worldwide on future investment in nuclear power.

9

OIL, GAS AND COAL

OIL

Oil Industry Structure

The US oil industry is dominated by a few very large companies and more than 7 000 smaller independent companies.

The major oil companies continue to focus their attention in less explored parts of the world where the prospects of finding very large fields still exist. The majors are still active in two areas of the US where high capital costs exclude smaller companies. These are deep-water Gulf of Mexico, which is lacking in development infrastructure, and the North Slope of Alaska, which has limited infrastructure, unusual distance from markets, and extreme climatic operating conditions.

Independent producers have played a growing role since the oil price collapse of 1986. By 1998, the majors' share of oil and gas production was about 54%, while the combined share of publicly traded independents and other publicly traded producers was about 19%, and the share of privately-owned producers was about 27%. Production shares more or less mirror reserve holdings. As well as the majors, diversified companies, pipeline companies and utilities have also reduced production following the oil price collapse.

In 1998, reserve replacement costs were substantially lower for majors than independents. Independents increased their investment in US exploration and development in the 1990s, while the majors sharply reduced their commitments to such investment in the late 1980s.

Exploration and Production

At the end of 1999, the US had 21 765 million barrels of proven crude oil reserves. This represented an increase of 731 million barrels or 3.5% over the end of 1998, the largest annual increase in more than two decades. On average over the last several years, proven reserves have been stable, with reserve additions replacing 85% of production in 1996, 125% in 1997, 124% in 1998 and 137% in 1999. Nonetheless, reserves were about 2% lower at the end of 1999 than they were at the end of 1995, when they stood at some 22.3 billion barrels. Reserves were 21% lower at the end of 1995 than they were at the end of 1985, when they stood at 28.4 billion barrels, owing to a sharp decrease in drilling after crude oil prices fell by half in 1986. The relative stability of reserves in more recent years is due in part to technological developments that increase the finding success rate and reduce exploration costs.

The US Geological Survey estimates a high potential for oil and gas resources in the National Petroleum Reserve – Alaska, with a mean estimate of 2.1 billion barrels of oil and 8.5 trillion cubic feet of gas. A leasing programme began in 1999 for the north-east sector of the National Petroleum Reserve – Alaska, resulting in the award of 133 leases covering 900 000 acres. Eight exploratory wells have been completed in the past two years, and additional exploratory wells are expected to be completed during the winter of 2001-02.

The US is the world's second-largest oil producer after Saudi Arabia. Production averaged 8.1 million barrels per day in 2000, including small amounts of natural gas liquids, fuel ethanol blended into finished motor gasoline, and oxygenate production from merchant MTBE plants. Production has declined from a peak of 11.3 mmbpd in the early 1970s, offset in 1977 following the start-up of Alaskan North Slope production. The decline has occurred mainly because the US is the most mature producing region in the world, with over three million oil and gas wells completed since the first was drilled in Pennsylvania in 1859. The decline would have been greater if it had not been for technological developments such as horizontal drilling that have made production from smaller fields more economical.

The National Energy Policy recommends:

- Promoting enhanced oil and gas recovery from existing wells through new technology.
- Improving oil and gas exploration technology through continued partnership with public and private entities.
- Reviewing land status and lease stipulation impediments to federal oil and gas leasing.
- Expediting the current study of impediments to federal oil and gas exploration and development.
- Reviewing public lands withdrawals and lease stipulations.
- Considering economic incentives for oil and gas development such as royalty reductions for enhanced oil and gas recovery; for reduction of risk associated with production in frontier areas or deep gas formations; and for development of small fields that would otherwise be uneconomic.
- Reviewing regulation of energy-related activities and the siting of energy facilities in the coastal zone and on the Outer Continental Shelf, continuing Outer Continental Shelf oil and gas leasing and approval of exploration and development plans on predictable schedules.
- Considering further lease sales in the National Petroleum Reserve – Alaska, including areas not currently leased within the north-east corner of the reserve.

- Authorising exploration and possible development of the 1002 Area of the Arctic National Wildlife Refuge.

Oil Trade

The US is the world's largest oil importing country. Gross imports of crude oil and petroleum products rose to a record 11.46 million barrels per day in 2000. This represents an increase of 30% from the 8.84 mmbpd imported in 1995 or 126% from the 5.07 mmbpd imported in 1985. Exports in 2000 amounted to 1.04 mmbpd, up just 10% from 0.95 mmbpd in 1995 or 33% from 0.78 mmbpd in 1985. Net imports in 2000 thus came to 10.42 mmbpd, an increase of 32% from 7.89 mmbpd in 1995 or 143% from 4.286 mmbpd in 1985.

Dependency on external sources has grown. Gross imports have increased from 32% of final domestic demand for petroleum products in 1985 to 50% in 1995 and 58% in 2000. Net imports have risen from 27% of final domestic demand in 1985 to 45% in 1995 and 53% in 2000.

Crude oil imports were 9.07 mmbpd in 2000, accounting for 79% of total petroleum imports. Short-haul imports from Canada, Mexico, and South America made up about half of both crude and total imports. Sixty percent of US crude imports came

Table 10

Imported Crude Oil and Petroleum Products

(million barrels per day)

Country	*1985*		*2000*	
	Imports from Total	*Imports from Crude*	*Imports from Total*	*Imports from Crude*
Canada	0.770	0.468	1.807	1.348
Saudi Arabia	0.168	0.132	1.572	1.523
Venezuela	0.605	0.306	1.546	1.223
Mexico	0.816	0.715	1.373	1.313
Nigeria	0.293	0.280	0.896	0.875
Iraq	0.046	0.046	0.620	0.620
United Kingdom	0.310	0.278	0.366	0.291
Norway	0.032	0.031	0.343	0.302
Colombia	0.023	0	0.342	0.318
Angola	0.110	0.104	0.301	0.295
Virgin Islands	0.247	0	0.291	0
Kuwait	0.021	0.004	0.272	0.263

Source: Department of Energy.

from four countries, each of which supplied between 1.2 and 1.5 mmbpd: Canada, Mexico, Venezuela, and Saudi Arabia. These same four countries, which supply mainly heavier grades of crude, accounted for 62% of crude imports in 1995 and 51% in 1985. In all, the 12 countries from which imports exceed a quarter million barrels per day accounted in 2000 for 93% of crude imports and 85% of total petroleum imports.

Imports from Iran and Libya are banned and sanctions apply against companies operating in countries perceived to have human rights abuses.

Crude oil exports play a minor role in the US crude oil balance, roughly averaging 100 000 to 200 000 barrels per day since 1985. Export of Alaskan North Slope production has been permitted since July 1996 subject to several restrictions.

Refining Capacity

Total refining capacity has not changed significantly in recent years, but hydrocracking, hydrotreating, alkylation, and isomerisation capacity has increased gradually to meet more stringent Clean Air Act and California environmental requirements. Atmospheric crude oil distillation capacity increased by about one million barrels per stream day or 7% between 1995 and 2000.

Table 11
US Refining Capacity
(million barrels per stream day)

Type of Refining	*1990*	*1995*	*2000*
Atmospheric Crude Oil Distillation	16.507	16.326	17.393
Catalytic Cracking	5.441	5.583	5.949
Hydrocracking	1.282	1.386	1.576
Hydrotreating	9.537	10.916	11.440
Alkylation	1.030	1.105	1.185
Isomerisation	0.456	0.502	0.643

Source: Department of Energy.

The National Energy Policy recommends:

- Ensuring adequate refining capacity through regulatory reform.
- Reviewing the impact of new Source Review regulations on investment in new refinery capacity and environmental protection.

Consumption

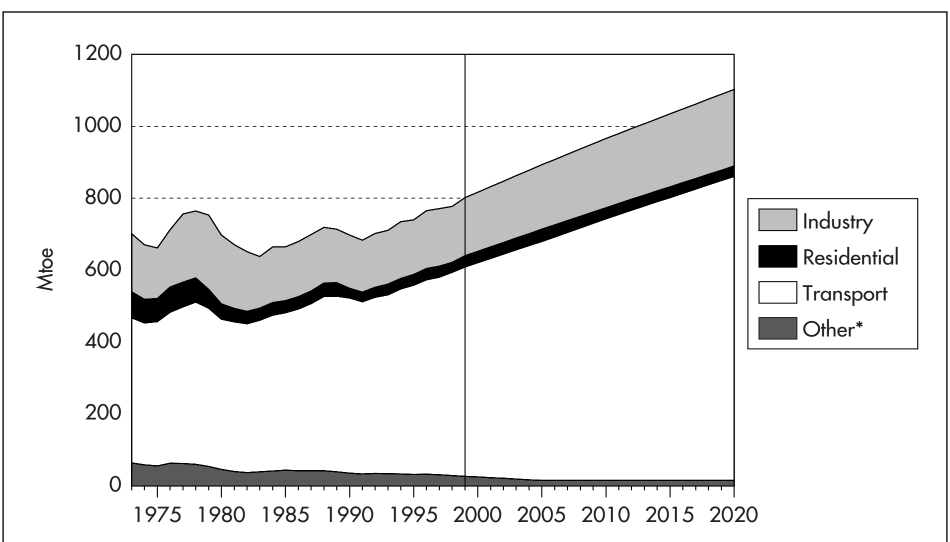
US oil consumption totalled 19.7 million barrels per day in 2000, exceeding the previous all-time high of 19.5 mmbpd in 1999. This represents an increase of 2.0 mmbpd or 11% over 1995 consumption levels, as well as an increase of 4.0 mmbpd or 26% over 1985 consumption levels, and 4.5 mmbpd or 30% over the low point in modern-era consumption that was reached in the mid-1980s.

Table 12
Oil Products Supplied in the United States
(million barrels per day)

Product	*1990*	*1995*	*2000*
Motor Gasoline	7.235	7.789	8.387
Distillate	3.021	3.207	3.711
Residual	1.229	0.852	0.837
Jet Fuel	1.522	1.514	1.769
LPG	1.556	1.899	2.191
Other	2.402	2.457	2.694
Total	**16.965**	**17.718**	**19.528**

Source: Department of Energy.

Figure 20
Final Consumption of Oil by Sector, 1973 to 2020



* Includes commercial, public service and agricultural sectors.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and country submission.

Of the total demand for oil in 2000, demand for motor gasoline accounted for a record high of 8.5 mmbpd. This represents an increase of 9% over 1995 or 24% over 1985 and 35% over the low point of the 1980s. However, gasoline's share of total oil product demand has been quite stable, at 44% in 1985 and 1995 and 43% in 2000, reflecting parallel growth in demand for distillate, jet fuel, liquefied petroleum gases and other petroleum products. Despite higher gasoline and jet fuel prices in 2000, demand for ground and air transport continued to grow, although the outlook for air transport has changed since the terrorist attacks of September 2001.

Prices and Taxation

Several states have "divorcement" legislation that prohibits oil companies from operating their own retail outlets, instead requiring them to lease the stations to independent operators to limit anti-competitive behaviour. Some states discourage low prices by banning below-cost marketing and by disallowing self-service at retail outlets.

In October 1997, federal excise taxes increased, to 4.86 cents per litre on motor gasoline (petrol) and 6.45 cents per litre on diesel fuel. As of July 2000, state taxes averaged 5.26 cents per litre for gasoline and 5.34 cents per litre for diesel. Many states and localities also levy a sales tax on purchases. US taxes on unleaded gasoline in the third quarter of 2001 averaged 10.2 cents a litre or 22.6% of the price paid by consumers at the pump.

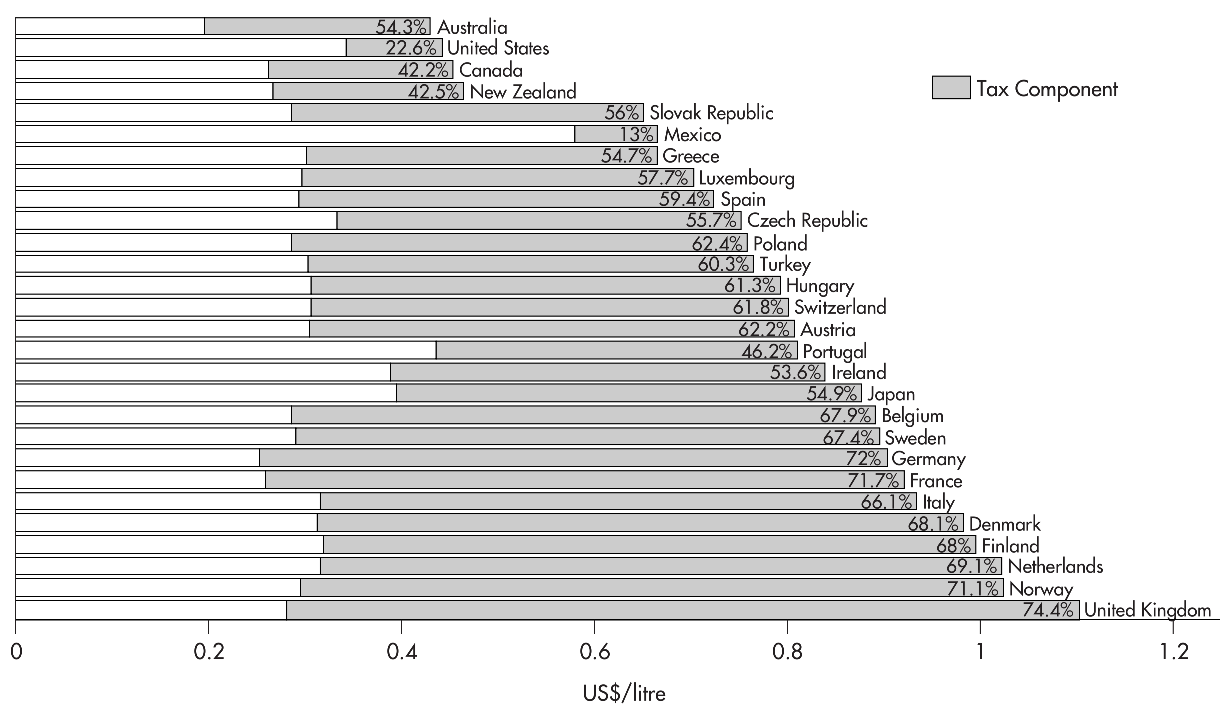
Emergencies Preparedness

The Office of Security and Emergency Operations in the Department of Energy is responsible for domestic co-ordination for an emergency response and for operating the Emergency Operations Center. Drawdown from the Strategic Petroleum Reserve is an important element of the US emergency response programme. In January 2000, 566.9 million barrels of oil were held in the Strategic Petroleum Reserve. In mid-2000, stocks were estimated to be equivalent to 120 days of net imports, compared with 143 days in 1999 and 90 days required by the IEA. The level of coverage is expected to fall as the level of imports rises. In an emergency, stocks would be released from the Strategic Petroleum Reserve on the basis of competitive bids by the industry. Crude oil can be drawn from the reserve at a maximum rate of 4.1 million barrels per day. The US does not require private companies to hold emergency stocks.

Market forces are expected to encourage increased production of oil during an emergency, but the potential for increased production is considered limited. Switching to natural gas may encourage additional gas production during an emergency. The Energy Information Administration estimates that

Figure 21

OECD Unleaded Gasoline Prices and Taxes. Third Quarter 2001



Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2001.

an additional 800 million cubic metres per day of natural gas could be produced during an emergency.

Demand restraint is not expected to play a primary role in the event of an emergency.

The National Energy Policy recommends ways of strengthening US capacity to respond to an oil supply emergency. It also recommends:

- Encouraging non-IEA Members to hold strategic petroleum stocks.

- Reaffirming that the Strategic Petroleum Reserve is not designed for managing oil prices.

NATURAL GAS

Industry Structure

There are 24 major gas producers and some 8 000 independent gas producers. 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 US gas industry is found in gas distribution. Publicly-owned gas utilities (distributors) account for only about 7% of all domestic gas sales.

The US natural gas market today is extremely open and competitive. Well-head gas prices were deregulated between 1979 and 1989 and are subject to market forces.

Exploration and Production

Onshore natural gas exploration and production are regulated by each state with indigenous production. Drilling a new or existing well requires a permit from a regulatory agency in the state where the well is to be located. Each state determines what royalties will be paid 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 Interstate Oil and Gas Compact Commission. The commission is an autonomous organisation founded by producer states to assist states, of which 36 are members, with the development of programmes, policies and regulations for oil and gas production.

Offshore natural gas exploration and production on the Outer Continental Shelf is federally regulated. Offshore drilling is regulated by the Minerals Management Service, an office within the Department of the Interior. Congress has designated

Figure 22
Natural Gas Network

Source: International Energy Agency.

about 610 million acres off limits to leasing. Leasing is effectively confined to the central and western Gulf of Mexico, a small portion of the eastern Gulf, existing leases off of California, and areas off of Alaska.

The number of gas drilling rigs in operation has more than doubled from 392 in the third week of April 1999 to 636 in December 1999, to 854 in December 2000. An average of 720 gas drilling rigs were in operation in 2000, up 45% from 1999. From 1999 to 2000, with a rise in gas well completions, production increased by 0.1 trillion cubic feet, from 18.83 Tcf to 18.99 Tcf.

The *Oil and Gas Journal* has reported that 54 independent US producers increased capital spending by 48% in 2000 and that top independents planned to increase spending by about another 35% in 2001.

In addition to recommendations on oil listed earlier that also apply to gas, the National Energy Policy recommends:

- Expediting construction of a pipeline to deliver natural gas from Alaska to the lower 48 states.

- Supporting legislation to improve the safety of natural gas pipelines.

- Continuing efforts to improve pipeline safety and expediting pipeline permitting.

- Considering improvements in the regulatory process governing approval of interstate natural gas pipeline projects.

Gas Trade

The US imported approximately 3.8 trillion cubic feet or 15% of its natural gas supply in 1999, up from 11% in 1996. About 94% of total imports were via pipeline from Canada. Imports by pipeline from Mexico more than tripled in 1999 to 55 billion cubic feet, but dropped to 12 billion cubic feet in 2000. Liquefied natural gas (LNG) imports reached 226 billion cubic feet, up 38% from the 1999 level and the highest level since 1979. LNG imported in 2000 came mainly from Trinidad and Tobago (44%), Algeria (21%), and Qatar (21%), but some was also imported from Nigeria and Oman for the first time.

Import or export of natural gas must receive prior approval, but under the North American Free Trade Agreement, the approval process is basically automatic. The only limitation to natural gas imports is the capacity of pipelines serving US markets. The construction of new or upgraded facilities used to import natural gas is authorised by FERC. All importers and exporters are required to report on a quarterly basis the volume of gas exported or imported.

Regulation

Interstate pipelines are regulated by the Federal Energy Regulatory Commission, which regulates pipeline rates, construction of new or expanded pipelines and facilities, and certain environmental aspects, and ensures open, non-discriminatory access to gas transport for all competing suppliers.

FERC Order 436, issued in 1985, provided for open access to pipelines by requiring them to transport third-party gas. FERC Order 636, issued in 1992, unbundled pipeline sales and transportation functions, with transportation remaining a regulated monopoly but sales opened to competition. Partly as a consequence, there are now some 260 unregulated independent natural gas marketers which supply and transport gas to consumers. The system of pipelines on which producers compete is extensive, with 285 000 miles of pipe owned by some 140 different companies. In recent years, several major pipelines have changed hands, but most of the acquisitions represent expansion into outside markets rather than a consolidation of ownership within markets.

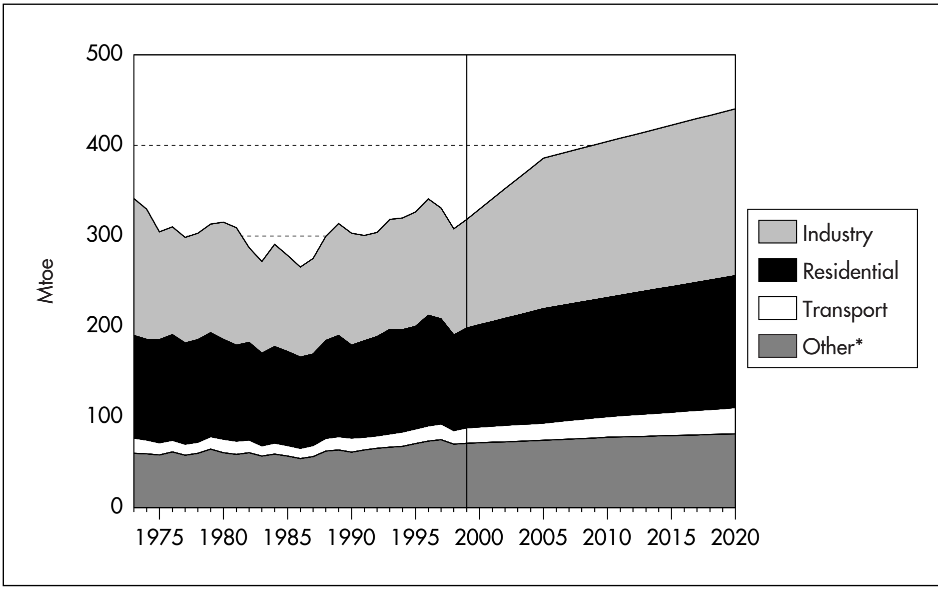
State Public Utility Commissions regulate natural gas distribution. They are responsible for regulating all aspects of gas distribution, including consumer rates. Many states are opening up functions like billing and metering to competition, while continuing to regulate local grids. There are some 1 400 local gas distribution utilities in all, varying in size from many small companies with a few thousand customers to several that have over a million customers.

Prices

Deregulation of gas production and marketing, in combination with ready access to long-distance pipelines, has had major benefits for all types of natural gas customers. For industrial customers, the real price was halved from over US$ 6 per thousand cubic feet in 1983 to about US$ 3 in 1999 in 1999 dollars. The real price for utility customers was also halved from about US$ 5 to about US $2.50 over the same period. Real residential and commercial prices declined by about a third. Largely in response to lower prices, demand has grown substantially, from 16 trillion cubic feet in 1984 to 23 trillion cubic feet in 1999.

Several factors pushed up gas prices sharply from mid-2000 to mid-2001, including flat domestic gas production, steady growth in gas demand, and below-normal gas storage. Well-head prices were 63% higher in 2000 than in 1999, increasing from US$ 2.11 to US$ 3.43 per million Btu (US$ 2.17 to US$ 3.53 per thousand cubic feet) in 1999 dollars. Well-head prices were 2.7 times higher in the winter of 2000-2001 (November to February) than during the previous heating season. Spot prices at Louisiana's Henry Hub, a baseline for US spot prices, remained above US$ 5 per million Btu from September 2000 to February 2001 in response to aggressive filling of storage in the autumn and high heating demand in the winter.

Figure 23
Final Consumption of Natural Gas by Sector, 1973 to 2020



* Includes commercial, public service and agricultural sectors.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and country submission.

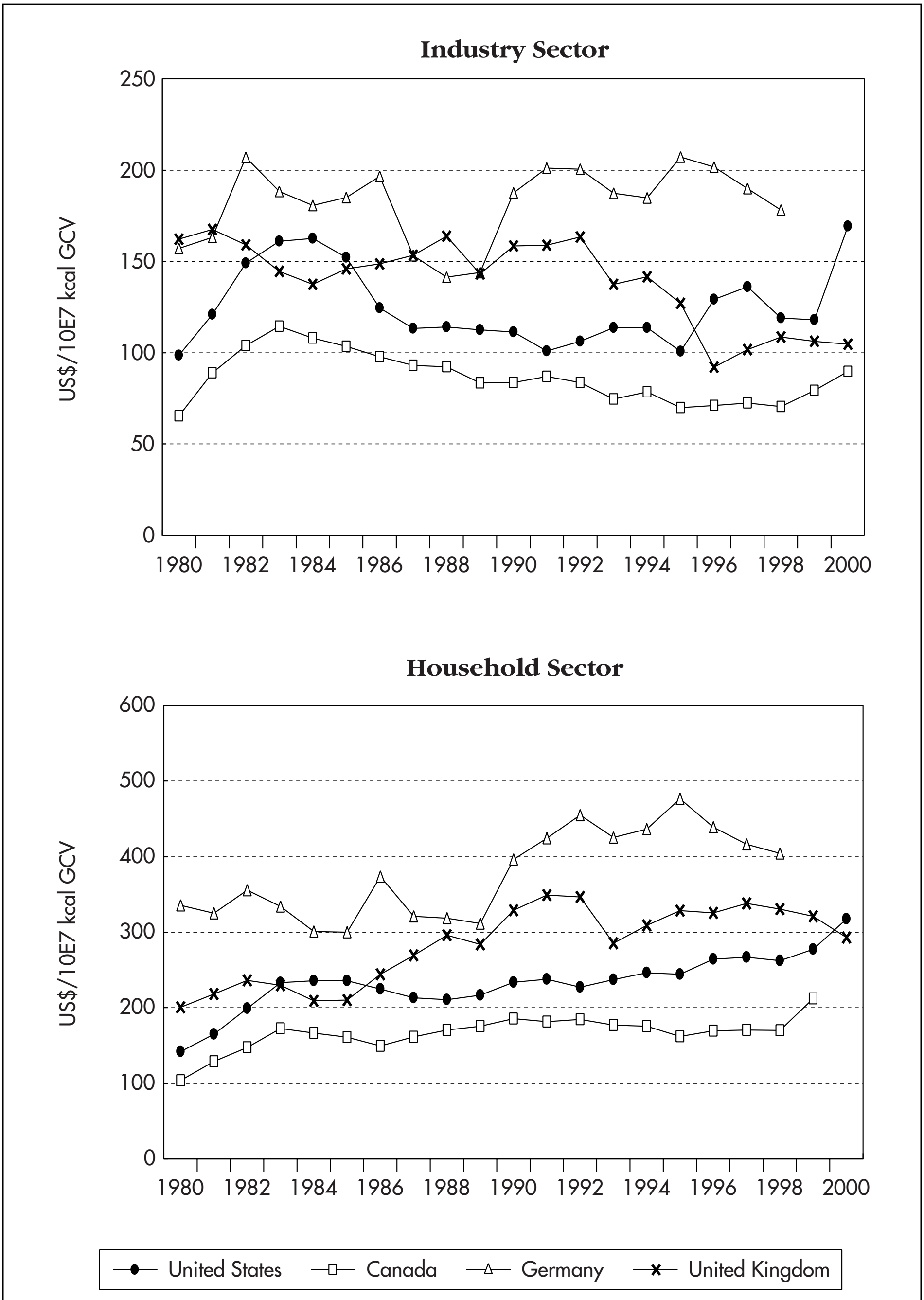
Since mid-2001, gas prices have moderated substantially, in response to increased gas production, faltering industrial gas demand, and mild summer weather. In September 2001, the average well-head price was expected to reach just US$ 4.20 per thousand cubic feet in 2001 (a 20% increase from 2000 instead of 40% as projected in May) and to drop to near US$ 2.65 per thousand cubic feet in 2002 (one-third less than in 2001). Well-head prices are expected to average less than US$ 2.50 per thousand cubic feet in the spring and summer of 2002, after which they might drop to US$ 2 per thousand cubic feet if the weather is mild or rise to US$ 3 or US$ 3.50 if the weather is severe during the following autumn and winter.

Spot prices at the Henry Hub had fallen below US$ 2.50 per million Btu by the end of August 2001, about half the prices seen the previous winter, in response to weak demand and plentiful supplies of working gas in storage.

Severe spikes in natural gas prices were experienced in California but have not persisted. On the SoCal system, the average differential from the Henry Hub benchmark jumped from US$ 0.81 per million Btu in the third quarter of 2000 to US$ 7.18 in the fourth quarter and US$ 8.75 in the first quarter of 2001. The price differential in SoCal averaged US$ 16.92 per million Btu in December 2000 and spiked as high as US$ 49.49 that month, when the price reached US$ 59.40. In February 2000, the differential averaged over US$ 13 per million Btu and peaked at nearly US$ 31. In March 2000, the minimum differential remained in excess of US$ 4, suggesting that difficult conditions in southern California might continue for

Figure 24

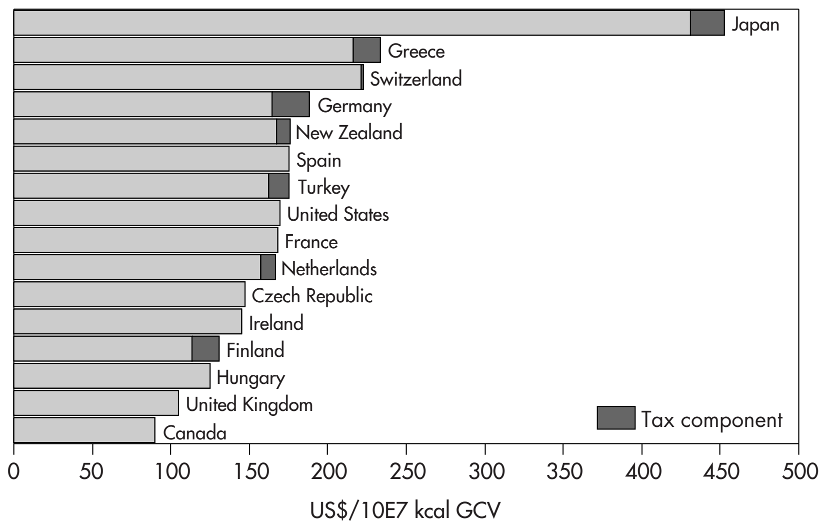
Gas Prices in the United States and in Other Selected IEA Countries, 1980 to 2000



Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2001.

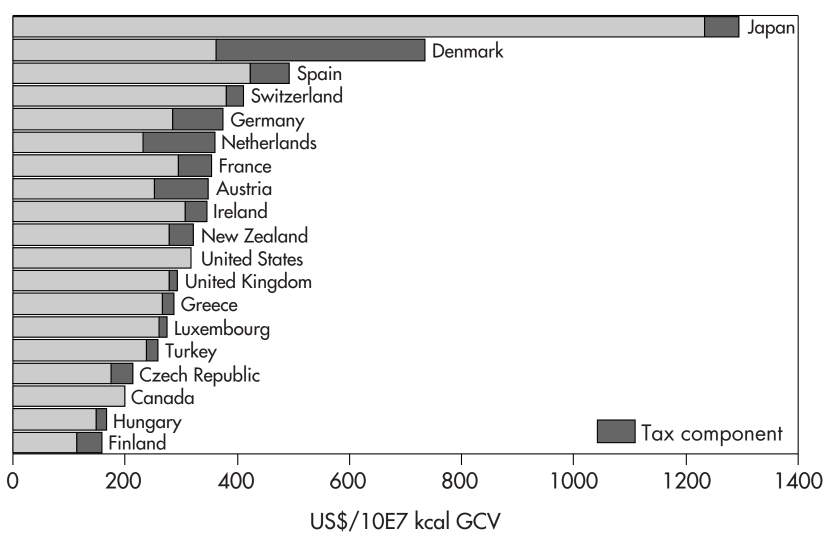
Figure 25
Gas Prices in IEA Countries, 2000

Industry Sector



Note: Tax information not available for Canada and the United States. Data not available for Australia, Austria, Belgium, Denmark, Italy, Korea, Luxembourg, Norway, Portugal and Sweden.

Household Sector



Note: Tax information not available for Canada and the United States. Data not available for Australia, Belgium, Italy, Korea, Norway, Portugal and Sweden.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2001.

some time. However, by late August 2000, the differential from the Henry Hub benchmark more or less evaporated as gas prices at the California border had fallen to just US$ 2.56 per million Btu.

Demand

Much of the price increase for gas in early 2001 can be attributed to strong demand, which jumped by 4.3% in 2000 after increasing an average of 1.6% per year between 1990 and 1999, reaching an all-time high of 22.55 trillion cubic feet. Demand growth has been particularly strong in the electric power sector, averaging nearly 11% per year between 1996 and 2000, as the gas-fired share of US electricity generation, including co-generation, rose from 13.2% in 1996 to 16% in 2000. About 22 gigawatts of new gas-fired generating capacity were added in 2000 – more than the 21.4 gigawatts added in the four-year period from 1995 to 1999. It is estimated that about 25 gigawatts of gas-fired capacity will be added in 2001.

In September 2001, natural gas consumption for the year 2001 was projected to decline by about 1.3% from 2000 because of sharp reductions in industrial gas demand. This was a substantial contributing factor to the moderation of natural gas prices. In the first half of 2001, total industrial gas use fell by about 6.5% from the year before, but excluding non-utility power generators, industrial gas use fell by about 22.5%.

In contrast, use of natural gas for electricity production by independent power producers and industrial and commercial co-generators increased by 23% in the first quarter of 2001 and is estimated to grow a similar amount in the second quarter relative to 2000 levels.

Storage

In general, storage of gas makes sense when the cost of storage is less than the difference between the withdrawal cost in the peak season and the refill cost in the off-peak season. During the refill season of 2000, with higher than usual natural gas prices, net injections into storage were down by almost 10% from 1999 levels, leading to low storage levels and increased pressure on natural gas prices going into the winter of 2000-2001.

At the end of October 2000, stocks stood at 2 699 billion cubic feet, the lowest level since 1996, when stocks were 2 810 Bcf. At the end of the 2000-2001 heating season, stocks were estimated at 742 billion cubic feet, also a record low and 2% below the previous end-of-season low of 758 Bcf in 1996. The situation was particularly severe in the West, where storage facilities were called upon in the summer of 2000 to supplement supplies lost by the El Paso pipeline disruption in New Mexico in August. By the end of February 2001, inventories in the West were estimated at just 99 billion cubic feet, less than half the average level. By August 2001, gas stocks had rebounded in response to increased production, loss of industrial demand, and mild summer weather. Working gas in storage at the end of August was 2 576 Bcf, well above the 2000 level and above the average for 1996-2000.

Gas storage levels at the start of the 2001-2002 heating season on 1 November 2001 were 12% higher than at the start of the previous heating season.

Pipeline Investment

The gas pipeline network has also expanded substantially in response to rising demand. More than 20 billion cubic feet per day of interregional capacity were added in the period 1990 to 2000 – an increase of 27% over the last decade.

Over the two years to September 2001, more than 60 natural gas pipeline construction projects were completed, providing 12.3 billion cubic feet per day of new pipeline capacity, an increase of 15% over total capacity available in 1998. Pipeline companies have announced 88 further projects that should provide an additional 20.8 billion cubic feet per day of capacity to the national network, of which 4.8 Bcf would serve the North-East and 2.6 Bcf would serve the West.

Much of the planned expansion is based on the 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.

COAL

Industry Structure

The coal industry in the US is entirely owned by private companies. The number of coalmines (lignite and hard coal) declined from 3 430 in 1990 to 2 104 in 1995, and this trend of consolidation has continued. Mines in the eastern coalfields, as well as older western mines, often combine underground and open cast operations, while newer developments in the Powder River and San Juan basins are entirely surface operations.

Hard coal production in the US has expanded steadily, though its share of world production has generally remained at just under a quarter of total output. Production increased from 501 Mt in 1971 to a peak of 936 Mt in 1998, but fell to 916 Mt in 1999 and again in 2000 to 899 Mt.

Figure 26
United States Coalfields

Source: IEA Coal Research, *Major Coalfields of the World*, IEA/OECD Paris, 2000.

There are six main coal basins. The Appalachian and Illinois basins are east of the Mississippi River. The Powder River, Green River, Uinta and San Juan basins are in the West. Demonstrated reserves in 1997 were 460 740 Mt, of which estimated recoverable reserves were 249 680 Mt. Recoverable reserves at producing mines were 17 390 Mt. There are also large reserves of lignite. About two-thirds of US lignite reserves are in North Dakota (see Table 13).

The largest coal ports are in Los Angeles, Baltimore (Maryland), Hampton Roads (Virginia), Mobile (Alabama), Buffalo (New York) and Cleveland (Ohio).

Owing to increasingly stringent environmental requirements under the Clean Air Act Amendment of 1990, the share of low-sulphur coals, predominantly from western fields in Wyoming, Montana, Colorado and Utah, is expected to continue growing. From 1999 to 2020, low-sulphur coal production is projected to increase by 2% per year from 490 Mt to 740 Mt, while high- and medium-sulphur coal production will decline by 0.2% per year from 616 Mt to 592 Mt.

The main mode of transport for coal is rail. While the rail system is extensive, most mines are served by only one major rail carrier. Coal accounts for about 40% of total rail freight traffic in the US. For the western fields, distances by rail to ports are long, averaging 2 250 kilometres from Wyoming and 1 300 kilometres from Utah. For eastern fields, rail distances are much shorter.

Table 13
US Coal Resources
(million tonnes)

Basin	*Identified*	*Demonstrated*	*Recoverable*
Appalachian		97 101[1]	4 203[2]
Illinois		81 630	1 364[3]
Powder River		150.1[4]	
Green River	54 400		
Uinta	61 030		
San Juan	152 000		12 000[5]
North Dakota	318 000[6]		
Texas	46 100[6]		

1. Bituminous and anthracite.
2. Recoverable reserves at producing mines.
3. Recoverable reserves at producing mines in Illinois, Indiana and western Kentucky.
4. Demonstrated reserve base of sub-bituminous coal in Montana and Wyoming.
5. Remaining strippable reserve base.
6. Lignite.

Source: IEA Coal Research, *Major Coalfields of the World*, 2000.

Consumption

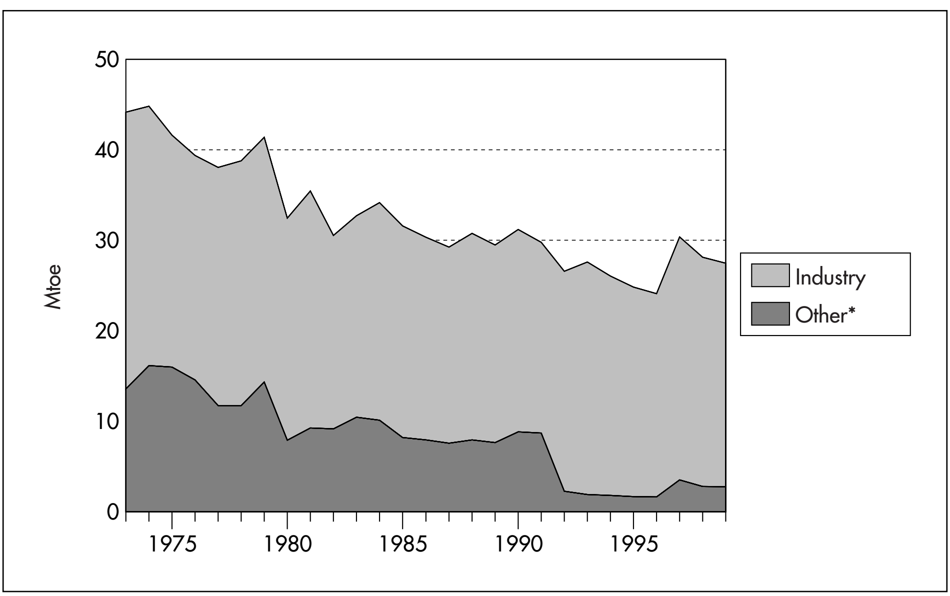
Coal is used in the US almost exclusively to generate electricity. Coal power plants account for over 50% of all US electricity generation, and over 80% of generation in twelve states in the Midwest, South-East and West. Coal electricity generation costs are low, and coal prices have proved remarkably stable.

Over the past decade, greater efficiencies, lower capital costs, fewer emissions and quicker start-up times have made new power plants fuelled by natural gas a more attractive choice than new coal-fired generation. But recent natural gas price increases have renewed interest in building coal power plants. Coalmine productivity has improved by an average of 6.7% yearly since 1979, and the price of coal to electricity generators is projected to decline by 1.3% per year to 2020. Hence, domestic coal demand is projected in the Energy Information Administration's reference case forecast to increase from 981Mt in 1999 to 1 365 Mt in 2020 – an increase of 26% in a little over two decades. Coal consumption for electricity generation, excluding co-generation, is projected to grow from 875 Mt to 1 254 Mt over the same period.

The National Energy Policy recommends:

- Investment of US$ 2 billion over ten years to fund research in clean coal technologies.

Figure 27
Final Consumption of Coal by Sector, 1973 to 1999



* Includes residential, commercial, public service and agricultural sectors.
Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001.

- A permanent extension of the existing research and development tax credit for such technologies.

- Exploring regulatory approaches that will encourage advancements in environmental technology and provide greater regulatory certainty relating to coal electricity generation through clear policies that are easily applied to business decisions.

Coal Trade

Hard coal exports peaked in 1990 at 95.9 Mt but still amounted to some 83 Mt in 1996, the same level as in 1980. Coal exports have since continued declining, to 53 Mt in 2000. The Energy Information Administration projects that exports will stabilise at 56 Mt by 2020. The US share of total world coal trade is forecast to decline from 11% in 1999 to 8% by 2020 as international competition intensifies and demand for coal imports in Europe and the Americas grows more slowly or declines. Exports have been mainly coking coal, although the proportion has fallen from about 60% in 1990 to about 43% in 2000[16]. The largest single market is Canada, to which 17 Mt were exported in 2000. Imports are far smaller than exports, totalling 11.3 Mt in 2000, of which 6.9 Mt came from Colombia, 1.8 Mt from Venezuela, 1.5 Mt from Canada and 0.7 Mt from Indonesia.

CRITIQUE

Oil

Oil exploration in prospective areas is limited on environmental grounds. Agreement to expand exploration and production activities would require boosting public confidence that such activities could be conducted in an environmentally responsible manner.

Oil exploration is restricted in many of the most prospective locations left in the US. Onshore and offshore Alaska, the Gulf of Mexico, and the far West (Washington, Oregon, California, Idaho, Nevada, and parts of Utah and New Mexico) are the only regions in which significant undiscovered conventional oil and gas resources remain which could be exploited at competitive costs. The most promising oil prospects in onshore Alaska and offshore California have been administratively or legislatively declared off-limits to oil and gas exploration for many years.

16. The US Energy Information Administration estimates that coking coal exports accounted for 56% of total exports in 2000. The percentage quoted in the text uses IEA statistics.

Offshore, enormous sections of federal lands have been barred from leasing or drilling by congressionally-imposed restrictions to the Department of the Interior's annual appropriations. Congress has designated about 610 million acres off-limits to leasing on the Outer Continental Shelf, which contains large amounts of recoverable oil and gas resources. The entire east coast, part of the Gulf of Mexico off Florida, the west coast, and Bristol Bay in Alaska are currently under moratoriums. This is despite strong industry interest in developing resources off Florida, California and North Carolina. Congressional moratoriums have been expanded by presidential action, effectively confining the federal Outer Continental Shelf leasing programme to the central and western Gulf of Mexico, a small portion of the eastern Gulf, existing leases off California's shore, and areas offshore Alaska.

It is projected that with advanced technology, recovery from the Outer Continental Shelf might amount to 59 billion barrels of oil and 300 trillion cubic feet of natural gas. Concerns over the potential impacts of oil spills have been a major factor behind imposition of the moratoriums. Yet exploration and production from the Outer Continental Shelf has an impressive environmental record. Since 1985, operators have produced over 6.3 billion barrels of oil, and have spilled only 0.001% of production. Naturally occurring oil seeps add about 150 times as much oil to the oceans.

An offshore area with particular potential is the Arctic Outer Continental Shelf, where there may be some 22.5 billion barrels of oil and 92 trillion cubic feet of natural gas to be discovered.

For those areas that are available for exploration and production activity, businesses must comply with a variety of federal and state statutes, regulations and executive orders. Aspects of these, under the Coastal Zone Management Act and the Outer Continental Shelf Lands Act and their regulations, attempt to provide for responsible development while considering important environmental resources. However, effectiveness is sometimes lost through a lack of clearly defined requirements and information needs from federal and state entities, as well as uncertain deadlines during the process. These delays and uncertainties can hinder exploration and production projects.

Onshore, federal lands managed by the Bureau of Land Management of the Department of the Interior and the US Forest Service of the Department of Agriculture are available for leasing and development subject to multiple-use restrictions. Lands managed by the US Fish and Wildlife Service and the National Park Service, which are agencies within the Department of the Interior, are much less available. For example, the Arctic National Wildlife Refuge remains closed to oil and gas development. Wilderness designations and restrictions imposed in favour of wildlife habitat or recreation make other lands either unavailable or too expensive to develop.

The Alaskan North Slope is a promising area for discovery of additional reserves to increase domestic production of oil and natural gas. Currently, state lands on Alaska's North Slope provide about 17% of US oil production.

Agreement to permit more extensive oil and gas exploration and production in restricted areas on- and offshore would require gaining public confidence that these activities can be conducted in an environmentally responsible manner.

There is also major potential for oil and gas production on federal land in the lower 48 states. The US Geological Service and Minerals Management Service estimate that this land contains 4.1 billion barrels of oil resources and 167 trillion cubic feet of natural gas reserves. Many of these resources have been placed off-limits or are subject to significant restrictions.

Oil refining is operating at full capacity and new investment is deterred by low profitability.

The US refining industry is running at nearly full capacity during periods of peak petrol consumption and is producing record levels of needed products at other times. The strain on refining is largely due to a decade of low profitability and rates of return on investment in new refineries. No major refineries have been built in the last twenty-five years. During the last ten years, while 50 refineries closed, overall refining capacity grew by about 1% to 2% per year by expanding existing, larger refineries. Although there was a significant, sustained improvement in margins during 2000, those gains arose out of a very tight supply situation and high, volatile prices. Industry consolidation has been a key response to this poor profitability.

The US refining industry is also facing major infrastructure problems. While the industry expanded steadily through the 1970s, it went through a period of consolidation after the oil shocks of 1973 and 1978. Industry consolidation, in an effort to improve profitability, inevitably leads to the sale or closure of redundant facilities by the new combined ownership. This has been particularly true of terminal facilities, which can lead to reductions in inventory and system flexibility. While excess capacity may have deterred some new capacity investments in the past, more recently, other factors, such as regulations, have deterred investments.

Local regulations have required the production of high-cost "boutique" fuels that could be avoided by more consistent standards.

Refiners are subject to significant environmental regulation and face several new clean air requirements over the next decade. Refiners will face many clean fuel production standards, which require the production of many different kinds of gasoline and diesel fuel for different parts of the country. The proliferation of distinct regional and state gasoline and diesel product standards (requiring the production of local "boutique" fuels), the significant permitting needed, and the downtime to make the needed physical and operational changes will challenge refiners and governments to co-ordinate effectively in order to reduce the likelihood of supply shortfalls and price spikes.

Since 1990, refiners have met growing demand by increasing the use of existing equipment and increasing the efficiency and capacity of existing plants. Even with these efforts, however, refining capacity has begun to lag behind peak summer demand. Price volatility and the cyclical nature of oil markets inhibit investment in supply infrastructure.

Gas

The Canadian and US gas markets are closely integrated. Mexico is also interconnected with the US market.

Pipeline links and substantial flows of gas from Canada to the US have effectively created a single gas network, although interconnection between the countries varies among states and provinces. The western US is more closely integrated with Canada than it is with the eastern US market. Mexico is also connected to the US market, but the capacity for exchanges is small. The development of the market has been encouraged by the North American Free Trade Agreement.

The combined North American market amounted to 733 bcm in 2000, equivalent to 29% of global gas supply. Of this, the US accounted for 643 bcm. The region as a whole is largely self-sufficient, although there are imports of LNG mostly from Algeria, and Trinidad and Tobago into the US East Coast which just offset the small exports of pipeline gas to Mexico and of LNG to Japan from Alaska. US production is concentrated in the southern and central states. Texas and Louisiana account for close to half of total North American dry gas production. Most gas is produced from gas-only wells.

Consumption has been rising steadily since the mid-1980s. Most of the increase has been met by Canadian production. The region has a vast network of high-pressure interstate pipelines that carry gas from the major producing areas to the main markets both within the producing regions and in the North-East, Midwest and California. The North-East is the largest consuming region, served by some 25 pipelines from the South-West, Midwest and Canada.

The regional market is largely open to competition.

The North American gas industry has undergone profound structural changes over the last two decades, largely because of regulatory reforms aimed at promoting competition and improving efficiency. This process began with the lifting of controls on well-head prices, followed by mandatory open access to the interstate pipeline and storage system, and the unbundling of pipeline companies' trading, transportation and sales activities. Several states are now expanding open access and retail competition to small residential and commercial consumers. Pricing of transmission and distribution services remains for the most part regulated by FERC and by state regulators on a cost-of-service basis.

The American Gas Association estimates that more than 80% of the natural gas consumed in the US could be purchased from sources other than the local distribution utility. Using 1999 data, 61% of all gas consumed in the US was actually bought under a customer choice option. Customer choice is available for 99% of electric utility gas volumes and 95% of industrial volumes. About 90% of gas was actually purchased under a customer choice option for these purposes. The customer choice option is, or soon will be, available for about 72% of all commercial gas volumes and 50% of all residential volumes. Roughly 35% of commercial gas and 5% of residential volumes were purchased under a customer choice option in 1999. Residential participation in the liberalised market is low because the ability to choose suppliers is still limited for residential consumers. About 20% of residential consumers switched suppliers where the option was available.

Security of supply should be kept under review in light of recent exploration/ production trends.

Since Canada has been a long-term reliable supplier of gas to the US and most remaining supply is from indigenous production, security of natural gas supply is not considered to be a serious threat by the Department of Energy. Recent analysis by the IEA suggests that there may be some cause for concern, particularly with respect to the pace of domestic production[17].

Recent increases in the market price of natural gas have raised concerns about the strength of natural gas supplies, particularly in light of growing demand for gas for power generation. Increased wholesale prices have prompted a significant level of exploration activity and production has increased. Well-head prices have directly affected drilling rates. New production capacity for conventional wells can usually be brought on stream within six to eighteen months of drilling. Despite a surge in drilling following higher prices in 1999 and 2000, US natural gas production has not increased as fast as past trends would have suggested. Drilling activity increased by 45% in 2000, while production rose by only 4%.

In part, the low production response arises from conservative drilling programmes that have focused on sites close to existing production areas. Drilling in new onshore and deep-water offshore areas is expensive and carries higher risk. A sustained period of higher prices may be required as an incentive for investment. Well-head prices are expected to rise, but are not expected to be sustained at the very high levels of late 2000 and early 2001.

A key uncertainty for US gas production prospects is access to resources on federal lands. Two of the most promising areas for future production are the Rocky Mountains and the Gulf of Mexico, which are subject to strict access restrictions. According to the National Petroleum Council, 40% of the estimated resources in the Rocky Mountains is located on federal lands that are either closed to exploration or

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17. *World Energy Outlook – Assessing Today's Supplies to Fuel Tomorrow's Growth*, OECD/IEA 2001.

subject to restrictive provisions. The eastern Gulf of Mexico is largely closed to exploration. The US east coast is entirely off-limits and drilling on the west coast is restricted. If these resources could be exploited in an environmentally acceptable manner, production could be boosted at lower costs than in other areas.

Substantial investment will be required in new transmission and distribution capacity, and in storage.

There will be a need for substantial investment in new transmission and distribution capacity in North America, including new pipelines to bring gas from Canada into the US. Increasing reliance on Canadian gas located far from major markets could increase the need for new capacity and the size of required investment in the longer term.

Much of the increase in demand will probably come from the power sector, which will increase the load factor and will allow growth in capacity to lag growth in total demand. Investment in storage could also offset the transmission capacity required.

As noted in the IEA review of Canadian energy policies[18], governments have a role in keeping the level of investment in energy supply infrastructure under review to ensure security of supply through efficient and timely investment in new supply capacity. The US government ensures the market is informed through projections of key market parameters such as growth in demand. The government should continue to be proactive in this role and be prepared to alert the market if it judges that private investors are not responding adequately.

Coal

The US has been the swing producer in the international coal market. Falling production and exports suggest this role may change.

The US is by far the largest hard coal producer in the OECD and second only to China in the world. It is also a major exporter although exports account for only a small proportion of total production. Because of the relatively small proportion of production exported, and the relatively high cost of production on an international scale, the US has traditionally played the role of swing producer in the international coal market. US producers have historically increased the level of exports when international prices have risen, effectively capping any rising price trends resulting from shortfalls in supply. This situation has changed in recent years, and may foreshadow fundamental changes in the way the international market works. Only China is similarly placed, with its high total output and relatively small proportion of exports to production.

18. *Energy Policies of IEA Countries - Canada 2000 Review*, OECD/IEA 2000.

US hard coal production declined for the second consecutive year in 2000. Coking coal production and exports have risen, but steam coal production and exports have fallen. Eastern US production has declined steadily since 1997 as a result of more stringent sulphur emission standards encouraging utility coal consumers to shift to lower sulphur and less expensive western coal. Restrictions on mountain-top mining have also limited eastern output. The outlook for eastern US coal production is uncertain. Surprisingly, western production, which has been rising since 1992, showed a marginal decline in 2000, probably because of low prices since the mid-1990s.

Most new capacity is in the West, and not well located for exports because of high transport costs to ports. Moreover, expected high domestic demand for low-sulphur coal is expected to take up additional production from these areas. Imports have been rising and are expected to continue to rise. The US government expects exports to remain subdued to 2020.

Domestic coal consumption is expected to rise rapidly and be sustained by the application of advanced clean coal technologies. But incentives for deployment will be necessary.

Uncertainty about future environmental controls is of particular concern for companies that operate coal power plants. A number of regulations under development would require reductions in emissions of nitrogen oxide, sulphur dioxide and mercury. Rules on discharges to streams and cooling water intake structures, possible regulation of large-volume wastes as hazardous wastes, uncertainty over rules requiring air permits for certain modifications to power plants, and uncertainty over global and domestic efforts to reduce carbon dioxide emissions also play a role. Compliance decisions by businesses concerning each new regulation must often be made without the benefit of clear information regarding additional requirements that may be imposed. This regulatory uncertainty discourages power producers from building coal power plants and is one reason why the US is relying so heavily on natural gas power generation to meet growing electricity demand.

Technological advances, coupled with the successful development of markets to trade sulphur dioxide and nitrogen oxide, have led to substantial reductions in the cost of controlling sulphur dioxide and nitrogen oxide emissions. The Clean Coal Technology Program has contributed to make effective control technologies available. Both nitrogen oxide and sulphur dioxide control technologies have moved into the utility market-place and now provide a means to achieve cost-effective regulatory compliance.

Most power plants that can use low nitrogen oxide burners have now installed them, and about 25% of all coal power plants have either ordered or installed selective catalytic reduction technology, which reduces nitrogen oxide emissions. Technologies like fluidised-bed combustion and integrated gasification combined cycle that further reduce emissions have been developed.

Future coal electricity generation will need to reduce emissions further, especially mercury emissions. The Department of Energy is supporting efforts to develop more cost-effective control technology. Indeed, the goal of these research, development and demonstration programmes is to develop and demonstrate coal power systems with close to zero environmental emissions, while maintaining low production costs. Work is also under way to develop add-on sequestration technology that will permit upgrading of advanced combustion systems to further reduce carbon emissions.

The existing fleet of coal-fired power plants is expected to be replaced around 2030. It will be necessary to have policies in place by then if private investors are to choose advanced, probably higher-cost, technologies to replace or upgrade existing plants. Unless the new technologies are competitive with existing technologies, this will almost certainly require a regulatory regime restricting carbon emissions and economic instruments that value the emissions. The US has shown by its use of tradable sulphur dioxide and nitrogen oxide emissions that economic instruments are highly cost-effective in achieving environmental goals. The major advances achieved through the Clean Coal Technology Program will only be fully deployed if similar innovative policy measures are introduced to place an economic value on the benefits they potentially bring by reducing carbon emissions.

RECOMMENDATIONS

The Government of the United States should:

Oil

- ☐ Remove undue obstacles to oil and gas exploration both onshore and offshore, particularly on federal territory.
- ☐ Work with industry to reduce barriers to new investment in refinery capacity.
- ☐ Develop consistent standards for "boutique" fuels.

Natural Gas

- ☐ Maintain the momentum for opening the downstream gas market, giving particular attention to customer choice in the residential sector.

- ☐ Review the outlook for the gas supply and demand balance.

- ☐ Review the adequacy of investment in gas transmission, distribution and storage.

Coal

- ☐ Review policies for the deployment of clean coal technologies, including carbon dioxide sequestration.

10

ENERGY RESEARCH AND DEVELOPMENT

TRENDS IN FUNDING

Over the last few years, overall funding for energy research, development and demonstration has been fairly stable. The budget for 2002[19] is higher than in 1999, 2000 and 2001 in total but shows some variations in expenditure priorities. Comparing the budgets in each category for 2002 shows the following trends:

- Renewables funding is slightly lower than in 1999.
- Fossil energy funding has roughly doubled between 1999-2000 and 2000-2001 because of renewed emphasis on developing clean coal technologies.
- Significant resources continue to be devoted to the development of electric power technologies such as stationary fuel cells and superconducting transmission lines.
- Budgets for cross-cutting basic energy sciences and advanced computing technologies are significantly higher in 2001 and 2002 than in 1999 and 2000.

Conservation is similar in 2000 and 2001, but has grown substantially since 1999.

RESEARCH PROGRAMMES AND PRIORITIES

Energy Efficiency and Fuel Use

Priorities for energy efficiency include the development of new and advanced technologies for improving efficiency in energy-intensive industries, advancing the efficiency of transportation, and developing buildings technologies.

Industrial Technologies

The Industries of the Future Program[20] is identifying energy-intensive industries, defining industry goals, and developing roadmaps for public-private investments and partnerships. The roadmaps serve as strategic paths for research and development. The programme focuses on nine energy-intensive industries: forest products, steel, aluminum, metal casting, glass, chemicals, petroleum, mining, and agriculture. The roadmaps define a number of priority activities in each of these industries. Representative industry-specific activities include the following:

19. Where funding is concerned, the years referred to in this chapter are financial years.
20. Projects with partner industries are reported at **www.oit.doe.gov/industries.shtml**

- **Forestry and paper products:** 12 projects focusing on industrial energy efficiency, low-level heat recovery, new approaches to water removal in wood and paper drying, and pre-treatment technology to increase yield and efficiency, and decrease chemical consumption and cooking temperatures.

- **Steel:** Research to reduce energy while lowering emissions through improved sensing and controls, increased use of by-products and recycling, and process improvements.

- **Aluminum:** Development of an advanced cell with the potential to reduce energy consumption by 27%; scale-up of advanced cell development based on the most promising cell designs and anode/cathode materials combinations.

- **Metal casting:** Research on advanced casting technologies, focusing on the Advanced Lost Foam Casting technology and binders (chemicals that hold sand moulds together) for iron and steel casting. The process uses polymer foam patterns, which are decomposed by molten metal, but duplicates the details of the pattern, requiring less metal and machining.

- **Glass:** Initiate new fundamental knowledge of glass physics; better means of removing heat faster; better understanding of integrated product and process controls; and develop advanced sensor technologies and measurement techniques.

- **Chemicals:** Demonstrate new separation technologies, such as a novel membrane-based process to recover propylene from propane.

- **Petroleum:** Solicit new projects for industry-laboratory partnerships such as innovative separation processes, new catalysts and bio-catalysts, real-time process measurement of chemical composition, intelligent processing, minimisation of fouling, and new materials for membranes and heat exchangers.

- **Mining:** Technologies being developed include advanced minerals characterisation, integrated mining systems, and low-energy metals processing.

- **Agriculture:** Activities are aimed at achieving industry's target of a fivefold increase in market share for renewable bio-products.

Three cross-cutting activities with applications in industry are:

- High-efficiency, clean combustion technology that can produce uniform, high-quality end products at high production rates.

- Sensors/control systems that can operate in high temperatures and harsh environments while increasing process efficiency.

- The Advanced Industrial Materials Program and the Continuous/Fiber Ceramic Composites Programs, which combine common materials-based resources.

Table 14
Funding for Energy Research and Development
(US$ million, financial years)

	1999	*2000*	*2001*	*2002*
Energy Conservation	*480.3*	*538.8*	*581.6*	*594.1*
Transportation	198.7	28.8	255.4	252.7
Industry	162.8	137.4	148.6	148.9
Buildings	118.9	123.1	130.2	128.6
Electric Power	0	49.6	47.3	63.8
Renewables	*258.8*	*210.7*	*250.4*	*248.2*
Biomass	99.3	69.4	86.3	88
Solar Energy	93.8	81.4	92.7	89.4
Wind	34.4	31.7	39.6	38.6
Geothermal	28.2	23.3	26.9	27.3
Hydropower	3.2	4.9	5	5
Fossil Energy	*199.6*	*207.5*	*352.8*	*409.4*
Coal	126.5	120.9	240.9	318.9
Oil	47.3	55.7	66.9	45.3
Natural Gas	25.7	30.8	45	45.2
Nuclear Fission	*22.5*	*34.8*	*47.3*	*50.5*
Nuclear Fusion	*243.1*	*273*	*295.8*	*298*
Power Technologies	*127.3*	*123.8*	*135.3*	*147.3*
Turbines	43.4	43.1	30.9	18.5
Fuel Cells	43.1	43.4	52.6	58.1
Transmission	36.4	33.9	45.8	61.5
Storage	4.4	3.4	6	9.2
Cross-Cutting Technology	*984.7*	*912.9*	*1 198.6*	*1 186.2*
Basic Energy Science	791.7	752	991.7	999.6
Advanced Computing	153.5	122.3	165.8	157.4
Solar Photoconversion	14.5	14.3	14.3	0
Hydrogen	25	24.3	26.9	29.2
Total	**2 293.8**	**2 266.7**	**2 814.4**	**2 883.3**

Source: Department of Energy.

Transportation Technologies

The Partnership for a New Generation of Vehicles, initiated in 1994, has the goal of developing by the year 2004 an 80-mpg five-passenger family sedan that is capable of being mass produced. The goal for the year 2000 has been met with three concept vehicles: the Ford Prodigy, GM Precept and DaimlerChrysler ESC-3. All three concept cars incorporate a number of new technologies, including hybrid drive-trains, lightweight materials, low-emission diesel engines and high-power batteries. Research supporting the programme and other transportation goals is divided into three programmes:

- The **Vehicle Technologies** programme includes work on hybrid propulsion systems, fuel cells, advanced combustion, and electric vehicles.

- The **Fuels Utilisation** programme seeks to identify and develop new fuel options allowing PNGV, light trucks and other vehicles to meet increasingly challenging performance standards by improving fuel efficiency, and reduce emissions. The programme includes work on advanced fuels and blending additives, including biomass, natural gas-derived fuels, and oxygenates that enhance the performance and emissions characteristics of diesel engines; and research on methanol, ethanol, and natural gas-derived liquid fuels for fuel-cell vehicles.

- The **Technology Deployment** programme seeks to accelerate the adoption and use of alternative-fuel and advanced technology vehicles.

Buildings Technologies

The Buildings Technology programme conducts a broad range of activities to continue advances in lighting, space conditioning, refrigeration, appliances, buildings envelopes, and design. The goals in each area are as follows:

- **Lighting:** Technology breakthroughs for conventional lamps (incandescent, fluorescent, and gas discharge) to improve efficiency by 20-50%; and to develop revolutionary lighting technologies which can potentially double efficiency.

- **Space conditioning and refrigeration:** Efficiency improvements in central air-conditioners and heat pumps through optimum selection of equipment components and improvements to their heating and cooling cycles.

- **Appliances and emerging technologies:** High-efficiency dryers that are at least 20% more efficient than conventional products.

- **Building envelope:** Energy-efficient materials and building envelope components, including advanced window technologies, thermal insulation, and building materials.

- **Energy tools and design strategies:** Development, testing, and transfer of analysis tools for the design of high-performance residential and commercial buildings.

Oil and Gas

The Exploration and Production programme covering oil and gas, has the following components:

- **Advanced drilling, completion, and stimulation systems** focuses on technologies to drill, complete and stimulate wells, as well as to improve the efficiency of surface operations.

- **Advanced diagnostics and imaging systems** focuses on technologies and methodologies that more clearly define petroleum reservoirs and associated reservoir rock, fluid distributions and rock-fluid interactions that affect production.

- **Reservoir efficiency processes** develops and demonstrates tools and methodologies that permit operators to recover hydrocarbons from known reservoirs not producible by current technology. It also supports university research in extraction technologies and recovery-process modelling to ensure a supply of well-trained workers, and helps smaller producers with day-to-day problems.

- **Planning and analysis** supports the programme by providing accurate data on hydrocarbon resources, supply and utilisation trends, industry activities and research and development needs.

The Reservoir Life Extension/Management programme focuses on advanced technologies for extraction of hydrocarbons from known, or discovered, oil reservoirs. The National Energy Technology Laboratory undertakes widespread distribution of project results, including through the Petroleum Technology Transfer Council with its ten regional centres.

The Preferred Petroleum Upstream Management Practices programme develops management practices in advanced oil recovery, data management, and environmental compliance. These projects are designed to provide integrated solutions to technological, regulatory, environmental and data constraints to increase the near-term oil supply.

Effective Environmental Protection research activities focus on technologies and practices that reduce the threat to the environment and decrease the cost of effective environmental protection and compliance in oil exploration, production and processing. There are four elements: risk assessment, regulatory streamlining, technology development, and programme planning and analysis.

Natural Gas

In addition to the Exploration and Production programme, research is organised in the following areas:

- **Gas hydrates:** Focused on extraction of conventional oil and gas resources located near hydrate deposits, and economic production of gas from hydrates; also assessment of extraction on the global carbon cycle.

- **Infrastructure:** To enhance reliability of pipelines and gas storages.

- **Effective environmental protection:** Focused on detection and control of air emissions from gas equipment and facilities, treatment of produced water to meet environmental standards, remediation of hydrocarbon or produced water-contaminated soils, treatment and disposal of wastes containing naturally occurring radioactive materials, and other approaches to manage oil and gas field wastes.

Coal

The coal programme seeks cost-effective reductions in coal power plant emissions of sulphur dioxide, nitrogen oxides, carbon dioxide, and particulates. The ultimate goal, known as Vision 21, is the construction of a zero-emissions coal-fired power plant.

Advanced Electric Power Technology

The programme includes the development of the following:

- Low-emission boiler systems in which re-engineered pulverised coal boilers are combined with advanced combustion and innovative flue gas cleaning systems.

- Advanced combustion systems combining fluid-bed combustion systems that capture sulphur pollutants inside the boiler, with technologies such as supercritical steam cycles, hybrid gasification/combustion, and high-temperature heat exchangers. These technologies also support the development of sub-systems and components for future Vision 21 plants.

- Integrated gasification combined cycle using a coal gasifier instead of a combustor, coupled with an advanced gas turbine. Further advances in gasifier technology such as a transport reactor gasifier, advanced air separation via membranes, and advanced gas conditioning are also being developed to contribute to future Vision 21 plants.

Work on environmental control includes the following:

- Super-clean emission control devices to remove 99% of the sulphur dioxide and 95% of the nitrogen oxides from the flue gas of power plants.

- Toxic emissions control: a survey of potential toxic emissions with a focus on mercury, a study to trace how impurities in coal are transformed into toxic emissions, and development of innovative approaches for removing trace elements from coal or its combustion products through advanced coal cleaning or improved flue gas clean-up devices.

- Fine particulate matter (particulate matter with a diameter of 2.5 microns or less): nationwide monitoring of ambient particulates, characterisation of fine particulate emissions from power plants, and control technology research and development.

- Solid waste management: to find ways to use solid wastes from advanced coal systems.

Clean Coal Technology Program

Major emphasis has included the development of:

- Advanced electric power generating systems.

- Environmental control devices.

- Industrial applications, to improve ways to manufacture steel and other commodities.

- Coal fuels and cleaning, to convert coal feedstock to produce a stable fuel of high energy density for use in electricity generation or as a transportation fuel.

The programme began in 1986. Through five competitive solicitations the programme has broadened its objectives to include a total of 38 first-of-a-kind projects that have been undertaken in 18 states. To date, 29 projects have been completed. Most of the early projects, including all of the environmental control technologies, are generating data or have finished their testing programme. Several, such as low-polluting coal burners and post-combustion sulphur-removing devices, are being applied commercially. Others are attracting interest overseas, particularly from developing nations looking for low-cost technology to bring older power facilities up to modern environmental standards.

More recently, several of the larger advanced power generating projects have demonstrated their operational abilities in commercial utility environments with additional projects currently in the design and construction phases. These projects are intended to provide the basis for prototype demonstration power systems.

The programme selected projects in five rounds of competition:

- Round I, from which eight projects remain in the programme, covered a broad spectrum of advanced coal technologies.

- Round II, from which nine projects remain, focused on acid rain control technologies that could be commercialised in the 1990s.

- Round III, from which twelve projects remain, focused on technology for retrofitting and repowering existing facilities with cleaner technologies.

- Round IV, from which five projects remain, was aimed at technologies that could meet the longer-term emissions reduction requirements of the 1990 Clean Air Act Amendment.

- Round V, from which four projects remain, focused on options for reducing sulphur dioxide emissions to meet post-2000 Clean Air Act requirements and raising efficiencies to limit releases of carbon dioxide.

Achievements of the programme to date include the following:

- Over 2 200 MW_e of capacity, including five fluidised-bed combustion systems, four integrated gasification combined cycle systems, and two advanced combustion/heat engine systems.

- Seven nitrogen oxides emissions control systems installed on more than 1 700 MW_e of utility generating capacity, five sulphur dioxide emissions control systems installed on approximately 770 MW_e, and six combined sulphur dioxide/nitrogen oxide emissions control systems installed on approximately 670 MW_e of capacity.

- Five projects substituting coal for 40% of the coke in iron-making, integration of a direct iron-making process with the production of electricity, reduction of cement kiln emissions and solid wastes, and several environmentally clean industrial-scale combustors.

- Four projects comprising two that produce high-energy-density solid compliance fuels for utility or industrial boilers, one of which also produces a liquid for use as a chemical or transportation fuel feedstock; a third project demonstrating a new methanol production process; and a demonstration of a computer software system that enables a utility to predict operating performance of coals being considered for a utility boiler.

Clean Coal Power Initiative

The Clean Coal Power Initiative will focus on demonstrating advanced coal technologies that can be deployed over the next several years. Technologies for improving capacity, efficiency, reliability, and environmental performance at existing and new plants would be included. This is a joint government-industry demonstration programme with at least 50% cost-sharing from the private sector.

Carbon Sequestration

The programme is studying ways of capturing carbon dioxide, such as biological, cryogenic, or other techniques, and reusing or disposing of it economically.

Clean Coal Fuels Program

Three programmes are developing more affordable and efficient techniques for converting coal to liquid fuels and chemicals:

- Direct coal liquefaction to break down the large, complex molecules of coal and convert them to liquid fuels in a single process. Hydrogen is added to the coal during the conversion process to upgrade the liquid products, giving them characteristics comparable to petroleum.

- Indirect coal liquefaction which first converts coal into a gaseous state using a coal gasifier, then recombines the gaseous molecules into liquid products.

- Novel coal-to-liquid approaches including biological processes to convert coal to liquid fuels, and an integrated two-stage synthesis gas fermentation process for producing a mixture of alcohols from coal.

The projected cost of coal-liquids approached US$ 60 per barrel in the late 1970s. The cost is currently below US$ 25 per barrel. Close to US$ 20 per barrel may be achievable.

Fuel specifications for coal slurries are being determined to show which fuels are satisfactory substitutes for oil, and which have to be reformulated to improve their handling and combustion characteristics. Alternative solid forms of coal are also being developed. For example, coal can be crushed and cleaned, then reconstituted in powders, granules or pellets. In this form, the coal can be more easily handled, transported and used.

Advanced Coal Research

The Advanced Research programme conducts cross-cutting research in the enabling science and technologies that underpin advances in all fossil fuel technologies. These include the following:

- **Coal utilisation science:** Research on the fundamental mechanisms and processes that influence and control coal utilisaton.

- **Materials:** Research is focused on developing high-temperature, corrosion-resistant structural ceramic composites and alloys, and materials which perform specific functions in advanced fossil energy systems.

- **Focus area for computational energy science:** Formed in the National Energy Technology Laboratory in 2000 to provide simulation and computational resources to Fossil Energy Programs which will speed development and reduce costs for the development of advanced technologies by avoiding construction steps of smaller research units.

- **Instrumentation and diagnostics:** Adaptation and application of state-of-the-art techniques to the specialised requirements of coal systems. Improved sensors and controls are needed to support both improved combustion efficiency and improved environmental controls. Similarly, at the research scale, improved measurement is required to determine and validate information on the mechanisms that govern coal utilisation processes.

- **Bio-processing of coal:** Biochemistry and microbiology are creating potential breakthroughs in the use of coal. Activities focus on three areas: bio-conversion of coal to fuels, removal of pollutants from combustion gases, and bio-process engineering studies.

- **Support for university and small business coal research.**

Renewable Energy

Wind Energy

The applied research programme includes:

- Research on wind-hybrid systems for remote, island and mini-grid applications.

- Preparation of an improved national wind atlas.

- Research to minimise impacts on bird populations.

- Testing advanced drive-train, rotor, and power electronics/control systems.

- Competitively selected projects from universities for advanced wind turbine and systems research.

The Turbine Research programme focuses on developing the next generation turbine with the goal of designing and fabricating prototypes and testing of utility scale (500 kW – 2 MW) turbines capable of achieving wind energy costs of 2.5 cents per kWh. A Small Wind Turbine project is assisting US industry in developing wind turbines in the 6-40 kW range for stand-alone, remote, and hybrid applications. Smaller applications, such as turbines of 5 kW or less for home/farm distributed applications, are selected competitively for cost-shared projects that test advanced technologies.

The Co-operative Research and Testing Program provides technical support for the Wind Powering American programme including studies of transmission system issues and project feasibility studies. Regional studies look at unique siting, regulatory and market issues.

Solar Energy

There are three programmes supporting a number of sub-programmes:

- **The Photovoltaic Program:** Fundamental research advances the fundamental understanding of photovoltaic materials and devices. The related Technology

Development activity conducts system engineering tests to validate performance, safety, reliability and cost of new systems, and the development of domestic and international standards and codes.

- **The Concentrated Solar Power Program:** Advanced Components and Systems Research, which is testing new heat-pipe technology to achieve a 20% increase in system efficiency; prototype development of advanced converters; and work on advanced controls, analysis tools, insolation data and technology roadmaps. Distributed Systems is improving the reliability of new 25 kW dish/engine systems, demonstrating a 10 kW dish/engine system for remote applications on Native American lands, and developing small, 1-5 kW dish-based prototype systems for residential applications.

- **The Solar Buildings Program** is developing and testing polymer materials to achieve longer lifetimes in typical building applications. Work includes development of prototype low-cost solar water heaters and approaches that will expand the geographical application of low-cost solar water heaters beyond the Sun Belt states.

Geothermal

The geothermal programme focuses on understanding and helping overcome the technical, institutional and environmental barriers to the use of geothermal energy.

Geoscience research facilitates finding and defining resources through the field testing of the electromagnetic fracture-detection tool and 3D seismic exploration research. The research seeks to detect and map new geothermal resources, working co-operatively with industries and universities.

Drilling research is developing components, such as the Diagnostics-While Drilling sub-systems and other advanced drilling techniques, to reduce the cost of drilling geothermal wells by up to 50%.

Energy Systems research provides technical support for the GeoPowering the West initiative, optimisation of heat and power systems for a broad range of geothermal resources, evaluation of the use of geothermal resources for combined heat and power systems, and test installations for new small-scale power plants less than 1 MW in size.

Biomass Energy

The BioPower programme addresses thermo-chemical conversion, systems development and feedstock production. The systems development work evaluates co-firing with coal, working with municipalities and rural electric co-operatives. The BioFuels programme focuses on ethanol production processes.

Hydrogen

The Hydrogen Research programme seeks to enhance and support the development of cost-competitive hydrogen production, storage technologies, and integrated systems. The Core Research programme covers thermal processes, photolytic processes, storage and utilisation:

- The thermal process activity seeks to lower the cost of fossil-based and biomass-based hydrogen production processes.

- The photolytic process research is developing genetically-engineered biological organisms to split water to hydrogen and oxygen, fabricating a modular photo-electrochemical production cell, and performing lifetime testing of high-efficiency coated cells.

- The storage work is developing and demonstrating safe and cost-effective storage systems for stationary and vehicle applications.

- The utilisation work is developing codes and standards for overcoming infrastructure barriers.

Nuclear

Nuclear Fission and Fuel Cycle

The Nuclear Energy Research Initiative funds nuclear technology research. An international version of the programme assists the formation of research partnerships between US and foreign nuclear research institutions. By mid-2001, agreements had been signed with the Republic of Korea and France.

The Generation IV Nuclear Energy Systems Initiative, which started in January 2000, has since evolved into an international programme under the Generation IV International Forum. The purpose of Gen IV is to develop one or more nuclear energy systems that could be deployed commercially by 2030 and that would offer advantages in the areas of economics, safety, proliferation-resistance and waste-minimisation. Gen IV activities include designs for small modular reactors and gas reactors.

The Nuclear Energy Plant Optimization programme is a joint government-industry programme to address issues related to optimal operation of nuclear plants throughout their life cycles. Among the research areas are material and component ageing associated with plant life extension.

The Advanced Accelerator Applications programme will explore a broad range of accelerator applications, including accelerator transmutation of waste.

Nuclear Fusion

The Fusion Energy Sciences Program seeks to advance plasma science, fusion science, and fusion technology. Research is organised around the two leading methods of confining the fusion plasma – magnetic and inertial using laser or particle beams. The Fusion Energy Sciences Advisory Committee conducted a major review, "Priorities and Balance within the Fusion Energy Sciences Program", which was released in September 1999. Based on the report, goals for the magnetic fusion energy programme were established to continue work in both areas.

Basic and Cross-cutting Research

The Office of Basic Energy Sciences in the Department of Energy manages programmes of fundamental research in materials science, chemical sciences, bioscience, geosciences and engineering which aim to improve the production, conversion, and efficient use of energy resources.

The Office of Biological and Environmental Research manages research programmes in life sciences, medical sciences, and environmental sciences. The Environmental Sciences Division supports a Global Climate Change Research programme that focuses on understanding the basic chemical, physical, and biological processes of the Earth's atmosphere, land, and oceans and on how these processes may be affected by energy production and use, primarily by the emission of carbon dioxide from fossil fuel combustion. The programme aims to:

- Improve understanding of factors affecting the Earth's radiant-energy balance.
- Predict accurately any global and regional climate change induced by increasing atmospheric concentrations of greenhouse gases.
- Quantify sources and sinks of energy-related greenhouse gases, especially carbon dioxide.
- Improve the scientific basis for assessing the potential consequences of climatic changes, including the potential ecological, social, and economic implications of human-induced climatic changes caused by increases in greenhouse gases in the atmosphere and the benefits and costs of alternative response options.

CRITIQUE

Technology is central to the achievement of US energy policy goals. Mechanisms to ensure deployment of research results should be integrated into the design of research projects.

Almost every area of US energy policy has a core component of energy research and development. Technology is the key government response on issues concerning environmental impacts of energy use, de-linking economic growth and energy use, increasing supplies of conventional energy sources and developing new energy sources. Most public expenditure is on fundamental science, and a very substantial amount is spent on nuclear fusion, with the government having very long-term goals in mind.

A review published by the National Academies[21] examines many of the government's energy efficiency and fossil fuel programmes, and shows that they often have high potential returns if incentives exist for the results to be taken up by the private sector. Successful programmes highlighted in the review included incentives for deployment of the technical advances made. These included:

- **Energy efficiency:** Advances in compressors for refrigerators and freezers, electronic ballasts for fluorescent lighting, low-emission/heat-resistant window glass.

- **Fossil fuels:** Atmospheric fluidised bed coal combustion, and nitrogen oxides control.

The review noted that standards and regulations for appliances, lighting and buildings would ensure that efficiencies attainable by the first group of technologies be adopted. Similarly, emission standards for sulphur and nitrogen oxides would encourage industry consideration of the second group of technologies for cleaner use of fossil fuels.

The review also commended some programmes for the important technical progress they made. These included:

- **Transport:** The Partnership for New Generation of Vehicles.

- **Fossil fuels:** Integrated gasification combined cycle, and advanced turbine systems.

In both these cases, the review concluded that the programmes "had created options that could produce large benefits *if economic or policy incentives support their commercialisation*."[22]

The review considers that designing the policy framework for the deployment of new technologies should begin at a very early stage in project design. For example, it comments that work on fuel cells for home and industrial use, and magnetohydrodynamic electricity production technology[23], are areas that have not lived up to expectations because they lacked mechanisms to review progress and/or incentives for adoption in the private sector. For fuel-cell technologies, the review criticised the absence of clear technological goals, the variety of programmes funded and the absence of partnerships with industry. Magnetohydrodynamic

21. *Energy Research at DOE: Was it Worth It?* National Academies (National Academy of Science, National Academy of Engineering, Institute of Medicine, National Research Council), July 2001.
22. Italics added.
23. These technologies include nuclear fusion, but also have potential in coal-fired and other electricity generation systems. In the long term, magnetohydrodynamic technology might be expected to achieve efficiencies of 45% to 60%. However, considerable research and development is first required, notably into appropriate components and materials for commercial-scale use.

electricity production from coal continued to be funded long after the technology was found to be too costly and complex for widespread use.

The principles which can be distilled from the National Academies review are relevant to all research programmes, but particularly in the US, where technology will play a central role in the success of energy policy as a whole. In summary, the following principles should be among those governing US research and development programmes:

- Objectives should be clearly defined.
- Performance targets and milestones should be set to monitor and assess work in progress.
- A policy framework for the deployment of new technologies should be integrated into project design from the beginning. Industry partnerships have an important role to play in this regard.
- External benefits should be taken into account in deciding on funding for potentially beneficial projects, and means developed to ensure that they are valued by the market to encourage deployment.

Research programmes require sustained funding. After a sharp increase in funding in 2001, due to increased funding for work on basic energy science and coal, growth in real funding levelled off in 2002. But funding priorities are now being matched with National Energy Policy goals.

As in most other IEA countries, the level of government funding for energy research and development has fallen in the US over the last twenty years. The figures may, however, disguise growth in private funding either encouraged by government efforts or replacing government funding in government-industry partnerships. The President's Council of Advisors on Science and Technology concluded in 1997 that the US is not investing enough nor investing in the right energy technologies to meet the opportunities and the challenges ahead[24]. Since then, funding has increased.

Distribution of funding should reflect energy policy goals. In 2002, funding is being brought into line with the goals of the National Energy Policy. The funding for fossil fuels projects is 16% higher than in 2001, and for coal, 32% higher. Funding for energy efficiency is also higher, but for renewables it is a little lower than in 2001 and 4% lower than in 1999.

24. President's Committee of Advisors on Science and Technology, Panel on Energy Research and Development,"Report of President on Federal Energy Research and Development for the Challenges of the Twenty-first Century", November 1997.

RECOMMENDATIONS

The Government of the United States should:

- ☐ Give priority to the development of economic incentives for the deployment of advanced technologies.

- ☐ Ensure that the level and distribution of funding for energy research and development matches the expectations for technology to meet environmental and energy policy goals.

A

ANNEX

ENERGY BALANCES AND KEY STATISTICAL DATA

Unit: Mtoe

SUPPLY

		1973	1990	1998	1999	2005	2010	2020
TOTAL PRODUCTION		**1455**	**1650**	**1700**	**1688**	**1821**	**1890**	**2038**
Coal [1]		333	539	573	559	635	657	679
Oil		534	433	383	367	357	339	352
Gas		503	419	444	438	496	550	690
Comb. Renewables & Wastes [2]		37	62	76	82	87	94	107
Nuclear		23	159	186	203	204	199	159
Hydro		23	23	25	25	26	26	26
Geothermal		2	14	13	15	14	23	24
Solar/Wind/Other		–	0	0	0	1	1	1
TOTAL NET IMPORTS [3]		**289**	**315**	**521**	**546**	**683**	**786**	**935**
Coal [1]	Exports	31	67	50	38	38	37	35
	Imports	1	2	7	7	10	11	13
	Net Imports	–30	–65	–42	–31	–28	–26	–23
Oil	Exports	11	39	46	46	43	43	46
	Imports	316	413	560	567	663	752	884
	Bunkers	9	29	23	26	19	19	19
	Net Imports	296	346	491	496	600	690	818
Gas	Exports	2	2	4	4	8	10	15
	Imports	24	35	73	83	113	130	152
	Net Imports	22	33	69	79	106	120	137
Electricity	Exports	0	2	1	1	1	1	1
	Imports	1	2	3	4	6	4	2
	Net Imports	1	0	2	2	4	3	2
TOTAL STOCK CHANGES		**–8**	**–39**	**–15**	**36**	**0**	**1**	**1**
TOTAL SUPPLY (TPES)		**1736**	**1926**	**2206**	**2270**	**2504**	**2677**	**2974**
Coal [1]		311	457	538	539	608	632	657
Oil		824	770	865	881	958	1029	1171
Gas		515	439	500	522	602	669	827
Comb. Renewables & Wastes [2]		37	62	76	82	87	94	107
Nuclear		23	159	186	203	204	199	159
Hydro		23	23	25	25	26	26	26
Geothermal		2	14	13	15	14	23	24
Solar/Wind/Other		–	0	0	0	1	1	1
Electricity Trade [4]		1	0	2	2	4	3	2
Shares (%)								
Coal		*17.9*	*23.7*	*24.4*	*23.8*	*24.3*	*23.6*	*22.1*
Oil		*47.5*	*40.0*	*39.2*	*38.8*	*38.2*	*38.4*	*39.4*
Gas		*29.6*	*22.8*	*22.7*	*23.0*	*24.0*	*25.0*	*27.8*
Comb. Renewables & Wastes		*2.2*	*3.2*	*3.4*	*3.6*	*3.5*	*3.5*	*3.6*
Nuclear		*1.3*	*8.3*	*8.4*	*8.9*	*8.2*	*7.4*	*5.3*
Hydro		*1.3*	*1.2*	*1.1*	*1.1*	*1.1*	*1.0*	*0.9*
Geothermal		*0.1*	*0.7*	*0.6*	*0.7*	*0.6*	*0.9*	*0.8*
Solar/Wind/Other		–	–	–	–	–	–	–
Electricity Trade		*0.1*	–	*0.1*	*0.1*	*0.2*	*0.1*	*0.1*

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

Unit: Mtoe

DEMAND

FINAL CONSUMPTION BY SECTOR

	1973	1990	1998	1999	2005	2010	2020
TFC	**1246**	**1283**	**1432**	**1476**	**1735**	**1863**	**2102**
Coal [1]	44	31	28	27	65	64	64
Oil	701	698	777	802	893	966	1103
Gas	341	303	308	318	386	404	440
Comb. Renewables & Wastes [2]	16	23	29	34	66	70	80
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	–	–	–	–	–
Electricity	143	226	282	287	320	352	409
Heat	–	2	7	7	6	6	6
Shares (%)							
Coal	*3.5*	*2.4*	*2.0*	*1.9*	*3.7*	*3.4*	*3.0*
Oil	*56.3*	*54.4*	*54.3*	*54.3*	*51.5*	*51.9*	*52.5*
Gas	*27.4*	*23.6*	*21.5*	*21.6*	*22.2*	*21.7*	*20.9*
Comb. Renewables & Wastes	*1.3*	*1.8*	*2.0*	*2.3*	*3.8*	*3.8*	*3.8*
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	–	–	–	–	–
Electricity	*11.5*	*17.7*	*19.7*	*19.5*	*18.4*	*18.9*	*19.5*
Heat	–	*0.1*	*0.5*	*0.5*	*0.3*	*0.3*	*0.3*
TOTAL INDUSTRY [5]	**406**	**378**	**411**	**424**	**557**	**586**	**643**
Coal [1]	31	22	25	25	63	63	63
Oil	161	149	155	162	180	192	213
Gas	151	124	117	120	166	172	184
Comb. Renewables & Wastes [2]	7	9	15	17	48	52	60
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	–	–	–	–	–
Electricity	56	75	93	95	95	101	117
Heat	–	–	5	5	5	5	5
Shares (%)							
Coal	*7.5*	*5.9*	*6.2*	*5.8*	*11.4*	*10.8*	*9.8*
Oil	*39.7*	*39.3*	*37.8*	*38.1*	*32.2*	*32.8*	*33.1*
Gas	*37.3*	*32.7*	*28.5*	*28.3*	*29.9*	*29.4*	*28.7*
Comb. Renewables & Wastes	*1.8*	*2.4*	*3.5*	*4.0*	*8.6*	*8.9*	*9.4*
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	–	–	–	–	–
Electricity	*13.7*	*19.7*	*22.7*	*22.4*	*17.0*	*17.3*	*18.2*
Heat	–	–	*1.3*	*1.3*	*0.9*	*0.8*	*0.8*
TRANSPORT [6]	**420**	**502**	**582**	**601**	**691**	**759**	**884**
TOTAL OTHER SECTORS [7]	**420**	**402**	**439**	**450**	**487**	**519**	**575**
Coal [1]	14	9	3	3	1	1	1
Oil	137	63	57	58	49	46	44
Gas	173	164	176	181	200	209	227
Comb. Renewables & Wastes [2]	9	14	13	15	13	13	13
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	–	–	–	–	–
Electricity	87	152	189	192	223	248	288
Heat	–	2	2	2	1	1	1
Shares (%)							
Coal	*3.2*	*2.2*	*0.6*	*0.6*	*0.3*	*0.3*	*0.2*
Oil	*32.6*	*15.6*	*12.9*	*12.9*	*10.1*	*8.9*	*7.7*
Gas	*41.2*	*40.7*	*40.1*	*40.2*	*41.1*	*40.3*	*39.5*
Comb. Renewables & Wastes	*2.1*	*3.4*	*2.9*	*3.3*	*2.6*	*2.5*	*2.3*
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	–	–	–	–	–
Electricity	*20.8*	*37.7*	*43.0*	*42.5*	*45.7*	*47.9*	*50.1*
Heat	–	*0.4*	*0.4*	*0.4*	*0.2*	*0.2*	*0.2*

Unit: Mtoe

DEMAND

ENERGY TRANSFORMATION AND LOSSES

	1973	1990	1998	1999	2005	2010	2020
ELECTRICITY GENERATION [8]							
INPUT (Mtoe)	**507**	**765**	**944**	**963**	**983**	**1054**	**1159**
OUTPUT (Mtoe)	**169**	**274**	**327**	**336**	**379**	**419**	**483**
(TWh gross)	1966	3182	3802	3910	4403	4867	5620
Output Shares (%)							
Coal	*46.2*	*53.4*	*52.8*	*51.8*	*51.9*	*49.4*	*44.7*
Oil	*17.1*	*4.1*	*3.9*	*3.1*	*1.2*	*0.7*	*0.7*
Gas	*18.6*	*12.0*	*14.7*	*15.7*	*19.6*	*25.0*	*35.6*
Comb. Renewables & Wastes	*0.0*	*2.1*	*1.7*	*1.6*	*1.9*	*2.0*	*1.9*
Nuclear	*4.5*	*19.2*	*18.8*	*19.9*	*17.8*	*15.7*	*10.8*
Hydro	*13.5*	*8.6*	*7.7*	*7.4*	*7.0*	*6.3*	*5.4*
Geothermal	*0.1*	*0.5*	*0.4*	*0.4*	*0.4*	*0.6*	*0.5*
Solar/Wind/Other	*–*	*0.1*	*0.1*	*0.1*	*0.2*	*0.3*	*0.3*
TOTAL LOSSES	**498**	**651**	**764**	**776**	**769**	**814**	**871**
of which:							
Electricity and Heat Generation [9]	338	489	608	617	597	629	668
Other Transformation	–1	15	5	5	26	30	27
Own Use and Losses [10]	160	147	151	153	146	155	176
Statistical Differences	**–7**	**–9**	**10**	**19**	**–**	**–**	**–**

INDICATORS

	1973	1990	1998	1999	2005	2010	2020
GDP (billion 1995 US$)	3990.10	6520.50	8292.80	8587.70	10603.69	12255.03	15977.59
Population (millions)	211.94	249.98	270.56	273.00	288.02	300.17	325.24
TPES/GDP [11]	0.44	0.30	0.27	0.26	0.24	0.22	0.19
Energy Production/TPES	0.84	0.86	0.77	0.74	0.73	0.71	0.69
Per Capita TPES [12]	8.19	7.70	8.15	8.32	8.69	8.92	9.14
Oil Supply/GDP [11]	0.21	0.12	0.10	0.10	0.09	0.08	0.07
TFC/GDP [11]	0.31	0.20	0.17	0.17	0.16	0.15	0.13
Per Capita TFC [12]	5.88	5.13	5.29	5.40	6.02	6.21	6.46
Energy-related CO_2 Emissions (Mt CO_2) [13]	4680.6	4845.9	5505.9	5584.8	6185.2	6624.1	7459.2
CO_2 Emissions from Bunkers (Mt CO_2)	45.2	129.8	125.5	139.4	116.9	117.4	118.5

GROWTH RATES (% per year)

	73–79	79–90	90–98	98–99	99–05	05–10	10–20
TPES	1.3	0.2	1.7	2.9	1.7	1.3	1.1
Coal	2.8	2.0	2.1	0.3	2.0	0.8	0.4
Oil	1.2	–1.2	1.5	1.9	1.4	1.4	1.3
Gas	–1.3	–0.7	1.6	4.4	2.4	2.2	2.1
Comb. Renewables & Wastes	5.9	1.5	2.5	7.8	1.0	1.7	1.3
Nuclear	20.3	7.7	2.0	8.9	0.1	–0.5	–2.2
Hydro	1.1	–0.3	0.9	–1.6	1.0	–0.0	–0.0
Geothermal	9.0	13.2	–0.5	13.1	–0.6	9.8	0.2
Solar/Wind/Other	–	–	3.5	38.4	12.3	6.0	1.2
TFC	0.8	–0.2	1.4	3.1	2.7	1.4	1.2
Electricity Consumption	3.1	2.5	2.8	1.7	1.8	2.0	1.5
Energy Production	0.8	0.7	0.4	–0.7	1.3	0.7	0.8
Net Oil Imports	5.1	–1.3	4.5	0.9	3.2	2.8	1.7
GDP	3.0	2.9	3.1	3.6	3.6	2.9	2.7
Growth in the TPES/GDP Ratio	–1.7	–2.6	–1.3	–0.6	–1.9	–1.5	–1.6
Growth in the TFC/GDP Ratio	–2.2	–3.0	–1.6	–0.5	–0.8	–1.5	–1.4

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

Footnotes to Energy Balances and Key Statistical Data

1. Includes lignite.
2. 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.
4. Total supply of electricity represents net trade.
5. Includes non-energy use.
6. Includes less than 1% non-oil fuels.
7. Includes residential, commercial, public service and agricultural sectors.
8. Inputs to electricity generation include inputs to electricity, CHP and heat plants. Output refers only to electricity generation.
9. Losses arising in the production of electricity and heat at public utilities and autoproducers. For non-fossil-fuel electricity generation, theoretical losses are shown based on plant efficiencies of 33% for nuclear, 10% for geothermal and 100% for hydro.
10. 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.
11. Toe per thousand US dollars at 1995 prices and exchange rates.
12. Toe per person.
13. "Energy-related CO_2 emissions" specifically means CO_2 from the combustion of the fossil fuel components of TPES (i.e. coal and coal products, peat, crude oil and derived products and natural gas), while CO_2 emissions from the remaining components of TPES (i.e. electricity from hydro, other renewables and nuclear) are zero. Emissions from the combustion of biomass-derived fuels are not included, in accordance with the IPCC greenhouse gas inventory methodology. Also 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 1999 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.

B

ANNEX

INTERNATIONAL ENERGY AGENCY "SHARED GOALS"

The 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 hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

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

3 **The environmentally sustainable provision and use of energy** 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

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

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

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

6 **Continued research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, 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.

9 **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.)

ANNEX

GLOSSARY AND LIST OF ABBREVIATIONS

barrel	42 US gallons, 34.97 imperial gallons, 158.98 litres
Bcf	billion cubic feet
bcm	billion cubic metres
b/d	barrels per day
Btu	British thermal unit; one Btu = 1.055 joules or 0.000025199 toe
BWR	boiling water reactor
CAFE	corporate average fuel economy standards for cars and trucks
CO_2	carbon dioxide
DOE	Department of Energy
DOT	Department of Transport
EIA	Energy Information Administration
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
GDP	gross domestic product
GHG	greenhouse gas
gpv	gallons per vehicle
GW	gigawatt, or one watt $\times 10^9$
Gwe	gigawatt of electrical energy
GWh	gigawatt hour
IEA	International Energy Agency
IPCC	Inter-governmental Panel of Climate Change
IPP	independent power producer
ISO	independent system operator
kWh	kilowatt hour
LNG	liquefied natural gas
mmbpd	million barrels per day
mpg	miles per gallon
mpv	miles per vehicle

MMTCE	million tonnes of carbon equivalent
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 × one hour
NAFTA	North American Free Trade Agreement
NO_x	Nitrogen oxides
OASIS	open-access same-time information systems
OECD	Organisation for Economic Co-operation and Development
PNGV	Partnership for New Generations of Vehicles
PUC	Public Utilities Commission
PWR	pressurised water reactor
RTO	regional transmission organization
SUV	sport utility vehicle
Tcf	trillion cubic feet
toe	tonne of oil equivalent, 10^7 kilocalories
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 × one hour $\times 10^{12}$
UNFCCC	United Nations Framework Convention on Climate Change

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