UNITED STATES

GENERAL ENERGY POLICY

Energy policy in the United States is determined both at the level of individual states and at the federal level. Consequently, energy market and policy development yields a highly dynamic and complex picture, of which only the main features can be rendered in this review.

Growing reliance on imported oil was a major consideration in the development of the government's National Energy Policy (NEP) issued in May 2001. The National Energy Policy places a priority on increased domestic production and energy efficiency, and conservation improvements through technological development. In particular, the NEP aims at reducing external oil dependence to less than half of US needs by 2011. The NEP also sought to introduce US$ 34 billion in tax cuts and other incentives to boost oil, gas and coal production, and other energy initiatives. This was granted preliminarily with the passage of the Securing America's Future (SAFE) Bill through the House in early August 2001, a bill focusing largely on facilitating domestic energy production. A second part of the Energy Policy, known as the Energy Policy Act, was passed in the Senate in April 2002. This bill focuses on improving co-ordination and integration of energy policy at the federal level, stimulating domestic oil and gas production, increasing energy efficiency and integrating energy and climate change mitigation policies. The Senate and House passed two different versions of the corporate tax legislation that includes a 10-year, approximately $18 billion package of tax incentives. The two bills are in the process of being reconciled in Conference Committee.

SUPPLY AND DEMAND

The US is the world's largest energy consumer, with more than 25% of global consumption of oil, natural gas, coal and nuclear energy. In 2003, it imported close to 30% of its energy needs, and 60% of its oil. It has the world's largest reserve for coal.

TPES grew at an annual rate of 1.4% since 1990, to reach 2 291 Mtoe in 2003. The share of oil in TPES was 40%, followed by coal (23%), natural gas (23%), nuclear (9%) and renewables (4%).

In 2002, TFC was 1 557 Mtoe, 1.2% up from 2001 and growing at a 2.5% annual rate since 1990. Transport represents the largest energy-consuming sector (40%) followed by the residential/commercial sector (31%) and industry (30%).

CLIMATE CHANGE

The US is a signatory to the U.N. Framework Convention on Climate Change (UNFCCC). Although the US signed the Kyoto Protocol to the UNFCCC in November 1998, it has not ratified it.[8] Nonetheless, the US government is committed to achieving the goals of the UNFCCC.

The US energy sector released 5 652 Mt CO_2 in 2002. Approximately 85% of greenhouse gas emissions from anthropogenic sources come from energy production and use. Between 1990 and 2002, carbon emissions increased by 17%. By 2015, they are expected to rise to 40% over 1990 levels. US carbon emissions are about equally split between the transport (32%), industry (29%), and commercial/residential (38%) sectors.

In February 2002, the government set a national goal to reduce greenhouse gas emissions intensity by 18% in 2012. To this end, the Administration has worked to engage industry sectors in voluntary partnerships – such as the Climate VISION (Voluntary Innovative Sector Initiative) Program in 2003 and SmartWay Transport Partnership in 2004 – to decrease growth in greenhouse gas emissions, develop improved standards for measuring and registering emissions reductions, promote energy efficiency and conservation, and create incentives for emissions reductions.

Internationally, the United States has formed 14 bilateral partnerships with key industrial and developing countries — representing more than 70% of global greenhouse gas emissions — on advanced energy technologies, climate monitoring and modelling, climate research, observation systems, and other activities – in co-ordination with the Climate Change Science Program.

The Climate Change Science Program's (CCSP) strategic plan, released in July 2003, is an effort of the government to advance knowledge of climate variability, the potential response of the climate system to growing greenhouse gas concentrations, the implications of these potential changes, and management options for natural environments. The plan also supports better observation systems that will be a crucial element in improving the understanding of climate change.

The Climate Change Technology Program (CCTP) co-ordinates and prioritises the government's nearly $3 billion annual investment in climate-related technology research, development, demonstration and deployment. The CCTP's strategic vision focuses on reducing emissions from energy use and infrastructure and from energy supply, capturing and sequestering CO_2, reducing emissions of other greenhouse gases, measuring and monitoring emissions, and bolstering the contributions of basic science.

8. The Kyoto Protocol calls for the US to reduce its emissions by 7% below 1990 levels by 2008-2012.

The Administration's fiscal year 2004 climate change spending request totalled more than $4.3 billion, which includes R&D funding on all technologies achieving low or zero emission levels (such as hydrogen, bioenergy, carbon sequestration, nuclear fission and fusion, etc.).

In February 2002, the government launched the Clear Skies Initiative, which is expected to cut power plants' emissions of sulphur dioxide, nitrogen oxide and mercury, through the implementation of a cap and trade system. The objectives of the Clear Skies Initiative are to:

- Cut sulphur dioxide (SO_2) emissions by 73%, from current emissions of 11 Mt to a cap of 4.5 Mt in 2010, and 3 Mt in 2018.
- Cut emissions of nitrogen oxides (NO_x) by 67%, from current emissions of 5 Mt to a cap of 2.1 Mt in 2008, and to 1.7 Mt in 2018.
- Cut mercury emissions by 69% – the first-ever national cap on mercury emissions. Emissions will be cut from current emissions of 48 tonnes to a cap of 26 t in 2010, and 15 t in 2018.
- Set emission caps to account for different air quality needs in the East and the West.

ENERGY EFFICIENCY

Energy intensity of the US economy expressed in TPES per unit of GDP ($1 000 at 1995 price) was equivalent to 0.24 toe in 2003.

The government has developed specific sub-goals in these areas with a time horizon to 2010. With respect to energy efficiency, the government strives to:

- Reduce energy consumption per gross square foot in federal facilities by 30% in 2005 and 35% in 2010, compared to 1985.
- Through hybrid and electric propulsion R&D, reduce the cost of a high-power 25 kW battery for use in light vehicles from $3 000 in 1998 to $500 by 2010.
- Between 1991 and 2010, contribute to a 20-25% decrease in energy intensity (Btu per unit of industrial output as compared to 1991) by the energy-intensive industries participating in US Department of Energy's (DoE) Industries of the Future programme (a potential energy savings of 3.6 to 4.5 quadrillion Btu); by 2020, contribute to a 30 to 35% decrease in energy intensity from 1991 (a potential saving of 6.3 to 7.4 quadrillion Btu).
- Improve the energy efficiency of the approximately 1.3 million new residential homes built each year and the 100 million existing homes, through research, development, demonstrations, and technology transfer

strategies aimed at energy uses such as space heating and cooling, ventilation, water heating, lighting, and home appliances.

- Achieve $3 billion in annual export sales of energy efficiency technologies, creating about 100 000 jobs in the country.

Support to research and development projects is considered as particularly important, but other mechanisms are also in use (energy efficiency legislation and standards, attempts to overcome institutional barriers to energy efficiency, *e.g.* through financial assistance and promoting energy savings performance contracting).

OIL

In 2003, oil amounted to 40% of the TPES, or 925 Mtoe, growing from 770 Mtoe in 1990. Net imports represented close to 60% of the total. Final oil consumption was 833 Mtoe in 2002, 19% above 1990 level. Transport consumed almost three-quarters of this amount, industry accounted for 20%, and 7% were used in other sectors.

The US remains the world's third-largest oil producer with 359 Mtoe in 2002, down from 433 Mtoe in 1990, as well as the world's single biggest consumer of oil.

Demand for imports is likely to carry on growing as oilfields in the lower 48 states reach maturity. This fact has led the government to formulate incentives to boost domestic production, improving exploration and drilling technology. The government also streamlined the process by which permits are granted for important energy projects, such as pipelines and refineries; and accelerated the leasing of non-restricted federal lands where environmentally appropriate. The NEP also called for the development of the Arctic National Wildlife Refuge (ANWR); however, it was voted down by the Senate in 2003.

The NEP endorsed adding oil to the Strategic Petroleum Reserve (SPR) using the Royalty-in-Kind (RIK) programme. On 13 November 2001, the government ordered the SPR to be filled to its maximum capacity, approximately 700 million barrels, by continuing to use the RIK programme carried out jointly between the DoE and the Department of the Interior. The RIK programme applies to oil owed to the US government by producers who operate leases on the federally-owned Outer Continental Shelf. These producers are required to provide from 12.5% to 16.7% of the oil they produce to the US government. Between November 2001 and August 2004, approximately 119 million barrels of oil have been added to the reserve, rising from 545 million to 664 million. Deliveries continue at the rate of 100 000 to 200 000 barrels per day. The reserve is expected to be filled to capacity in 2005.

NATURAL GAS

Deliveries of gas to end-use customers in 2003, according to preliminary US data, amounted to an equivalent of 523 Mtoe, compared to 436 Mtoe in 1990. Gas represented close to a quarter of the TPES in 2003. Domestic production was equivalent to 87% of the total gas supply.

In 2003, production and net imports decreased by less than 2.7 billion cubic metres (bcm) as demand for natural gas slowed down. Working gas inventories increased by about 5.4 bcm in 2003. Total natural gas consumption in 2003, according to preliminary 2003 data, decreased to 622 bcm after an increase of 21.6 bcm, or just over 3%, in 2002. Although below the record high of 661 bcm in 2000, total consumption in 2002 was still the second-highest level ever. A primary factor contributing to this increase is a larger stock of gas-fired generating capacity. Gas consumption grew by 24% between 1998 and 2002 in the electric power sector as a result of the large build-up during the past couple of years of gas-fired generation plants, which have been viewed by industry as environmentally and economically advantageous to other fuels for electric generation. However, gas consumption in this sector declined in 2003, to a level that was 7% greater than in 1998. In 2002, approximately 51 000 megawatts fuelled by natural gas came on line. This was approximately 82% of the electric generating capacity that came on line during the year.

As consumption evolves in each of the sectors, the trend differences may have important implications for natural gas markets. At present, electric power use of gas is the third-largest consuming sector. It moved ahead of residential consumption in 1998 through 2002, but fell back to third in 2003. Industrial use of natural gas during the same period has declined from 41% of end-use consumption to less than 35%, according to preliminary 2003 data. The residential, commercial, and electric power-consuming sectors exhibit seasonal variation in their consumption. Consequently, the share of the market driven by seasonal factors is growing, which may add to seasonal fluctuations in aggregate demand.

Net imports to the United States in 2003 decreased for the second year in a row, to 94 bcm, or nearly 6% below the level for 2002, according to preliminary 2003 data. Net imports were about 3% lower in 2002 than in 2001. This had been the first decline since 1986.

LNG imports have grown significantly over the last couple of years from the levels of the 1990s, although they still accounted for only about 1% of total supply in 2002. LNG imports during 2002 totalled 6.5 bcm. The largest supplier of LNG to the US in recent years has been the Atlantic LNG facility, located at Point Fortin in Trinidad and Tobago, which supplied 66% of LNG imports in 2002. It supplied about 75% in 2003, according to preliminary 2003 data.

2003 was a crucial year for the US gas industry as prices hit record levels in February and March with spot prices at Henry Hub peaking at an average of \$18.85 per MBtu on 25 February 2003 and remaining relatively high throughout all of 2003 and the beginning of 2004. Spot gas prices at Henry Hub averaged \$5.47/MBtu in 2003. This is an indication of the tight supply/demand situation, putting pressure on the need for additional external sources of gas to meet demand in the US in the future. The US still possesses over 5 200 bcm of proven natural gas reserves, but production levels now tend to apparently peak around 500 bcm per year. Incentives are being offered to encourage more gas exploration, while plans for the construction of new LNG terminals progress to enable increased imports. The National Energy Policy proposes the construction of over 38 000 miles of new natural gas transmission pipelines. To find ways to manage short-term natural gas shortage, the government organised a gas summit in June 2004.

Although higher prices for natural gas and price volatility have dampened the interest for retail competition, restructuring of the gas markets is progressing at the state level. As of December 2003, five states had 100% eligibility for consumers to choose their suppliers, eight states were unbundling commodities and services and implementing more retail competition, and eight states were in the process of developing pilot programmes for unbundling and introducing competition.

COAL

The United States produces and consumes over one billion short tons of coal per year, second only to China. It is the US's most abundant fuel source and, at present consumption trends, will last about 250 years. Over 99% of US coal production is consumed domestically, with electricity generation accounting for about 90% of coal consumption. Virtually all projections show coal continuing to supply around half of the nation's electricity for at least the next 20 years.

After peaking in 1982, coal prices have generally declined on a per-Btu basis. This trend is projected to continue through 2020, reflecting an expanding shift into lower-cost western coal production and substantial increases in productivity. While coal is expected to remain the dominant fuel in meeting US electricity demand through 2020, energy policy goals must be carefully integrated with environmental policy goals. The Clean Air Act Amendments of 1990 and related state regulations require electricity generators to reduce emissions of sulphur dioxide and nitrogen oxide.

Among other initiatives, the DoE is implementing the government's \$2 billion, 10-year initiative to develop and improve the generation of coal-based electric power and pollution control technologies that will be environmentally superior to the technologies used in today's power plants. The pollution-free power plant, FutureGen, as announced by President Bush in February 2003, is expected to be a $1 billion, coal-fuelled prototype plant intended to prove the technical and economic concept of the world's first zero-emission fossil fuel plant co-producing electricity and hydrogen. And, under the Clear Skies Initiative, the DoE is developing new pollution control technologies that can meet tighter standards without resulting in major cost increases for ratepayers.

ELECTRICITY

Electricity production reached 3 984 TWh in 2003, a 24% increase over the 1990 production level of 3 203 TWh. While coal remains the nation's major fuel with 52% of total generation, natural gas is growing in importance and represents 17% of gross electricity generation; 20% comes from nuclear, 8% from hydro and 3% from oil. Most forecasts envisage that the largest number of power plants to be built in the next 20 years will consume natural gas. Natural gas is also likely to be a primary fuel for distributed power generators – mini-power plants that would be sited close to where the electricity is needed.

There is a general perception at state level that slowing down reforms is unlikely to eliminate opportunities. All states are continuing to use policies that protect consumers. Some states have chosen to reinforce efforts to develop a competitive market. A few have opted to return to previous regulatory frameworks and others have taken actions somewhere between these two ends of the continuum.

By February 2003, twenty-four states and the District of Columbia had either enacted enabling legislation or issued a regulatory order to implement retail access. The local distribution company continued to provide transmission and distribution (delivery of energy) services. Retail access allowed customers to choose their own supplier, but each state's retail access schedule varied according to the legislative mandates or regulatory orders. Twenty-seven states were not actively pursuing restructuring,[9] and a delay in the restructuring process or in the implementation of retail access was observed in six states (Arkansas, Montana, Nevada, New Mexico, Oklahoma and California).

The federal government has been largely focusing its activities on three fronts:

- Facilitating the development of new generating capacity.
- Reinforcing reliability of supply.
- Developing technology to keep coal in US electricity production.

9. Alabama, Alaska, Colorado, Florida, Georgia, Hawaii, Idaho, Indiana, Iowa, Kansas, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, North Carolina, North Dakota, South Carolina, South Dakota, Tennessee, Utah, Vermont, Washington, West Virginia, Wisconsin, and Wyoming.

Environmental law is being softened to promote new development. The so-called New Source Review (NSR) section of the 1970 Federal Clean Air Act has been amended by the Administration. The NSR subjected existing power plants that wanted to make revisions or additions to capacity to even stricter environmental standards than those applied to new ones. However, this has been amended so that companies are now able to replace as much as 20% of a facility before they must also include pollution-control measures as part of the repairs.

To increase reliability, the Administration is exploring the possibility of a national grid. While California was suffering rolling blackouts in 2000/2001, Texas was producing an electricity surplus, but the US does not have a national grid and transportation between states is very difficult. Similarly, the Administration also wants to buy more electricity from Mexico and Canada, but plans to upgrade the transmission system will have to be implemented to make this happen. A proposal in the NEP will grant the Federal Energy Regulatory Commission (FERC) more powers to seize private land in order to facilitate the laying of new electricity. The FERC has proposed the formation of regional transmission organisations (RTOs) and was hoping to get such measures passed in the Energy Bill. However, the major 2003 US blackout has given ammunition to opponents of the plans, including southern states, which fear that their fully-functioning transmission networks will be adversely affected by the plans. It now appears that the RTO proposals will be delayed until 2006 if the Energy Bill is approved, although there may be scope for some regions, such as the North-East US, to introduce the schemes early.

In July 2003, the FERC issued a new set of rules to standardise the interconnection of new generation facilities to transmission grids. The main purpose of the rules is to ensure non-discriminatory interconnection and access to transmission grids and hence to ensure competition in the wholesale market.

Following the August 2003 blackout that affected the North-East and Canada, the government created a Joint US-Canada Task Force on the Energy Outage that released its final conclusions in May 2004. Recommendations include: implementing mandatory and enforceable electricity reliability standards in both the US and Canada, with penalties for non-compliance, backed by appropriate government oversight. For this, the report recommended that the institutional framework of the North American Electricity Reliability Council (NERC) be strengthened.

RENEWABLES

Renewable energy represented 4.4% of the TPES in 2003, including 3.0% for combustible renewables and wastes, 0.9% for hydro, 0.4% for geothermal and 0.1% for solar, wind and others. This is equivalent to 99 Mtoe in 2002, against 91 Mtoe in 2001. The growth came essentially from combustible renewables and wastes, whereas hydro and geothermal capacity and production either stagnated or regressed since 1990.

Much of the policy support for renewables comes from state policies. Sixteen states currently have Renewable Portfolio Standards (RPSs), which require electricity providers to have a minimum amount of renewables in their generation mix. Public Benefit Funds (also known as System Benefits Charges) are a type of tax on electricity consumption, whose revenue is used to support various energy-related public goals, including expanding the use of renewables. In addition, a number of electricity providers, either voluntarily or as mandated by their states, offer green products – as green power or green tags.

Following the NEP, the proposed “Energy Law” contains provisions that would extend and modify the existing tax credit for electricity produced from some of the renewable energy sources. Current tax law allowed a 1.5 cent/kWh tax credit for electricity produced from wind, “closed loop” biomass (organic material from a plant that is used exclusively for the purpose of producing electricity), and poultry waste, until 31 December 2003. Under the proposed energy law, the tax credit for wind and biomass would be extended for three years. Other tax provisions are included for residential solar energy systems, for purchases of certain hybrid or fuel-cell vehicles; for energy produced from landfill gas; for certain combined heat and power systems; and for ethanol and renewable source methanol.

There are $10 billion worth of tax incentives in the NEP for energy conservation measures and the promotion of renewable energy technologies. In particular, about $4.5 billion could be spent on encouraging the development and greater utilisation of alternative fuels, and on household energy conservation – there is some $1 billion for developing methane gas from landfills electricity generation and tax credits of up to $2 billion for households that install solar panels on their property.

NUCLEAR

The 103 US nuclear units supplied about 20% of the electricity produced in the United States in 2003 – second only to coal as a fuel source.

The government is committed to nuclear energy, conducting research and development programmes to ensure nuclear energy’s future viability. The Nuclear Power 2010 Program is a joint government-industry cost-shared programme to identify potential sites for new nuclear power plants, develop nearer-term advanced nuclear plant technologies, and demonstrate untested regulatory practices that will lead to decisions by power companies to deploy new nuclear power plants within the next ten to fifteen years. The Generation IV Nuclear Energy Systems Initiative is conducting research and development in co-operation with other countries to establish the viability of longer-term advanced reactor concepts that offer significant improvements in economics, sustainability, safety and reliability, and proliferation resistance and physical protection. The Nuclear Hydrogen Initiative programme goal is to demonstrate the economic, commercial-scale production of hydrogen using nuclear energy. The Advanced Fuel Cycle Initiative is developing proliferation-resistant spent nuclear fuel treatment and transmutation technologies to enable a transition from the current once-through nuclear fuel cycle to a future sustainable, closed nuclear fuel cycle. The advancement of these programmes is supported by the research and development conducted by the Nuclear Energy Research Initiative and International Nuclear Energy Research Initiative programmes. The Nuclear Energy Plant Optimization programme is aimed at conducting research and development to support the continued effective operation of the existing fleet of operating reactors.

The current National Energy Policy (NEP), released in May 2001, addresses recommendations, among which that the government should support the expansion of nuclear energy in the United States. Specific components of the policy include encouraging the Nuclear Regulatory Commission (NRC) in the review of future applications to license advanced technology nuclear reactors, and in the re-licensing and uprating of existing nuclear plants. The NEP also supports the use of the best science to provide a deep geologic repository for nuclear waste; the renewal of the Price-Anderson Act; decommissioning funding improvements; and advance nuclear reactor and fuel-cycle technologies development.

In 2002, DoE reached a significant milestone in its high-level radioactive waste management programme when the President and Congress approved the Yucca Mountain site for development as a geologic repository. DoE is working to submit a Licence Application to the NRC by December 2004. In July 2004, the draft licence application was completed and is undergoing DoE acceptance review. Allowing about three years for NRC review, DoE would then seek authorisation to construct a repository by 2007, which would enable it to meet its key objective of having an operational repository by 2010. The DoE Office of Civilian Radioactive Waste Management (OCRWM) issued the National Transportation Strategic Plan in November 2003. The plan addresses policies; interactions with states, local and tribal governments; identifies necessary activities and describes the approach to ensuring a collaborative process is used to develop an operational transportation system by 2010. On the basis of the Yucca Mountain Final Environmental Impact Statement, in April 2004 DoE selected a rail corridor in Nevada to support the shipment of radioactive materials to the proposed repository.

The DoE OCRWM began a Science and Technology Program in 2003 as part of its commitment to further enhance understanding of long-term repository performance, reduce life-cycle costs, and improve operational efficiencies.

Projects already under way seek *i)* advances in welding, *ii)* advances in understanding corrosion, *iii)* other advances in materials (*e.g.* waste package coatings, and low-pH cements), and *iv)* enhanced credit for the natural system's barriers and for the performance of the waste form.

RESEARCH AND DEVELOPMENT

The DoE is the largest federal government supporter of fundamental research in basic energy sciences, biological and environmental sciences, physical sciences, computational sciences, and materials and chemical sciences. With the requested 2004 budget of close to $7 billion in R&D, the DoE maintains a comprehensive portfolio of R&D activities to support its missions, including energy resources, environmental quality, national security and science.

Global climate change is considered as a major long-term energy and environmental challenge, and hence represents a significant component of DoE 's R&D efforts to develop technologies that reduce emissions and help develop low-emission energy supply technologies (such as the FutureGen project mentioned above, among others). Federal government investments in R&D for climate change technology are now approaching $2.3 billion, essentially as activities undertaken through the CCTP mentioned above.

In February 2003, the government launched the Carbon Sequestration Leadership Forum (CSLF), an initiative aiming at promoting the international diffusion of related technologies.

DoE is conducting research, in partnership with the fuel-cell industry, to develop technology for the stationary power generation – for example, for power units that can serve as distributed electricity generation units. DoE has established research goals for stationary fuel-cell systems that include increasing the electrical efficiency of 50-250 kW stationary fuel-cell systems operating on natural gas or propane from 29% in 2002 to 40% by 2010. Extensive hydrogen production research is also under way that will enable hydrogen for fuel cells to be generated from not only natural gas, but also from biomass and other renewables, and from coal (with sequestration).

The government launched the FreedomCAR Partnership (2002) and Hydrogen Fuel Initiative (2003). Together, the extensive multi-year research efforts of the Hydrogen Fuel Initiative and the FreedomCAR Partnership are expected to facilitate a decision by industry to commercialise hydrogen-powered fuel-cell vehicles in the year 2015. In 2003, the International Partnership for Hydrogen Economy was established as an interface with international RD&D and the private sector on many aspects of developments related to hydrogen as a fuel (production, transport, use).

The federal government is leading a national effort to modernise and expand America's electricity delivery system to ensure a more reliable and robust electricity supply, as well as economic and national security, and reduce the likelihood and impact of blackouts. There are six major R&D programs: *i)* High Temperature Superconductivity, *ii)* Transmission Reliability, *iii)* Electric Distribution Transformation, *iv)* Energy Storage, *v)* Gridworks, a programme that supports R&D of advanced conductors and deployment of low-cost reliable sensors that monitor current flow and voltage throughout the grid, and *vi)* Gridwise, a programme that supports R&D on intelligent grid operations, distributed energy devices, and enhanced customer service.

In the field of renewable energy, the federal government attempts to achieve the following goals, through R&D efforts:

- *Biomass* – Platforms R&D – *a)* Reducing the cost of cleaned and reformed biomass-derived synthesis gas produced, from a mature gasification plant, from $9.8/MBTU in 2003 to $7.6/MBTU in 2010; and *b)* reducing the cost of a mixed, dilute sugar stream suitable for fermentation to ethanol, in a mature biochemical plant, from 15 cents/lb in 2003 to 10 cents/lb by 2010. Feedstock Infrastructure: reduce biomass harvesting and storage costs so that the delivered cost will be reduced from $53 per dry ton in 2003 to $38 per dry ton by 2005.
- *Solar* – Reducing the 30-year user cost from photovoltaic (PV) electric energy to 16-21 cents/kWh in 2006 from 19-24 cents/kWh in 2003; and reducing the cost of solar water heating in non-freezing climates to 4 cents per kWh in 2006 from 8 cents/kWh in 2003. The long-term cost goal (2020) for PV systems is 6 cents/kWh.
- *Wind* – Reducing the cost of energy from large, on-shore wind systems in lower wind classes (Class 4) to 3 cents/kWh in 2012 (from 5.5 cents/kWh in 2002), and 5 cents/kWh for offshore (shallow water) systems (from 7.5 cents/kWh in 2005); and develop a class of small wind turbine systems designed for residential and small business applications by 2007 for Class 3 wind resources that achieve costs in the range of 10-15 cents/kWh.
- *Geothermal* – Reducing the levelised cost of power generated from conventional geothermal sources from 5-8 cents/kWh in 2000 to 3-5 cents/kWh in 2010.
- *Hydropower* – Develop new technology that will enable 10% growth from 2005 in hydropower generation at existing plants with enhanced environmental performance, compared to an expected loss of 6% at federal and non-federal hydropower plants.
- *Hydrogen* produced from renewables (see above the references to DoE's FreedomCAR Partnership and Hydrogen Fuel Initiative).

The federal government is investing in R&D activities to develop new nuclear energy generation technologies to meet energy and climate goals; develop advanced, proliferation-resistant nuclear fuel technologies that maximise energy from nuclear fuel; and maintain and enhance the US nuclear infrastructure. One R&D programme is the Nuclear Hydrogen Initiative, focused on the development of advanced technologies that can be used in tandem with next-generation nuclear energy plants to generate economic, commercial quantities of hydrogen to support a sustainable, clean energy future. Another programme, the Generation IV Nuclear Energy Systems Initiative, establishes a basis for expansive co-operation with international partners to develop next-generation reactor and fuel-cycle systems. A third programme, the Advanced Fuel Cycle Initiative, seeks to develop advanced, proliferation-resistant nuclear fuel technologies that maximise the energy produced from nuclear fuels while minimising wastes.

The federal government invests in scientific research capacity and supports a broad array of research subjects in a number of areas: fundamental research in energy, matter, and the basic forces of nature; health and environmental consequences of energy production and development; fundamental science that supports the foundations for new energy technologies and environmental mitigation; a science base for fusion as a potential future energy source; and advanced computational and networking tools critical to research. Such research programmes include: the High Energy Physics programme; the Basic Energy Sciences; or the Biological and Environmental Research programme.