Alternative Energy: A Global Survey

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Executive Summary

Renewable energy technologies, which produce energy without using fossil fuels, contribute a small but rapidly growing portion of the world's energy portfolio. Worldwide investment in the industry totaled $70.9 billion in 2006, up from approximately $45 billion in 2005.[1] These technologies have the potential to help meet future energy needs, while also addressing increasing concerns about constraints on traditional energy supplies and the environmental impact of fossil fuels. In addition to increasing capital investment, renewable energy is also receiving increasing attention by policy makers in light of several structural changes in macro conditions, including:

- Rapid economic growth, particularly in the developing world.
- Demographic shifts, including continued population growth and increasing urbanization.
- Energy security concerns, including political instability in certain energy-rich nations.
- Climate change and other environmental concerns related to energy production and consumption.

This paper focuses on six renewable energy technologies: wind power, solar energy, biomass energy, biofuels, geothermal energy and hydroelectric power.[2] In addition, nuclear energy is briefly discussed as a significant but separate alternative to fossil fuels (see pages 22-23).* Each of these renewable energy technologies has its own "environmental footprint," with frequently contested positive and negative features that are not the subject of this paper. They also each face unique economic challenges that make it difficult for them to compete with energy generated by long-established fossil fuels.

This paper concentrates on the economic challenges associated with growth in the use of energy from renewable sources. If policy makers conclude that alternative technologies should be more widely deployed, what options exist to lower the costs, enhance the competitiveness, and increase the demand for such technologies? The discussion of policy options assumes that current market forces, by themselves, may not be sufficient to generate the desired expansion in alternative energy production. This paper considers several such policy options, including:

- **Feed–in tariffs**, which require power generators to purchase power from an alternative energy source at a higher than market rate.
- **Government mandates and targets**, such as renewable energy portfolio requirements or minimum volumes of biofuels.
- **Tax credits** to encourage investment, such as production and investment tax credits.
- **Tradable permits** and other related market-based incentives, such as a carbon-based "cap and trade" system, which could increase the competitiveness of low-carbon alternatives.
- **A carbon tax** on carbon-based energy sources.
- **Loans, grants, subsidies** and other support for alternative technologies, such as research and development support.

** The authors of this paper acknowledge that the limitations on growth in the nuclear energy industry are distinct from those confronting renewable energy technologies. Further, the market capitalizations of companies in the nuclear energy industry are of a different scale than market capitalizations in other alternative energy sectors and suggest unique policy treatment. Consequently, nuclear energy is treated separately from renewable energy technologies, and the terms "alternative" and "renewable" are synonymous for the purposes of this global survey.*

An additional consideration outside the scope of this paper concerns innovations in existing fossil fuel technology (e.g., "clean coal").

These and other policy tools are already being used in various countries throughout the world to encourage both the supply of and demand for energy generated by alternative technologies.

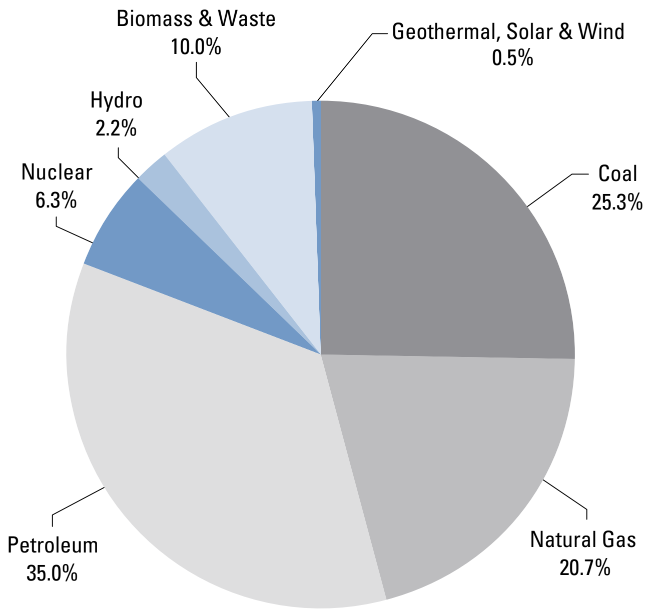
This paper describes the primary renewable energy technologies, outlines policies designed to overcome economic barriers for these technologies, and concludes with a survey of such practices in the United States, the European Union (EU), Japan, Brazil, India and China, hopefully providing policy makers and stakeholders with a useful reference and starting point for future decisions.

2 Renewable Energy: A Growth Industry

Many sources are used to meet the global demand for energy: fossil sources (petroleum, natural gas, and coal) account for 80% of global supply, and will remain indispensable in meeting the projected growth in energy demand.[3] Biomass – mainly wood and dung burned for heat – is today's largest non-fossil energy source. Nuclear power contributes about 6% and hydroelectric power supplies about 2% of today's energy. Only 0.5% of global energy demand is met by geothermal, solar, and wind (see Exhibit 1).[4]

EXHIBIT 1

World Energy Demand by Source Type



Source: IEA Key World Energy Statistics, 2006.

Growth in the Renewable Energy Market

Growth and investment in alternative technologies have increased in recent years and are expected to continue to rise significantly. Highlights of this trend include:

- Investments in new renewable energy capacity rose 25% between 2004 and 2005, from $30 billion to $38 billion.[5]
- Global wind capacity increased 32% in 2006, building on record growth of 41% in 2005.[6] Sustained growth has helped to drive down the investment costs for wind-based power by 3% per year over the last 15 years.[7]
- The global solar electricity market has grown 30% to 40% per year during the last decade.[8]
- Global production of biofuels has doubled during the last five years and is likely to double again during the next four years.[9]
- Global geothermal energy is expected to increase 55% between 2000 and 2010.[10]

Five factors stand out as the leading drivers of growth in the renewable energy industry:

- **High fossil-based energy costs** related to increased demand and uncertainties in supply.
- **Economies of scale** and falling capital equipment costs for alternative technologies, improving both yield and efficiency, and thereby improving competitiveness.
- **Legislative action** by governments worldwide.
- **Greater public awareness** of environmental concerns, particularly regarding greenhouse gas (GHG) emissions associated with fossil fuels.
- **The Kyoto Protocol**, through which certain countries have committed to reduce GHG emissions, and which in turn motivates those governments to implement policies that decrease the use of fossil-sourced energy and increase the use of alternative technologies.

Alternative energy is also increasingly the subject of policy discussion in light of structural changes in global macro conditions, including:

- **Continued global economic growth:** The global economy is witnessing a realignment of economic activity, with Brazil, Russia, India, and China (collectively, the BRICs economies) leading the way. Continued increases in energy production will be necessary to support this growth.
- **Continued population growth:** The world population continues to grow and, in 2008 – for the first time in history – more than half of the global population, or 3.3 billion people, will be living in urban areas (that is, towns and cities). By 2030, this urban population is expected to grow to almost five billion, creating unprecedented energy and land-use concerns.
- **Energy security:** Political instability in petroleum-rich nations is leading to a broader re-evaluation of energy policy, particularly regarding reliance on imported oil.
- **Climate change:** Scientific evidence regarding the threats posed by climate change and the extent to which this change is caused by human activity (e.g., GHG emissions associated with energy production and use) is raising important questions about how to achieve sustainable growth and the degree to which alternative sources of energy can substitute for fossil fuels.

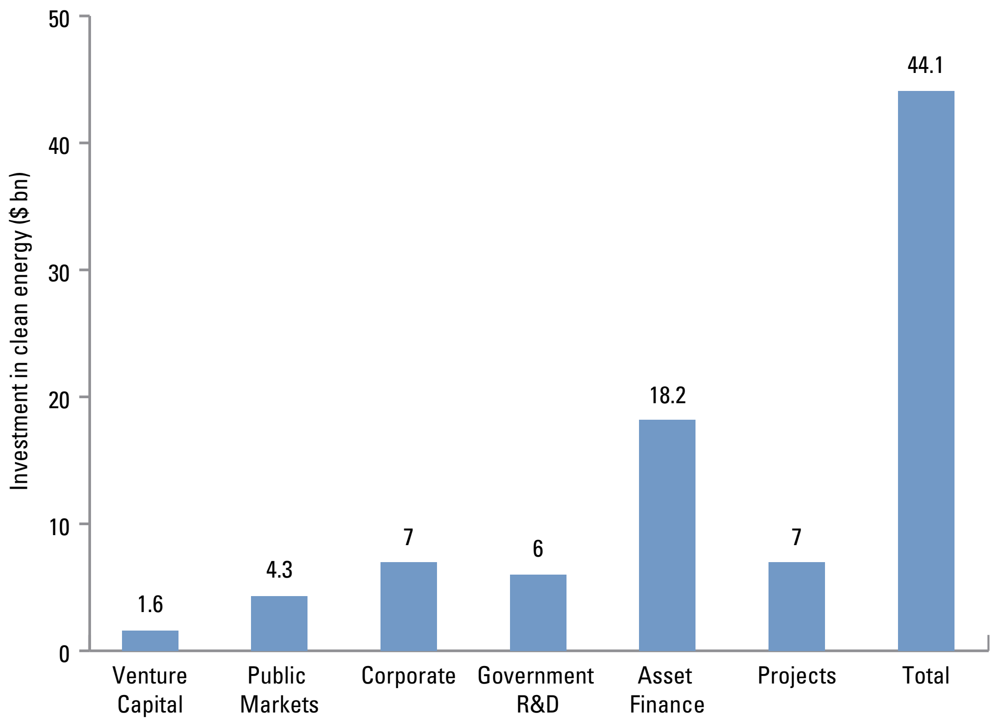
Investment in the Industry

Investment in the global alternative energy sector, excluding nuclear power, will top $90 billion in 2007 alone, a year-over-year increase of nearly 30%, according to the research firm New Carbon Finance.[11] The International Energy Agency's (IEA) 2006 World Energy Outlook projects an outlay of $20 trillion over the next 25 years.[12]

Although the boom in the investment in and development of alternative technologies is global, a few regions are at the forefront of this growth. The UN Environment Program concludes that Europe remains the top spot for investment, receiving $27.1 billion in 2006, while the United States is second, with $22.5 billion.[13] The turnover of renewable energy investment in Europe reached €15 billion by 2006, and employment in the sector grew to more than 300,000 people in 2006, up from 200,000 three years earlier.[14] Exhibit 2 illustrates primary sources of investment in alternative energy technologies.

EXHIBIT 2

Sources of Global Investment in Alternative Energy in 2005, $44.1 billion



Source: New Energy Finance, 2005.

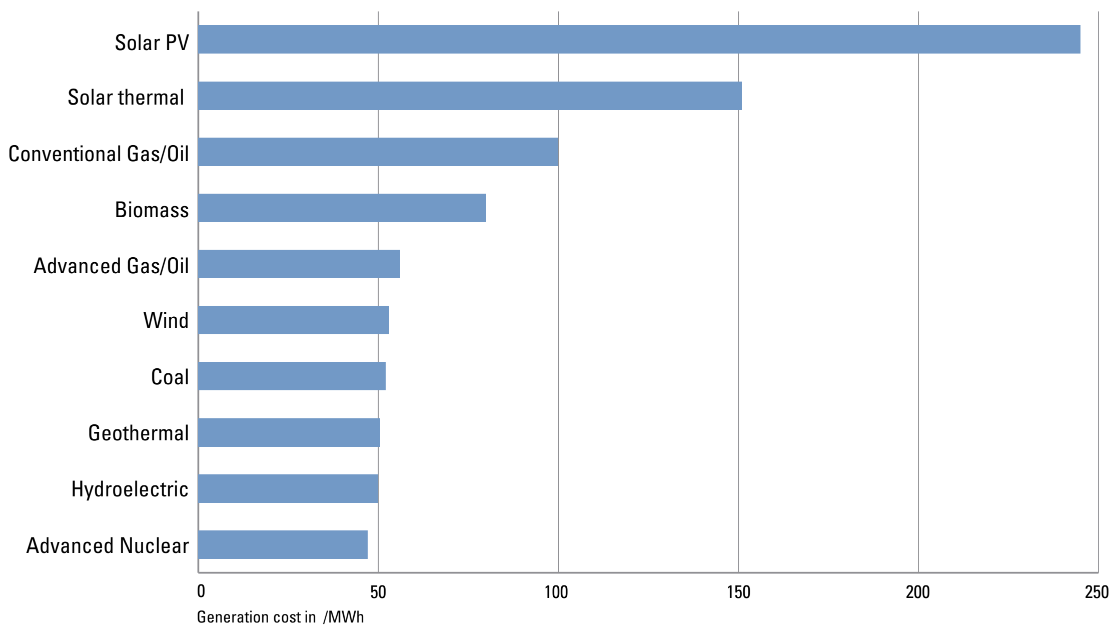
3 Alternative Energy Technologies

The alternative energy technologies addressed in this paper vary by level of maturity as well by market penetration in different regions. Alternative technologies face a variety of obstacles to entry. Technical barriers predominate in the initial stages of development, as do infrastructure constraints (e.g., grid-connectivity and pipeline infrastructure). Cost, social, legal and environmental obstacles also complicate growth. These issues can vary by sector. For example, biofuels are largely transportation oriented and face high-cost oil as their primary competitor, while the electricity-producing technologies (e.g., wind, solar) compete with a broader range of energy sources, including relatively low-cost coal. Such differences need to be taken into account when evaluating policy options aimed at encouraging alternative energy technologies, suggesting that a "one-size-fits-all" approach might not work.

Moreover, fossil fuels generally remain the less costly energy option from a financial standpoint when compared with their alternative energy counterparts. Exhibit 3 illustrates the cost comparison of alternative and conventional sources of electricity, for example.

Exhibit 3

Cost Competitiveness of Electricity Sources



Source: IEA, European Solar Thermal Industry Association, 2006.

Wind

Wind power technology harnesses the force of the wind passing through rotor blades to turn turbines and generate electricity. Wind energy is among the most mature technologies within the renewable energy industry.[15] Moreover, the reliability of technology has improved to a point where machines are available for generation approximately 96% of the time (that is, provided there is wind, turbines will be operational approximately 96% of the time).[16]

Wind power is one of the fastest-growing alternative energy technologies. In 2005, existing capacity grew 24% to reach 59 gigawatts (GW).[17] As Exhibit 4 illustrates, Germany leads the way in total capacity, though the United States made strides in 2005 due to the renewal of its production tax credit in late 2004.[18]

EXHIBIT 4

Added and Total Existing Wind Power, Top 10 Countries 2006

Country	Total in 2005 (megawatts, MW)	Added in 2005 (MW)	Total in 2006 (MW)
Germany	18,430	1,810	20,240
Spain	10,030	1,760	11,790
United States	9,150	2,430	11,580
India	4,430	1,430	5,860
Denmark	3,120	20	3,140
Italy	1,720	450	2,170
United Kingdom	1,350	450	1,800
China	1,260	500	1,760
Japan	1,230	240	1,470
Netherlands	1,220	120	1,340

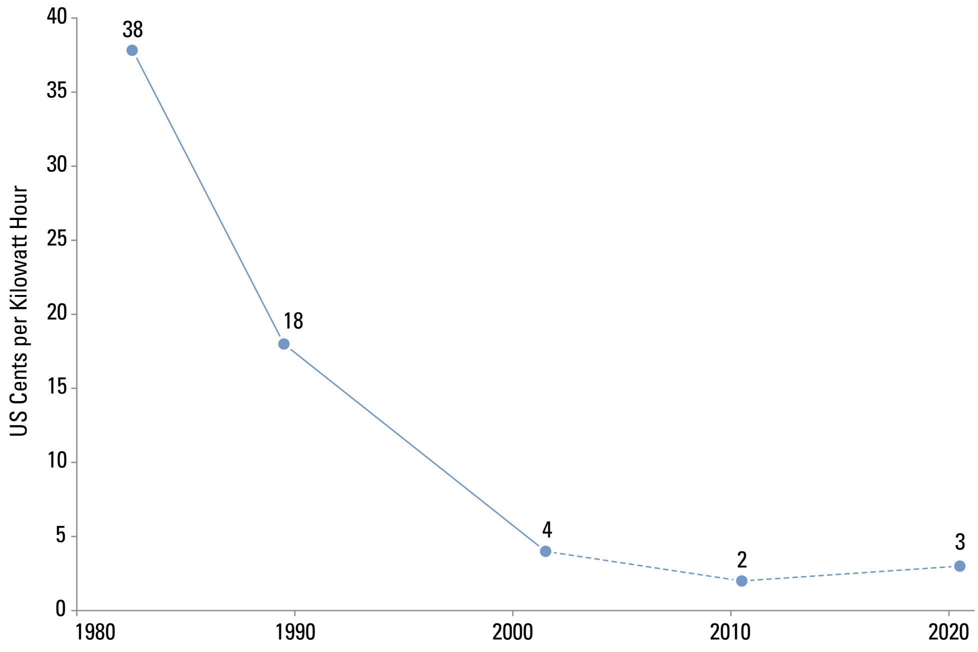
Source: Global Wind Energy Council, Global Wind 2006 Report, 2006.

The dramatic growth in worldwide wind capacity largely reflects advances in turbine technology and the low operating costs associated with wind power—once a turbine is constructed and connected to a power grid, the ongoing costs are primarily turbine operation and maintenance, land-use royalties, and taxes.[19] According to the US Department of Energy (DOE), the cost of wind power has declined more than 80% during the past three decades and now ranges from 4 to 6 cents per kilowatt-hour (kWh).[20]

Exhibit 5 illustrates how the cost of wind power in the US has declined sharply over time.

Exhibit 5

Average Cost per Kilowatt-Hour of Wind-Generated Electricity



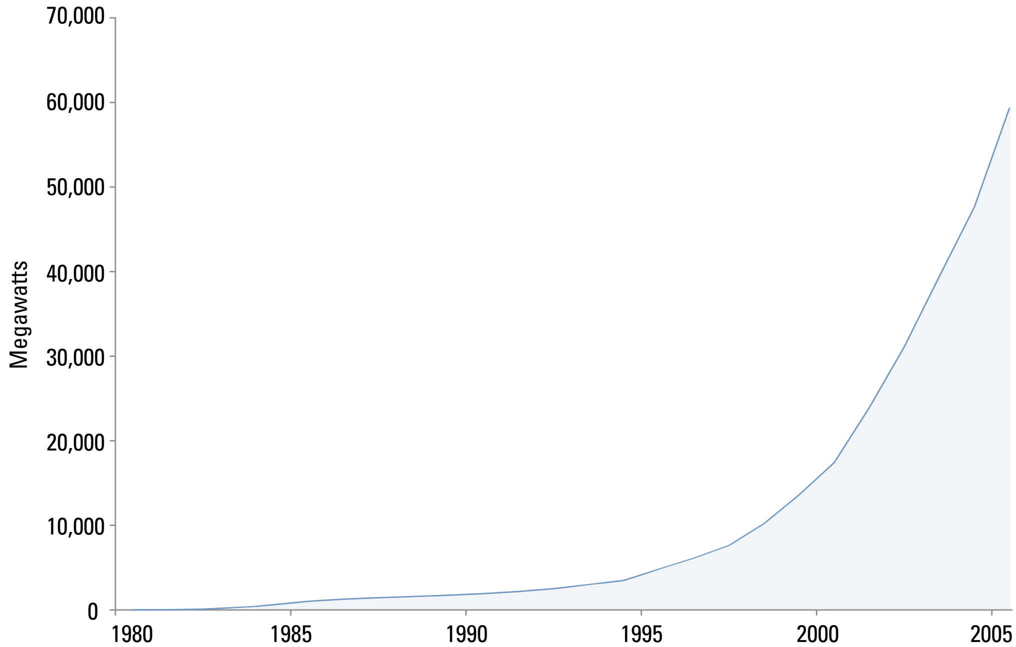
Source: GWEC, Worldwatch, 2002. Data as of 2002.

The wind industry is increasingly financing wind farms through the bond markets. In a project known as "Breeze Two," HVB Group, the largest bank in Italy, sold $597 million in bonds in May 2006 to support 39 wind farms in France and Germany.[21] Wind farm owners have typically financed projects with 12- to

14-year bank loans; however, bonds provide longer-term and less-expensive financing. With wind-produced electricity projected to grow to 151,000 MW over the next eight years, the wind industry appears positioned to continue its positive trajectory as shown in Exhibit 6.

EXHIBIT 6

World Wind Electricity-Generating Capacity



Source: GWEC, Worldwatch, 2005.

Looking Forward

Despite its advantages, the wind sector faces a number of obstacles to its continued growth. Historically falling costs are beginning to rise due to increased steel and labor costs as well as tight turbine supplies. Bottlenecks in the supply of critical components such as gearboxes, blades, towers and the bearings that go into gearboxes – driven by high growth in the sector – also restrict the potential of this technology. In addition, the intermittent nature of wind as a resource further complicates growth and conversion difficulties leave many wind facilities with a relatively low capacity (or utilization) factor, so that the observed energy output is small relative to the maximum potential output.

Solar – Photovoltaic And Solar Thermal

The solar industry is among the youngest renewable energies being developed today.[22] Solar energy includes photovoltaic (PV) and thermal technologies.

Photovoltaic Energy

Solar PV converts sunlight into electricity using solar cells which are made from a semi-conducting material, such as quartz, that is processed into poly-silicon. Typically, 40 solar cells are grouped together into a solar module. These modules are connected to the electricity grid and mounted in areas which are positioned to capture the most sunlight over the course of a day.

Since the 1970s, the price of PV modules has decreased by a factor of more than 20.[23] From 2004 to 2005, PV capacity rose by 1.1 GW to 3.1 GW, a 55% increase. See Exhibit 7 for the countries which have installed the most PV power.

Exhibit 7

Installed PV Power as of the End of 2005 for Top 5 Countries

	PV Capacity				
	Cumulative			Installed in 2005	
Country	Off-grid PV (KW)	Grid-connected (KW)	Total (KW)	Total (KW)	Grid-tied (KW)
Germany	29,000	1,400,000	1,429,000	635,000	632,000
Japan	87,057	1,334,851	1,421,908	289,917	287,105
US	233,000	246,000	479,000	103,000	70,000
Australia	41,841	8,740	60,581	8,280	1,980
Spain	15,800	41,600	57,400	20,400	18,600

Source: IEA Photovoltaic Power Systems Programme, 2005.

Worldwide PV production increased from 740 MW in 2003 to 1,150 MW in 2004 (to 2GW in 2006). Just over 1GW of this global production was installed in Germany, the world's largest solar market. For each doubling of installed PV capacity during this period, costs of production have dropped at a rate of approximately 20%.[24]

Since 2006, the poly-silicon price has increased from a historic low of $30/kg to contract prices of $70/kg in 2007 and spot market prices of up to $200kg. While the poly-silicon prices have increased, new technologies such as thin film are also being developed as a means to further reduce the costs of PV systems. As a result, and because many actors in the solar market contracted the necessary poly-silicon supplies before the more recent rise in supply prices, the overall cost of production for solar is falling approximately 5% per year, and some key market players estimate that by 2010, the cost of producing a crystalline solar cell will halve (against a baseline date of 2000).[25]

Europe, the United States, and Japan have dominated the global PV cell market with a combined 90% share in 2005 and are expected to continue to lead the market until 2010 due to government incentives. Germany is the world leader in solar PV and the home to the European solar industry. Southern Europe is expected to emerge as the next growth region for European solar energy due to a combination of a favorable climate and developing government support.[26]

Solar Thermal

Solar thermal “power plants” are a relatively new technology which uses lenses and reflectors to concentrate the sun’s energy and generate electricity. The main ways to collect the sun’s heat are through parabolic troughs (curved mirrors that focus the sun’s energy on a pipe), parabolic dishes (satellite-dish style concentrators which reflect radiation onto the receiver in the center of the dish) and solar central receivers (towers surrounded by mirrors reflecting the sun’s rays on the tower’s receiver). Solar thermal has a variety of uses, the most widespread being the superheating of water and its conversion into steam for thermal electricity generation in large scale solar power plants.

While the technology has proven itself, it is only beginning to be seen as having significant potential as a commercially viable alternative energy source. Compared with a very low base of approximately 350 MW in 2006, industry estimates project a compound annual growth rate (CAGR) for solar thermal of approximately 70%, with installations reaching 10GW by 2012.[27] This forecast is driven by declining costs, relative to rising costs associated with conventional energy production.[28]

Looking Forward

Several technical and market barriers limit the widespread development and deployment of solar power worldwide. In many countries, solar generation costs exceed those of other renewable energy sources, notwithstanding recent trends in the declining cost of solar power generation.[29] Further technology issues such as efficiencies in the conversion of sunlight into electricity, natural endowment realities such as the number of sunlight hours available, and component price sensitivities (e.g., silicon bottlenecks) also complicate the potential growth of solar energy.

Biomass

Biomass power generation uses a variety of resources, including agricultural, food processing, or forestry by-products, garbage, as well as methane gas from landfills. The biomass can be either burned to produce steam for use in electricity production, or converted into a combustible gas (i.e., biogas) for use in driving a turbine. Some countries are increasingly looking to solid biomass such as wood and wood waste, straw, and vegetal and animal waste to generate both heat and electricity.

In 2005, the United States was the largest producer of biomass power, followed by Brazil, the Philippines, Germany, Sweden, and Finland.[30] The portion of electricity generated by biomass and renewable waste in 2004 totaled 1.3% in the United States, whereas it reached 12.1% in Finland, 4.7% in Sweden, 3.2% in Brazil, 1.5% in Germany and Canada, and 1.4% in Japan.[31]

Looking Forward

Biomass is an abundant and potentially renewable fuel source. However, the burning of biomass can contribute to pollution and global warming (if the plants grown to produce biomass energy are not replaced, for example), and biomass may compete with food crops for land. Two key obstacles to increasing the use of biomass energy are ensuring a reliable fuel supply throughout the economic life cycle of a given project, and the pricing of biomass. A report by the National Commission on Energy Policy, entitled *Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges* (2004), further suggests that the contribution of biomass-generated electricity to overall energy supply will depend on three factors: technological innovation, maintaining economically viable and reliable feedstock sources, and reducing transportation costs.[32]

Biofuels

Biofuels are primarily transportation fuels derived from biological sources. A distinction is often made between first-generation biofuels (produced from crops such as corn or sugar beet) and second-generation biofuels (from lingo-cellulosic or "woody" sources, and via new technologies to convert biomass to liquid).

The two most advanced first-generation biofuels are biodiesel and bioethanol ("ethanol"). Biodiesel is produced from vegetable oils, animal fats, or recycled greases. Ethanol is a gasoline/petrol additive or substitute derived from sugar or starch crops such as corn. Cellulosic ethanol, a noted second-generation biofuel, is derived from cellulose, which is the main structural material contained in plant cell walls and the most common organic compound on earth. However, the process to break down cellulose is very difficult given its rigid structure, and the technology is in the early stages of development.

To a degree, biodiesel and ethanol can substitute for fossil fuel, either with or without engine modification, and consequently have their primary application in transport, although certain countries also harness the potential of biofuels for small-scale heating production. In addition, at the right blended ratios, biodiesel and ethanol can be fed into an existing pipe distribution network.[33]

As an alternative transport fuel, biofuel has been in use for several decades. It has a particularly strong history in Brazil, where a government-sponsored oil substitution program has led to a 70% penetration of vehicles capable of running on gasoline and ethanol (flexi-fuel) in the new car market.[34]

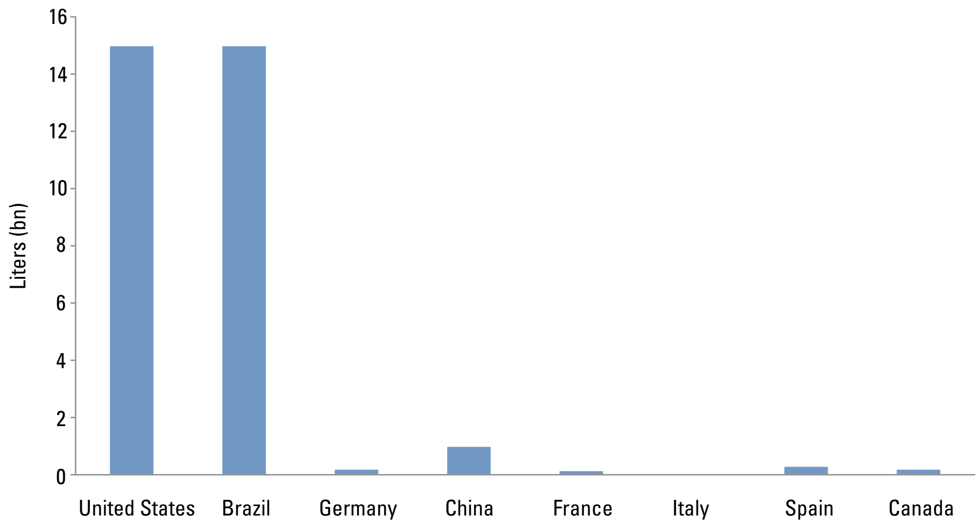
3

Growth in Biofuels

Biofuels have enjoyed tremendous growth during the past few years. As Exhibit 8 and 9 illustrate, ethanol dominates the biofuels markets in the United States (corn-based) and Brazil (sugar-based). In contrast, biodiesel production dominates in Europe, with Germany making a particularly strong contribution.

Exhibit 8

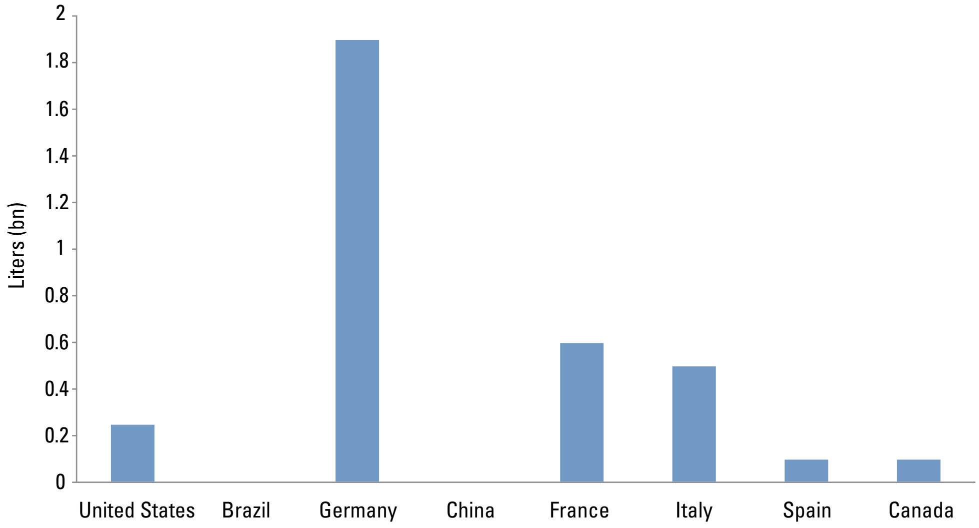
Ethanol Production, Top 8 Countries



Source: Global Status Report, 2006 Update, REN21; Global Status Report 2005, REN21.

Exhibit 9

Biodiesel Production,
Top 8 Countries



Source: Global Status Report, 2006 Update, REN21; Global Status Report 2005, REN21.

Looking Forward

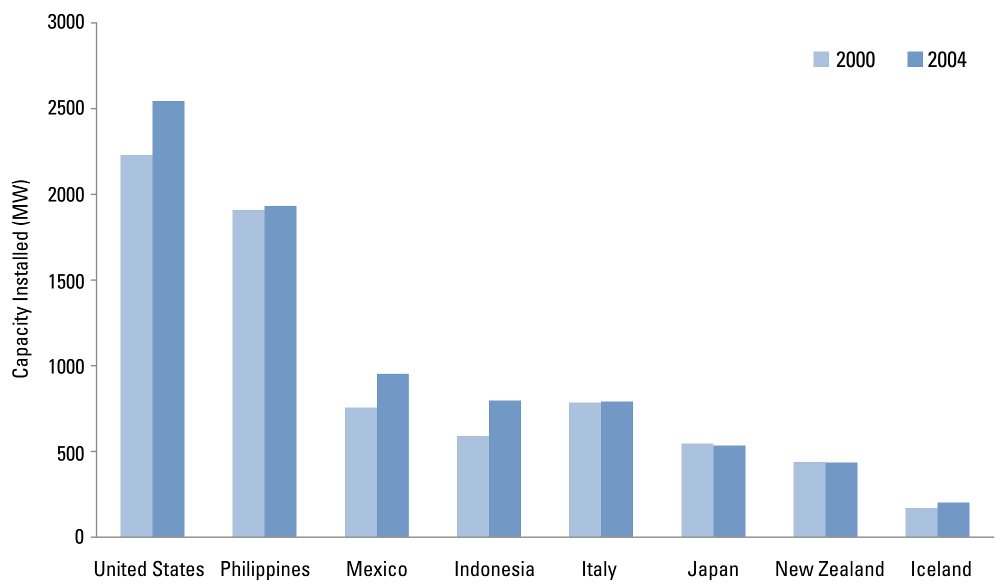
The key drivers for the growing interest in biofuels are its direct substitution for mineral fuels and support for the agricultural sector.[35] That said, biofuel production has notable obstacles to growth. Uncertainty regarding the long-term supply of biofuels feedstock given land availability constraints is the principal barrier, and rising agricultural commodity prices are a related concern. Similarly, rising biofuel demand provides farmers with a greater economic incentive to grow crops for biofuel production, contributing to reduced food production and higher food prices.

Geothermal

Geothermal energy is generated by proven technology that converts the natural heat within the earth's crust into electricity. Geothermal power draws energy from underground reservoirs of water that have been heated by geological processes. Despite high upfront costs, geothermal plants are reliable and can be used 90% of the time (e.g., they are not constrained by hours of daylight, lack of wind, etc.). It has been estimated that global geothermal power production could increase by 55% between 2005 and 2010.[36] The United States remains the dominant producer of geothermal energy in the world, followed by the Philippines, Mexico, Indonesia, and Italy (see Exhibit 10).[37] While geothermal energy accounts for 0.35% of total US electricity production, it accounts for 17% of the electricity generated from renewable sources.[38] Building on a rising geothermal capacity, as of May 2007, the United States had 2,850 MW of installed geothermal energy capacity, compared with 2,228 MW in 2000.[39] Of this amount, a majority (approximately 1,875 MW) is located in California.[40] Although 15 countries were actively engaged in new or additional geothermal development in 2005, another 40 countries were considering geothermal plants by 2007.

Exhibit 10

World Geothermal Capacity in 2004



Source: Geothermia Barometer, EURObserv'ER, December 2005.

Looking Forward

For the continued deployment and commercialization of geothermal energy, non-technical market barriers such as financing and environmental considerations must be addressed. In particular, the major barrier to the further use of geothermal energy is high financial risk, mainly due to the geological uncertainty of developing reservoirs. As a result of this high-risk premium, financing in the absence of insurance policies and/or state intervention is difficult.

Hydroelectricity

Hydroelectric power generates electricity by forcing water, usually held in a dammed reservoir, through a turbine that is connected to a generator. The amount of energy extracted depends on the volume of water and the height between the reservoir and the outflow. As a result, hydroelectric plants are usually built in areas with high precipitation rates and elevation changes.

The countries with the greatest annual hydroelectric energy production and installed capacity are listed in Exhibit 11.

Exhibit 11

Hydroelectric Production and Installed Capacity in 2006, Top 8 Countries

Country	Annual Hydroelectric Energy Production (terawatt hours, TWh)	Installed Capacity (GW)
China	416.7	128.57
Canada	350.3	68.974
Brazil	349.9	69.080
USA	291.2	79.511
Russia	157.1	45.000
Norway	119.8	27.528
India	112.4	33.600
Japan	95.0	27.229

Source: British Petroleum, "Statistical Review of World Energy 2007," 2007.

China is actively developing hydroelectricity. The installed capacity of hydroelectric generators in the country will reach 165 million KW in 2010 and 250 million KW by 2020, and some estimate that potential hydroelectricity generating capacity in the country exceeds 400 million KW.[41] China has over 50% of the world's small hydro capacity, and the Three Gorges dam, scheduled for completion in 2009, will be the world's largest hydroelectric river dam with a maximum capacity of 22,400 MW.

Looking Forward

Compared to other renewable technologies, hydroelectricity is older and relatively more established. It is not a major option for future energy production in most developed nations as most of the possible sites have already been exploited or cannot be expanded for environmental reasons. While hydroelectric plants continue to be developed in emerging markets such as China, plant construction may require population relocation or cause environmental damage (changes in surrounding ecosystems, downstream river flows, and animal habitats). Going forward, the European Small Hydropower Industry Association projects that small hydro will grow faster than large hydro, which is seen as less environmentally friendly.[42]

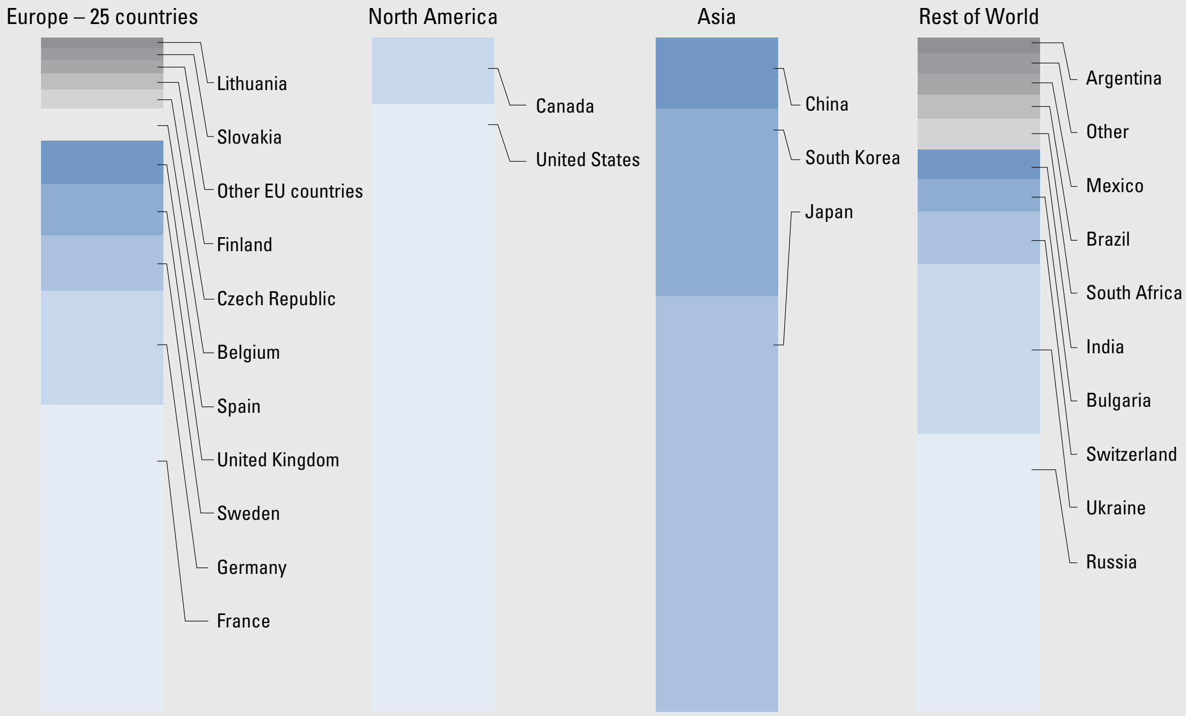
Nuclear Power: An Alternative Energy Source with Unique Benefits & Challenges

While this paper explores innovations in renewable energy technologies and policy options that may catalyze these markets, nuclear power remains a significant source of non-fossil power. Nuclear power now supplies approximately 17% of worldwide electricity consumed – more than any other alternative energy source. At the national level, nuclear energy provides 78% of electricity in France and it is the third-leading source of electricity in the United States, providing nearly 20%.*

Of the total global nuclear capacity, 36% is located in the European Union, including 17% in France. Of the 27 EU member states, nuclear energy has a 32% market share of the electricity generation mix. The total nuclear capacity split within the European Union, North America, Asia, and the rest of the world is displayed in Exhibit A.

Exhibit A

Total Nuclear Capacity Split



Source: International Atomic Energy Agency, BP Statistical Review, Eurostat; Goldman Sachs, Global Investment Research, Nuclear Energy Overview, March 2007.

** "President Bush Discusses Energy Initiatives in Athena, Alabama", Press Release, July 21, 2007, available at http://www.whitehouse.gov/news/releases/2007/06/20070621-12.html.*

Nuclear energy provides unique benefits, including low and stable electricity prices. The increasing cost competitiveness of nuclear power over the past decade has been documented in various studies, including a recent report by the Organisation for Economic Co-operation and Development.**

Nuclear energy remains outside the scope of this paper as the challenges to the expansion of the industry – namely, environmental and long-term management of radioactive waste, security concerns, and permitting processes – are unique. Moreover, the market capitalization and maturity of the sector are distinct from the renewable energy landscape considered in this global survey. Policymakers around the world continue to weigh the societal benefits and other challenges to nuclear energy as an alternative to fossil fuels.

*** "The Economics of Nuclear Power" Briefing Paper, Uranium Information Centre Ltd., June 2007, available at http://www.uic.com.au/nip08.htm.*

4 Policy Options

The current cost disadvantages of alternative technologies that make it difficult for them to compete with fossil fuel-sourced energy can be offset through various policy mechanisms (see Exhibit 3 for the cost comparison). These policies encourage (or even mandate) the use of energy produced by alternative technologies in the hopes of eventually lowering the costs of and establishing a predictable investment environment for such technologies.

Feed-In Tariffs

A feed-in tariff requires a utility to purchase power from a renewable energy source at a fixed rate, typically above the market price. By establishing a set price, feed-in tariffs can create stability and reduce financing barriers and costs for alternative energy sources.

A typical program distributes the overall cost of the subsidies (i.e., the above-market price) to ratepayers through a fee on electricity sales. Feed-in tariff programs typically include stable long-term payments (10-year minimums), a scheduled decrease in the subsidy over time (known as a tariff digression), varying incentive levels for each different technology, and stepped tariffs which target specific types of technology to encourage a more efficient use of energy.[43]

There are two primary types of feed-in tariffs: the Standard Offer and the Advanced Renewable. The Standard Offer feed-in tariff sets the same price for all renewable energy technologies and project sizes. The Advanced Renewable feed-in tariff offers a distinct price for each different technology and rates fluctuate to ensure profitable operation of renewable energy projects after installation.

The rates in the Advanced Renewable approach range dramatically among technologies and also fluctuate throughout the day. Decreasing the subsidy over time creates a predictable investment environment while producing pressure on the renewable energy industry to reduce the costs of a technology, and has been shown to increase competition among manufacturers.[44]

Targets And Mandates

Governments around the world have set both performance- and technology-related targets and mandates in an effort to increase the use of alternative energy resources. Two examples are highlighted below.

Renewable Portfolio Standard

Renewable Portfolio Standards (RPSs) are prevalent in various US states and Japan. Typically, they require that a certain percentage of a utility's overall or energy sales be derived from renewable sources (the definition of what is "renewable" can vary considerably).[45] Some RPSs will specify the technology mix, while others leave it up to the market. Most RPSs allow for flexibility of implementation by using tradable Renewable Energy Credits (RECs), which are tradable certificates showing that one megawatt hour (MWh) of electricity has been generated by a renewable energy source. RECs enable the utility to either generate its own renewable energy or buy credits from other suppliers.

A specific example of an RPS is the Renewables Obligation (RO) in the UK, which requires all licensed electricity suppliers to produce evidence that they derive a defined proportion of their power from renewable energy sources each year, or else pay a penalty. The RO was initially set at 3% for the period 2002-2003, and commitments are scheduled to rise to 10.4% by 2011-2012, increasing 1 percentage point annually for the five years following. The obligation runs until 2027, when all suppliers will have to ensure that they meet the target of 15.4% of their power generation from renewable sources.[46]

The RO is administered by the Office of Gas and Electricity Markets (Ofgem), which requires suppliers to produce evidence of their compliance via Renewable Obligation Certificates (ROCs). Each ROC represents one MWh of renewable electricity generated from eligible resources. Solar PV, wind, biomass, biofuels, and hydroelectric power qualify for ROCs. Accredited renewable generators can sell their ROCs to electricity companies or suppliers.[47]

The government sets the initial values of ROCs, and the price increases each year with inflation. ROCs are bought and sold in the marketplace by large generators, traders, brokers, and electricity suppliers, and market prices vary on a daily basis.

Renewable Fuel Standard

Renewable Fuel Standard (RFS) programs establish a minimum content of renewable fuel that refiners must introduce into their transportation fuels. They are intended to increase the use of renewable fuels in transportation and to an extent serve as a replacement for fossil fuels. RFS programs create a guaranteed market for renewable fuels.

4

The United States established an RFS program through the Energy Policy Act of 2005, which gave the Environmental Protection Agency (EPA) the responsibility to promulgate regulations to ensure that gasoline sold in the US contains a minimum volume of renewable fuel. This US RFS is projected to result in the use of more than 7.5 billion gallons of ethanol and biodiesel by 2012.[48]

Numerous US states including Kansas and California, and other nations including Brazil, have also adopted RFS programs.

Tax Credits

Tax credits can be used to promote the development and use of alternative energy technologies. Using tax credits for such purposes is far more prevalent in the United States than in other nations. The two major approaches are tax credits on production and on investment.

Production tax credits (PTC) provide credits based on the amount of energy produced each year. Investment tax credits (ITC) provide credits based on amounts invested in a project. In both cases, the credit can be provided against personal or business income tax. In addition, for state tax purposes, the credit can be provided and property eligible for ITCs may also be eligible for sales tax incentives.

A criticism of tax credits is that they can be removed and that the development of an alternative energy technology will suffer should credits not be renewed. One possible solution is to set a schedule of declining incentives, thereby allowing the industry to plan around the change. A workable schedule could be based either on time or on the development of a number of alternative energy technologies.

Cap And Trade Frameworks

GHG cap and trade systems provide a market-based mechanism to encourage those who can reduce GHGs emissions most economically to do so. Regulators must determine which sectors of the economy will be covered by the system and the total amount of emissions that will be allowed within a specific period of time. Permits to emit a given amount, such as one metric ton of carbon dioxide (CO_2) equivalent, are then allocated or auctioned as credits. The permits can be traded, encouraging sources that can eliminate the emissions for less than the market price of a permit to do so, while sources for whom emissions control is more costly can buy permits from others.[49] Cap and trade frameworks encourage the use of renewable energy insofar as they provide an incentive to switch to renewables in order to comply with cap requirements.

A 2007 study by the World Bank shows that the global carbon market tripled in 2006, to $30 billion. This market was driven by the sale and resale of European Union Allowances at a value of nearly $25 billion. The projects-based market in developing countries with economies in transition also grew sharply, more than doubling during 2005 to $5 billion.[50]

Carbon Tax

A carbon tax is a tax on carbon-based energy sources. The tax rate is typically based on the proportion of carbon content in fossil fuels used for energy. Sweden, Norway, the Netherlands and Finland each enacted a carbon tax during the 1990s.

Loans, Grants And Subsidies

As discussed in more detail in Section 5 of this paper, several national and regional governments have well-established loan, grant and subsidy programs to encourage renewable energy development. In addition, these tools are also utilized by development agencies and supranational organizations such as the World Bank and the United Nations.

The World Bank committed nearly $8.3 billion to renewable energy projects between 1990 and 2004, which represents 13% of its power sector portfolio.[51] Half of that amount was directed towards large hydroelectricity plants, with the remainder allocated to wind, solar, biomass, geothermal, and smaller hydro projects. Much of the World Bank's renewable energy lending is through the International Bank for Reconstruction and Development (IBRD), the International Development Association (IDA), the Multilateral Investment Guarantee Agency (MIGA), and the Global Environment Facility (GEF).[52]

The GEF in particular is a significant source of financing for renewable energy projects. Established by donor governments at the first Earth Summit in 1991, it has since provided more than $6.2 billion in grants and $20 billion in co-financing for renewable energy projects.[53] In addition to the World Bank, GEF projects are implemented by the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP). The UNDP's renewable energy portfolio is $2 billion, including GEF co-financing. UNEP's renewable energy portfolio is $35 million and its climate change portfolio is $135 million, of which $43 million is from GEF.[54]

5

A Global Survey of Alternative Energy Policies

The United Nations' Kyoto Protocol entered into force in February 2005. The Protocol requires those countries that undertook commitments to reduce GHG emissions to about 95% of their 1990 levels by 2012 and has encouraged the enactment of programs to reduce carbon emissions. Governments at the state, regional, national, and supranational levels (whether or not parties to the Kyoto Protocol) have also undertaken broad energy strategies. Further details on significant policies and programs in selected countries are provided below.

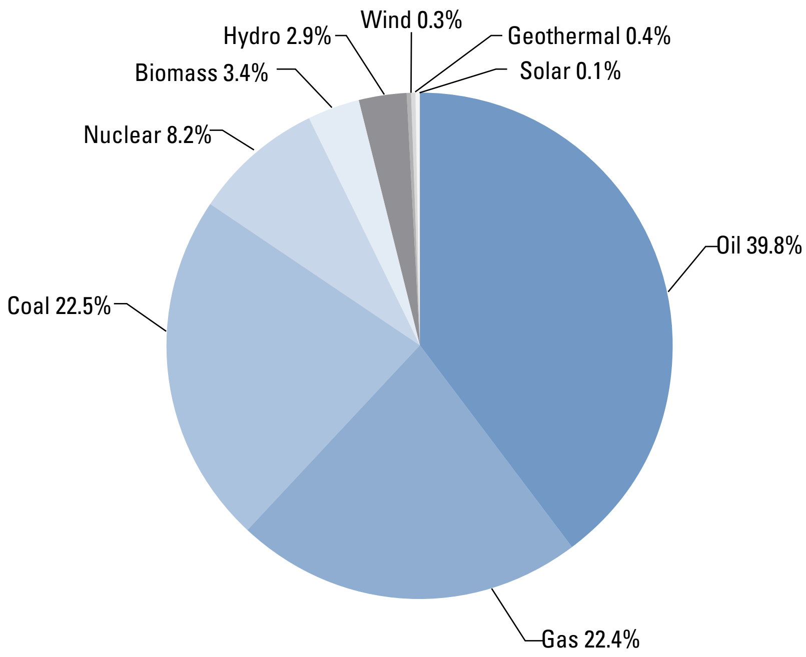
United States

In the United States, incentives that promote alternative technologies are not limited to national policies: indeed, several states have emerged as alternative energy pioneers. This section outlines several national and state policies.

Exhibit 12 below specifies the energy mix in the United States.

EXHIBIT 12

United States
Energy Mix, 2006



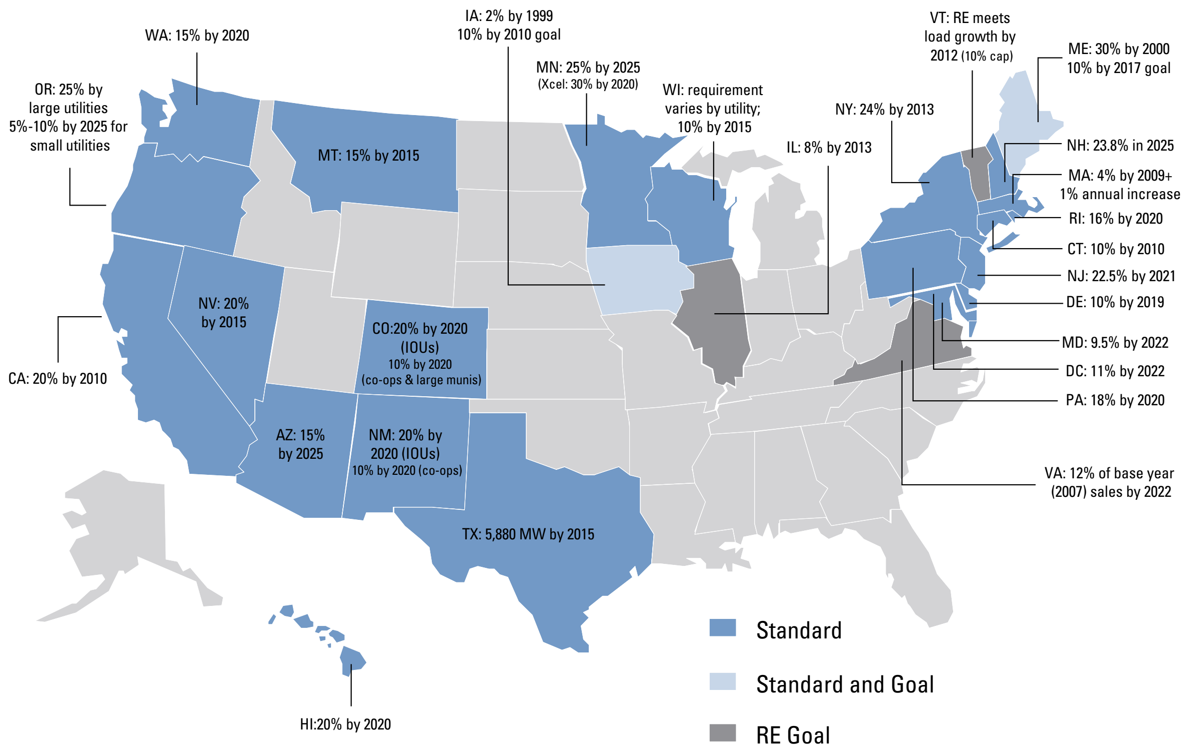
Source: EIA Energy Consumption Statistics.

Energy Standards

The United States does not have a national renewable portfolio standard. Instead, 24 states plus the District of Columbia have adopted their own RPS policies (see Exhibit 13).

Exhibit 13

State Renewable Portfolio Standards



Note: RE Goal: Renewable Energy Goal; IOU: Investor Owned Utility; Xcel: Xcel Energy.

Source: Interstate Renewable Energy Council, Union of Concerned Scientists, National Conference of State Legislatures, Database of State Incentives for Renewables & Efficiency.

The basic features of each state-level RPS are similar. Electricity suppliers are required to purchase specified percentages of renewable energy, with each state adopting a distinct definition of what constitutes renewable energy. Most states allow for flexibility by using tradable renewable energy credits. Some states' RPSs use tiered classification systems that provide increased credit levels for more expensive technologies. New Jersey and Pennsylvania, for example, place solar in a separate classification and mandate a strict procurement percentage from this more-expensive resource. Many of these programs are in early stages of development and conclusive data on their impact is unavailable.

Tax Credits

The US Renewable Energy PTC is a per kWh credit for electricity generated from renewable sources. Eligible sources include wind, biomass, geothermal and certain hydroelectric power. The PTC provides a tax credit of 1.9 cents per kWh for wind, certain biomass, and geothermal energies. The length of the credit period varies by fuel source. The PTC is not refundable, but it does carry back one year and forward for 20 years. Therefore, younger companies without net taxable earnings have an extended period of time to claim the credit going forward. The PTC expires on December 31, 2008. See Exhibit 14 for a summary of the PTC.

EXHIBIT 14

Summary of PTC Credit Rate and Credit Period for Selected Facility Types

Renewable Resources of Electricity	Credit Amount for 2005 (cents per kWh; dollars per ton)	Credit Period (years from placed in-service date)
Wind	1.9	10
Closed-loop Biomass (organic material produced specifically for fuel)	1.9	10
Open-loop Biomass (including agricultural livestock wasted nutrient facilities)	0.9	5
Geothermal	1.9	5
Solar	1.9	5
Small Irrigation Power	0.9	5
Municipal Solid Waste (including landfill gas facilities and trash combustion facilities)	0.9	5

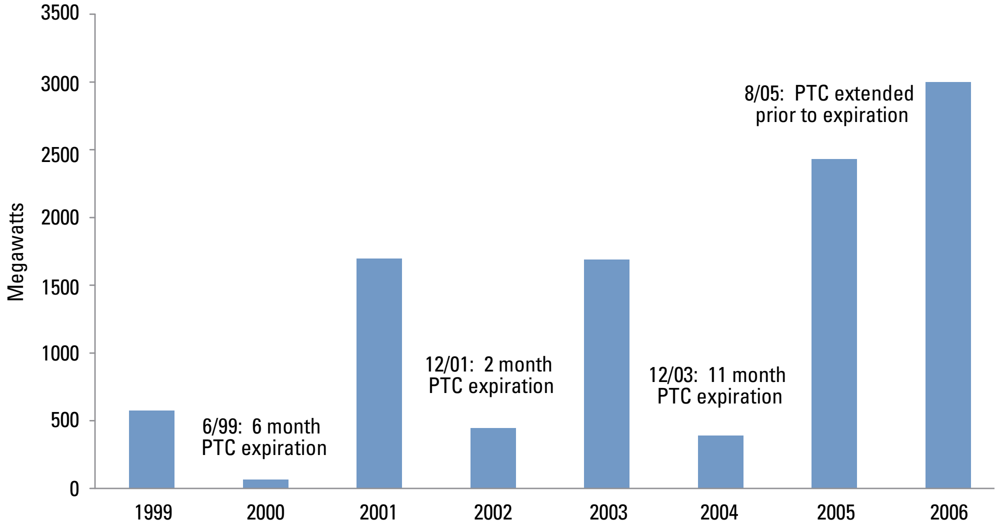
Source: Joint Tax Committee.

The PTC is a legislative creation historically set to expire after a specified number of years. A key obstacle to the success of the PTC has been its short-term and unpredictable nature. The PTC has been extended five times since its original adoption in the Energy Policy Act of 1992. The first three extensions came after the credit expired. This has been problematic for all affected renewables industries because it undermines the predictability and stable economic conditions necessary to support long-term investment. It has had a particularly adverse impact on the US wind industry, slowing the growth curve because of periodic slowdowns in project development within six months of the credit's expiration on each occasion. Industry estimates indicate that a five-year extension of the PTC would provide enough certainty to reduce electricity costs from wind energy by 8%.[55]

See Exhibit 15 for the relationship between the PTC's longevity and annual installed wind capacity.

Exhibit 15

Annual Installed Wind Capacity



Source: American Wind Energy Association.

The other major federal tax incentive related to alternative energy is the Investment Tax Credit. The ITC's impact on investment is described in more detail below in connection with the specific energy technologies to which it relates.

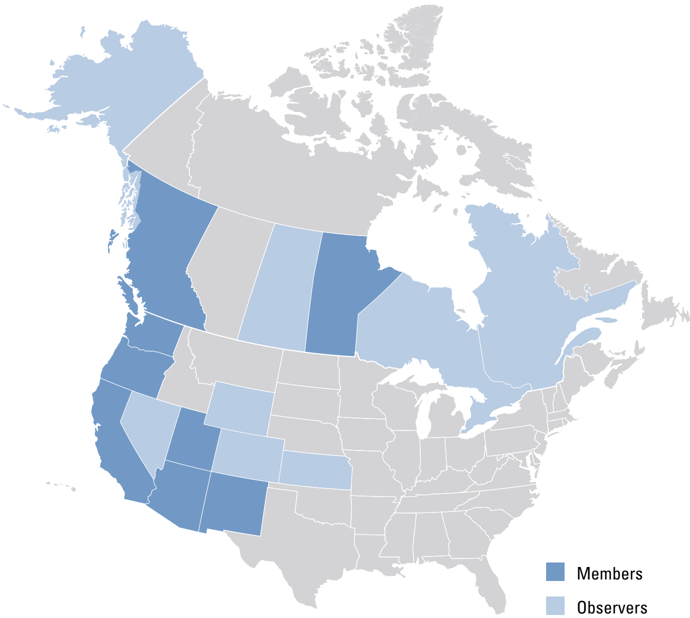
Cap and Trade Frameworks

Over a dozen states have adopted cap and trade policies restricting GHG emissions. Under the Regional Greenhouse Gas Initiative (RGGI), ten northeastern states have agreed to cap CO_2 emissions from power plants for six years, starting in January 2009. RGGI members include Maine, New Hampshire, Vermont, Connecticut, New York, New Jersey, Delaware, Massachusetts, Maryland, and Rhode Island. Between 2015 and the beginning of 2019, participating states will be required to cut CO_2 emissions from utilities by 10%.

More recently, the Western Regional Climate Initiative (WRCI) was formed (see Exhibit 16). Launched in February 2007, this program is a collaboration between the Governors of Arizona, California, New Mexico, Oregon and Washington to meet the regional challenges raised by climate change, and it calls for a regional target for reducing GHG emissions through a cap and trade program by mid-2008.[56] It also bars the importation of electricity generated out of state from coal-fired plants, and sets a goal of reducing GHG emissions by 15% from 2005 levels by 2020.[57]

EXHIBIT 16

The Western Regional Climate Initiative



Source: The Western Climate Initiative.

In addition, California has expressed interest in linking to the European carbon trading system.

Highlights: Specific Energy Technologies

Wind: The United States in 2005 ranked third in the world in installed wind capacity, with 9,150 MW of capacity in 2005. Approximately 2,500 MW of wind capacity were brought online during 2006, an increase of 27% from 2005 levels. In addition to the PTC and the ITC, wind benefits from the Modified Accelerated Cost-Recovery System, which allows businesses to depreciate certain property over a five year time horizon.

As a part of the 2005 Energy Policy Act, Congress sought to encourage greater investment in transmission infrastructure through the Renewable Energy Production Incentive (REPI). In addition, Texas, the number one wind-producing state in the country, has enacted incentives that require competitive alternative energy zones to be designated in key wind-producing areas, with the requirement that electric transmission infrastructure be constructed to move energy from these areas to the market. By providing greater predictability that installed wind energy capacity will be connected to the power grid, these measures work to increase investment in wind power.

Lastly, the President's 2007 Budget includes $44 million for wind energy research: a $5 million increase over FY2006 levels. This additional research is intended to improve the efficiency and lowering the costs of conventional wind turbine technologies. In combination with ongoing efforts to make available additional Federal land for wind energy development, this additional funding is intended to help expand the use of wind energy in the United States.

Solar: At the end of 2005, the United States had approximately 479,000 KW of total solar energy capacity. The majority of this capacity is provided by central station solar thermal-electric facilities in Southern California.

Solar energy benefits from the PTC and two ITCs: the Residential Solar and Fuel Cell Tax Credit and the Business Energy Tax Credit. These incentives help offset the high generation costs associated with solar energy. See Exhibit 3 for further detail regarding the relatively generation costs per MWh.

The Residential Solar and Fuel Cell Tax Credit establishes a 30% tax credit, up to $2,000, for the purchase and installation of residential solar electric and solar water heating technology. The Business Energy Tax Credit is also set at 30% of expenditures for solar technologies, fuel cells, and solar hybrid lighting. Solar energy also benefits from the Modified Accelerated Cost-Recovery System.

Most recently, the President's 2007 Budget proposes a new $148 million Solar America Initiative – an increase of $65 million over FY2006. The Solar America Initiative is intended for further research into the development and deployment of advanced PV materials.

At the sub-national level, over 30 states have incentives relating to solar energy. California, for example, provides more than $3 billion in solar incentives.[58]

The State of Washington provides production incentives for the development of certain renewable technologies, including solar energy. The state's production incentive offers a tax credit for the money disbursed by utilities for the development of PVs, up to the greater of $25,000 or 0.25% of the utility's taxable income. If a utility pays one dollar for the development of PV, then it can take a one-dollar tax credit against the taxes the utility would otherwise pay.

Biomass: According to the DOE, biomass is the United States' single largest existing source of non-hydro renewable electricity production. As of 2003, approximately 9,799 MW of biomass generation capacity were installed around the country.[59] Private entities that generate electricity from biomass are eligible for a PTC.

The President's 2007 Budget also increases the DOE's biomass research funding by 65%, to a total of $150 million.

Biofuels: Over the past decade, the US federal government has implemented a range of both supply- and demand-side incentives intended to increase biofuel production.

Supply-side incentives include ITCs, grants, loans and loan guarantees as well as the federal Volumetric Ethanol Excise Tax Credit (VEETC) which provides ethanol blenders/retailers with a $0.51 per gallon tax credit; and a tax credit of up to 30% of the cost of alternative refueling property, up to $30,000 for business property. Biodiesel receives a tax credit of $1 per gallon.

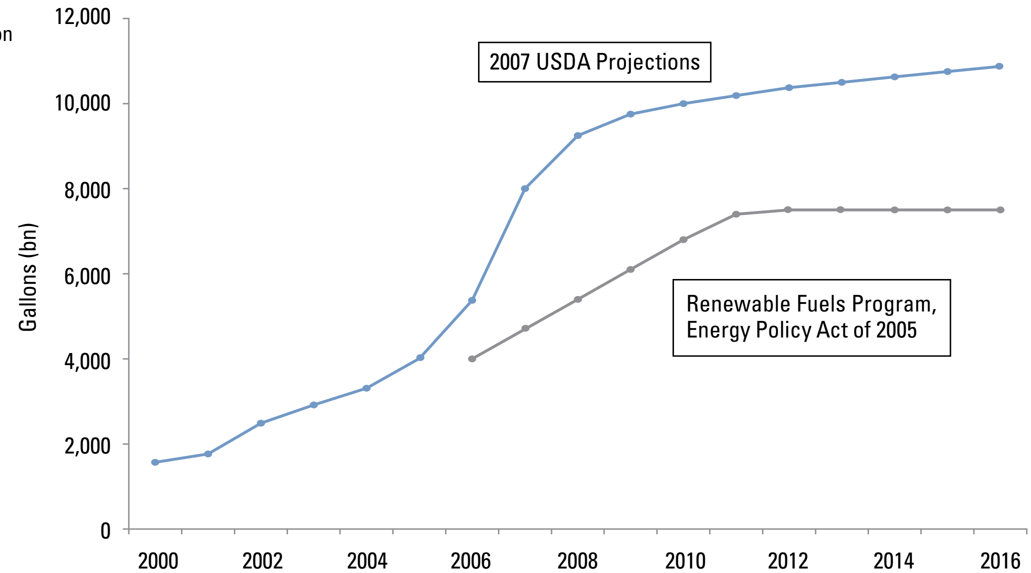
The US Department of Agriculture (USDA) and the DOE provide financial support to promote biofuels. For example, the USDA manages a program that provides grants, loans, and loan guarantees to farmers, ranchers, and rural small businesses for the development of alternative energy projects such as the construction of a biofuel plant.[60] Additionally, Title XVII of the Energy Policy Act of 2005 authorized the DOE to establish a program that allots $2 billion per year to biofuel loan guarantees.[61] A Director of the loan guarantee program was appointed in August 2007, and will manage the DOE's Loan Guarantee office, reporting directly to the DOE's Chief Financial Officer.

The major demand-side incentive is the Renewable Fuel Standard, which requires that increasing amounts of biofuels be blended with gasoline, from 4 billion gallons in 2006 to 7.5 billion gallons in 2012.[62] After 2013, at least 250 million gallons of biofuel must be cellulosic ethanol. In January 2007, President Bush set a new goal of 35 billion gallons of biofuels by 2017, and in June, the Senate raised the production mandate to 36 billion gallons by 2022.[63]

By 2006, ethanol accounted for 2.4% of the country's motor vehicle fuel use, and biodiesel accounted for 0.5%.[64] The United States is expected to surpass its existing renewable fuels target before 2012 (see Exhibit 17).

Exhibit 17

Corn-Based Ethanol Production Exceeds Renewable Fuels Mandate



Source: US Department of Agriculture, February 2007.

Nuclear: The United States has significant investment in nuclear energy. Various incentives measures are either existing or under discussion. And although no new nuclear plants have been established since 1978 (notwithstanding the recent recovery and restart of Browns Ferry Nuclear Plant Unit 1), nuclear power provides nearly 20% of the country's electricity (and 8% of the country's overall energy mix). To maintain its current capacity, however, the US nuclear industry will need to expand. Assuming that all currently operating reactors in the United States receive 20-year license renewals and no new reactors are constructed, the US fleet will cease operations by 2056.[65]

As a direct incentive, the Energy Policy Act of 2005 provides for a tax credit of 1.8 cents per kWh for up to 6,000 MW of new nuclear capacity for the first eight years of operation, or the equivalent of $125 million annually per 1,000 MW, or a total eight-year credit of up to $6 billion for 6,000 MW. This Act also provides regulatory risk insurance for utilities that is designed expressly for nuclear energy. This "standby support" insurance covers the principal and interest on debt and other costs incurred in buying supplemental power resulting from a licensing delay caused by the Nuclear Regulatory Commission (NRC) or related licensing litigation.[66] Finally, the Energy Policy Act makes new nuclear plants eligible for federal loan guarantees covering those energy projects that reduce air pollutants.[67]

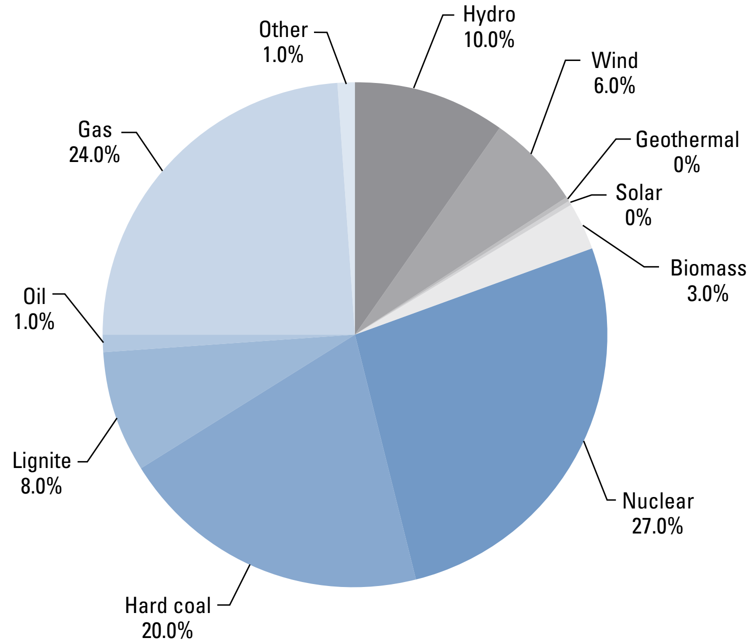
As part of a broader energy strategy, the federal government has established the Nuclear Power 2010 initiative to reduce regulatory and other barriers to the development of new nuclear power plants. As part of this strategy, the NRC is working to streamline the regulatory process, including implementing a more efficient review process. As a result, the NRC now expects 20 applications for combined construction and operating licenses for up to 30 new reactors over the next three years.[68] And in September 2007, NRG Energy announced it would ask the NRC for permission to construct two new reactors.[69]

European Union

Since 1990, the European Union has been committed to a plan to become the world leader in alternative energy production. The projected mix of total electricity output in the European Union in 2010 is outlined below in Exhibit 18, illustrating the diverse state of development of various alternative energy technologies within the EU.

Exhibit 18

European Union Energy Mix, 2010



Source: Goldman Sachs Global Investment Research, Nuclear Energy Overview, March 2007.

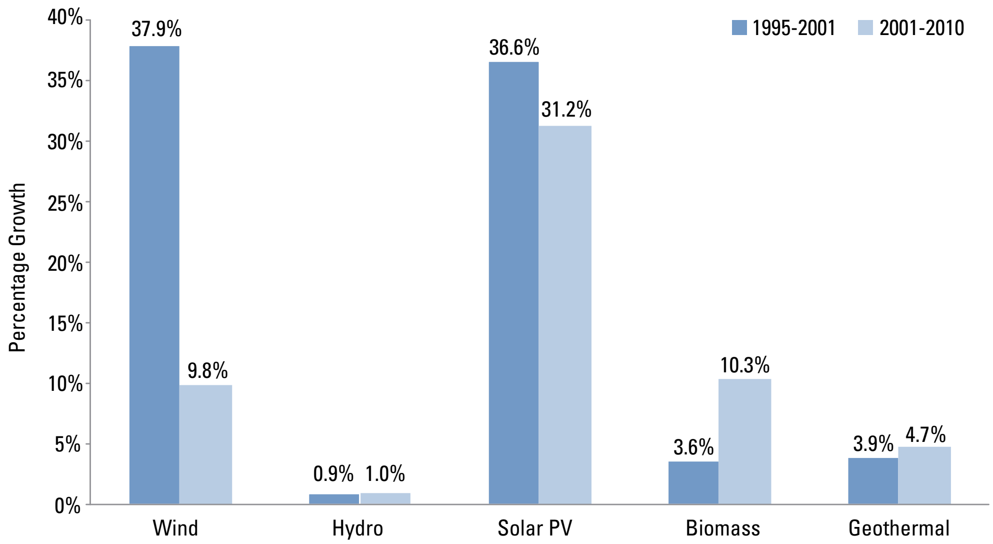
Legacy Objectives for Renewable Energy

In a 1997 White Paper, the EU suggested a target that by 2010, 12% of all energy consumption and 22.1% of electricity production (later changed to 21% through EU enlargement) should come from renewable energy sources. In 2001, the Directive on Electricity Production from Renewable Energy Sources ("RES Directive") set indicative targets for renewable energy production from individual EU member states, and also put forward ways to evaluate and support member states' progress.[70]

The goals are ambitious. A compound annual growth rate of 18.8% in the production of energy from renewable technologies is required to reach the White Paper's 2010 targets, with some energy technologies requiring far greater growth than others (see Exhibit 19).

EXHIBIT 19

Annual Growth Rates Needed to Reach White Paper Targets



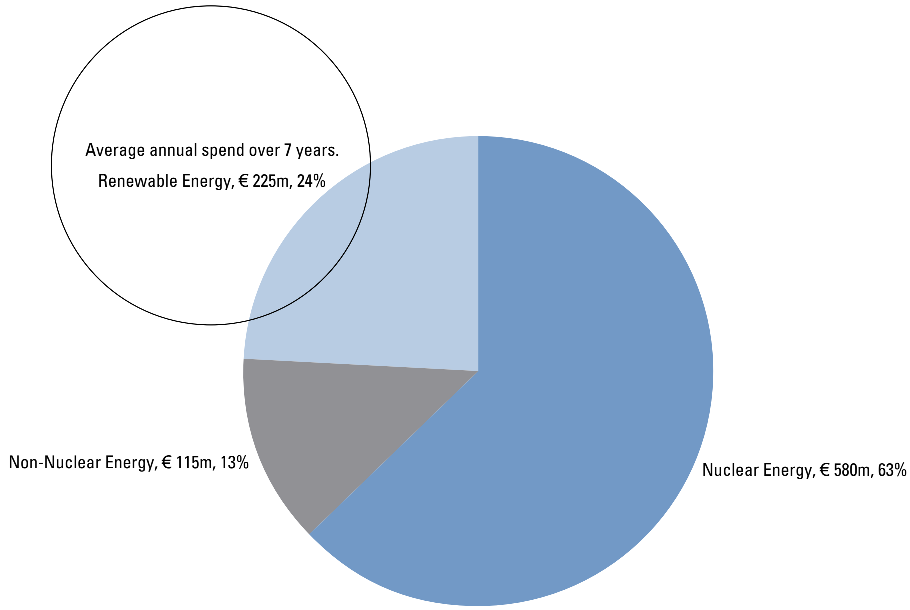
Source: European Renewable Energy Council.

Building on Alternative Energy Objectives Within the EU

In 2006, the European Parliament acted to dedicate two-thirds of the non-nuclear energy research budget toward renewable energy sources and energy efficiency (see Exhibit 20 below). These measures have helped the sector gain momentum.[71]

EXHIBIT 20

The European Union's Energy z Research Budget



Source: European Renewable Energy Council.

In January 2007, the EC proposed a Renewable Energy Roadmap as part of an overall EC Energy Package. The Roadmap suggests legally binding targets for renewable energies in the EU's overall energy mix (20% by 2020) and for biofuels in transport (10% by 2020). The Roadmap does not, however, set sector-specific targets, deferring instead to a more flexible, member state-driven approach to the promotion of renewables.

Emissions Trading: Beginning in 2005, the EU launched a cap and trade Emissions Trading Scheme, which allocates approximately 2.2 billion tons of emissions allowances annually.

Member-State Policies

The political structure of the EU means that while the EC may set overall targets for alternative energy, it is left to individual member states to develop their own implementation policies.

- Germany aims to generate 12.5% of its energy from renewable sources by 2010 and 20% by 2020.
- France is heavily focused on nuclear power to reduce carbon emissions. In addition, France recently implemented a feed-in tariff for solar PV, and plans to install 10,000 MW of wind power by 2010 and has one of the high biofuels blending targets (7%).
- In Spain, targets include 12.1% of energy consumption from renewable energy by 2010. Spain also has a 6% biofuels target for 2010.
- Italy targets generating 22% of its electricity from renewable energy sources by 2010. Italy has significant hydro/geothermal resources and it is currently reviewing wind and solar incentive plans.
- In the UK, targets include 10% of electricity generation from renewable energy sources by 2010 and 5% of transport fuels from biofuels by 2010.

Various incentives have been used by individual European member states, principally feed-in tariffs, tax credits, and subsidies.

Feed-in Tariffs: Eighteen EU member states have adopted some form of feed-in tariff. The tariffs require utilities to purchase renewable electricity at a price high enough to cover long-term costs of generating the renewable energy, thus making renewables a more attractive investment.[72] Tariffs vary by technology, plant size, and location. Member states have supplemented the feed-in tariffs with subsidies (e.g., Austria), reduced permitting requirements (e.g., Greece), and exemptions from energy taxes (e.g., Finland), but the tariffs remain the primary incentive. Exhibit 21 shows policies in various jurisdictions in Europe and elsewhere.

Exhibit 21

First Year Renewable Tariffs

Region/Country	Wind	Photovoltaics	Hydro	Biomass
	Selected First Year Renewable Tariffs in US$/kWh			
Austria	$0.101	$0.615		$0.227
Brazil	0.074		$0.052	0.065
Czech Republic	0.115	0.620		
France	0.110	0.736	0.073	0.120
Germany	0.105	0.658	0.100	0.147
Italy		0.595		
Portugal	0.106	0.381	0.110	
South Korea		0.776		
Spain	0.078	0.451	0.078	0.078
Turkey	0.067			

Source: Renewable Energy Tariffs in Europe and elsewhere, compiled by the Ontario Sustainable Energy Association.

The German government has actively employed feed-in tariffs. First enacted in 1991, they required utilities to purchase renewable power at 90% of the retail rate for electricity. The Renewable Energy Law of 2000 sets specific prices, gradually decreasing over time, that renewable electricity producers would receive. Gradual reduction of the tariffs by 5% over 20 years allows for investment security and creates incentives to reduce the costs of alternative energy.

Exhibits 22 through 24 describe tariffs supporting Germany's renewable energy industry, as set out in the Renewable Energy Law.

EXHIBIT 22

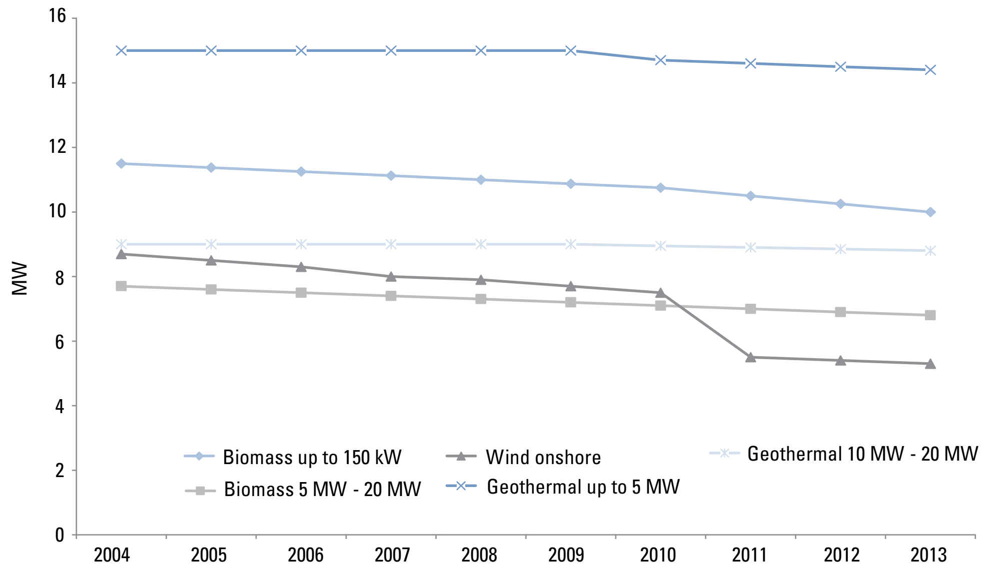
Germany's Feed-in Tariff

Biomass Tariff	A small biomass generator less than 150 kW that went online in 2004 receives approximately 11.5 cents for each kWh it feeds to the grid in Germany for a guaranteed 20 years. The same system that goes online in 2013 will only receive around 10 cents per kWh for the full 20 years. Large systems receive less compensation.
Wind Tariff	As wind turbines are already the most abundant and competitive source of renewable energy in Germany, the financial support will drop drastically in 2011. Turbines going online in 2007 will receive around 8 cents per kWh for the first four years, but only around 5.5 cents starting in 2011, when this five-year "start-up bonus" will be eliminated.
Geothermal Tariff	Since geothermal plans are still in their infancy, lawmakers and industry have given them until 2010 to attain lower prices, so the chart will reflect a steady line before a drop-off occurs in 2010. Just like the biomass tariff, the larger systems receive less compensation.
Photovoltaics	The rates for PV are by far the highest in Germany, and also the highest in the world. However, they also experience the most severe drop, at about 6.5 percent per annum. Germany calculated that PV would need as much as five times more support than wind technologies, and has designed rates accordingly.

Source: Renewable Energy Law of 2000.

Exhibit 23

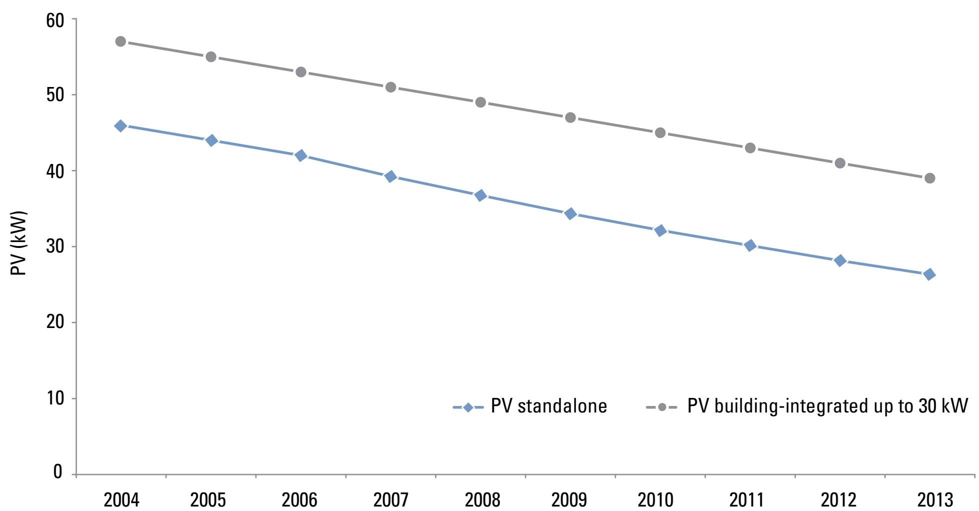
German Feed-in Tariff Rates



Source: Craig Morris, Energy Switch: Proven Solutions for a Renewable Future, May 2006.

Exhibit 24

German Photovoltaic Feed-in Tariffs



Source: Craig Morris, Energy Switch: Proven Solutions for a Renewable Future, May 2006.

Germany's feed-in tariff system and additional subsidies have helped to make the country a leader in solar and wind power.[73]

Tax Credits: Although the EU favors feed-in tariffs and targets, tax incentives are also utilized in various member states. Exhibit 25 provides examples of some existing policies.

Exhibit 25

Select Tax Incentives in EU Nations

France	"New House Tax Credit" - A tax credit for renewable energy equipment in new residences that covers 15% of eligible expenses.
Germany	"Eco-Tax Reform" - In 2002, biofuels were exempt from nationwide oil taxes until the end of 2008, thus making the fuel more competitive in the marketplace. In 2006, biofuels were again taxed, but at a lower rate than conventional gasoline or diesel. And diesel is taxed at a lower rate than gasoline.
Denmark	"Wind Energy Cooperative Tax Incentive" - Participants in a wind-energy co-operative can choose between normal taxation and a simplified model where a percentage of the production value is tax-free and the remainder is taxed at 60% of the regular tax rate.
Italy	"Tax Credit for Geothermal Energy and Biomass" - Under a 2000 law, users connected to either a geothermal or biomass-fuelled district heating grid received a tax credit equal to €20.65 per kWh of power consumed.
Sweden	"Renewables Tax Exemption" - Small-scale renewable energy- based electricity production is partially or totally exempt from the energy tax levied on households and the service sector.
United Kingdom	"Climate Change Levy" - A tax on the use of energy in industry, commerce, and the public sector, with an offsetting 0.3 percentage point cut in employers' National Insurance contributions and additional support for energy efficiency schemes and renewable sources of energy. The aim of the levy is to encourage users to improve energy efficiency and reduce emissions of GHGs.

Source: International Energy Agency, Global Renewable Energy Policies and Measures Database.

Loans, Grants and Subsidies

The EU member states employ various subsidies and loans to develop the alternative energy industry. One example of their use is in Germany.

In 1986, Germany began its 250-KW Prototype Program, which subsidized the first five wind turbines of a company after a prototype was constructed and passed trial tests. This program proved too expensive, and in 1989 the government began providing instead a subsidy of 0.08 Deutsche Marks (about $0.055) per kWh for qualifying turbines or a 60% capital investment grant for the cost of the facility.[74] In 2005, wind power installed in Germany had reached 18,430 MW, compared with slightly over 9,000 MW in the United States and less than 1,500 MW in Japan.[75]

To promote solar PV systems, the German government built on its previous programs and in 1999 instituted the 100,000 Solar Roofs Program, providing low-interest loans for the purchase and installation of PV systems. These subsidies, in addition to the feed-in tariffs discussed above, helped increase PV capacity from less than 50,000 KW installed in 1997 to over 600,000 KW installed in 2005.[76] In 2005 alone, Germany added more than 600 MW to surpass Japan in grid-connected solar PV.[77]

In biofuels, a production cost of about $2.90 a gallon and a government subsidy of $1.81 a gallon have helped German producers earn $0.42 for every gallon of biodiesel in 2006.[78]

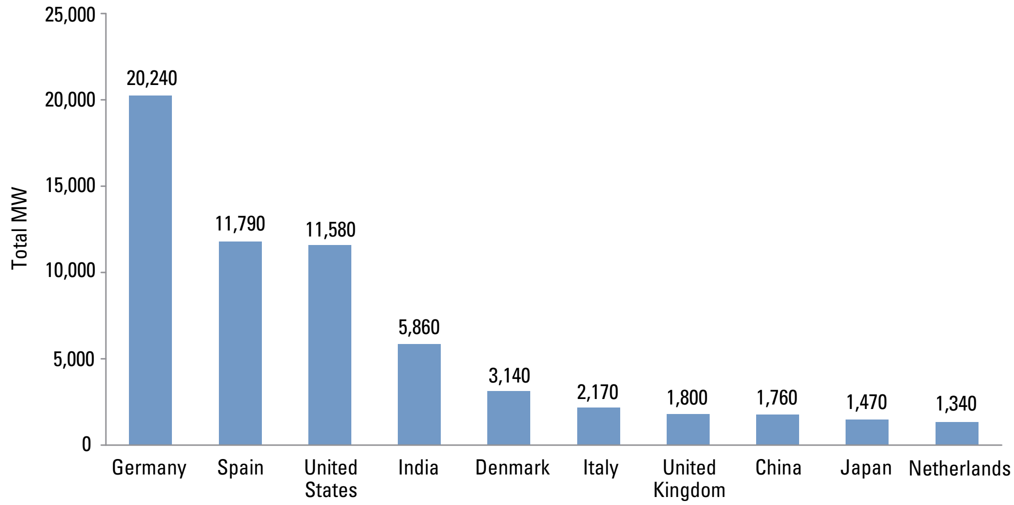
Highlights: Specific Energy Technologies

Electricity – Biomass, Wind, Photovoltaics, and Geothermal: The Roadmap predicts that Europe will miss the 21% target of total electricity produced from renewable energy sources by 2010. Instead, the EU is likely to see 19% of its electricity produced from renewable energy sources, with performance varying across sectors and among member states.

Of the various alternative energy sectors, wind has performed strongly. The leading position of European countries in the installed capacity for wind energy is illustrated in Exhibit 26.

EXHIBIT 26

Installed Wind Energy Capacity



Source: Global Wind Energy Council, 2006.

Transport – Biofuels and Biodiesel: A 2007 progress report indicates the biofuels will have approximately 4.2% of the market in 2010, shy of the EU's 5.75% target.[79] The report further indicates that by 2005, biofuels represented only 1% of the market and that only two countries (Sweden and Germany) reached the intermediate target of 2% by 2005. As a result, the EC's Energy Package proposed to renew efforts and demanded a mandatory target of 10% by 2010.

Following on the Energy Package, the EU is moving toward the mandatory blending of biofuels – with a minimum target level of B10 (i.e., all transportation fossil fuels must have a 10% biodiesel content) by 2020. The Biofuels Directive adopted in 2003 has encouraged member states to support the industry through a combination of tax breaks and blending requirements.[80] The European biodiesel market has seen substantial announcements of capacity additions, suggesting that announced new capacity could reach approximately 12 million tons per year by 2010. With 85% of world production in 2005, Europe is now the largest producer of biodiesel.[81]

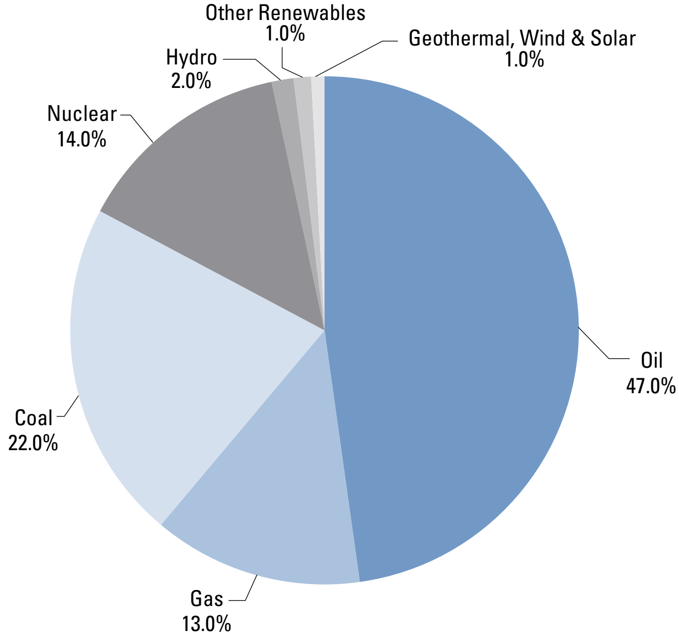
In addition to mandatory blending, Europe's agricultural policy has aided the production of biofuels. For example, the Common Agriculture Policy allows farmers to grow non-food crops on set-aside land, and this land has become one of the main sources of crop acreage for biofuels.[82]

Japan

Japan is sensitive to energy shocks because it is a highly urbanized island reliant on imports to meet most of its food and energy needs. During the 1970s, the country tried to diversify away from oil, which at the time supplied more than three-quarters of its electricity.[83] More recently, Japan has looked to alternative energy as a means of reducing carbon emissions to 1990 levels, as mandated by its Global Warming Prevention Law of 1998. While oil contributes 47% of total primary energy supply in Japan, the country had reduced its reliance on oil for electricity generation to approximately 12% by 2004. Renewables played only a minor role in the shift away from oil, which was based upon increasing the use of gas, nuclear, and coal. As of 2004, Japan generated approximately 2.2% of its electricity from non-hydro renewable resources.[84] The overall national energy mix of Japan is outlined in Exhibit 27 below.

Exhibit 27

Share of Total Primary Energy Supply in Japan, 2004



Source: IEA.

Energy Standards

In 2003, Japan instituted an RPS obligating utilities to source 1.35% of their electricity from renewable sources by 2010, and 1.6% by 2014, excluding large hydro-based sources.[85] Utilities can purchase generation from others, invest in new generation, or trade with other power companies through a certificate trading system. Every four years, the government will reevaluate utilization targets based on an eight-year window.[86] Utilities that fail to meet the standards of the RPS may be fined up to ¥1 million ($8,261, based on the prevailing exchange rate as of July 24, 2007).

Also in 2003, the government passed the Electricity Utility Law, which benefited wind producers by allowing new independent energy providers with comparatively little capacity to sell to a broader array of clients.[87]

Highlights: Specific Energy Technologies

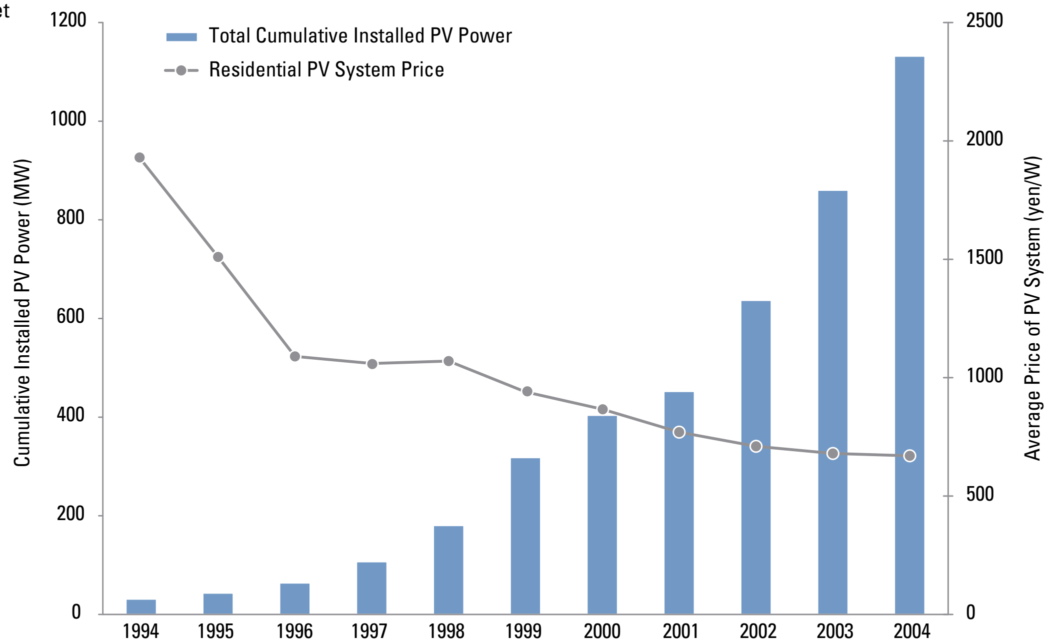
Wind: The government set a goal of 20 MW of installed wind capacity by 2000, and 600 MW by 2010 to advance the commercialization of its wind energy. As a result of both market incentives, in terms of the price paid for the output of renewable sources and in the form of capital grants towards clean energy projects, as well as the relatively long lifespan (15 to 17 years) of most power purchase agreements for renewables, Japan has seen an increase in installed wind power capacity form under 500 MW at the end of 2002 to 1,470 MW in 2005.[88]

Solar PV and Solar Thermal: Japan has achieved some success in using solar technology, although it still accounts for less than 1% of electricity generation. Japan has the second-largest solar PV capacity and third-largest solar hot-water capacity in the world.[89] It also manufactures about one-half of the world's PV technology.[90]

Beginning in 1994, the government subsidized the purchase and installation of PV systems for homeowners, homebuilders, and public organizations. Originally the subsidy covered half the cost, but as the program grew, the subsidy levels were reduced by 50%. Over the first six years of the program, more than 50,000 houses were equipped with PV systems, and by the time the subsidy ended in 2003, over 50,000 buildings were equipped during that year alone for a total of 223,000 buildings.[91] By 2004, Japan was the first country to install a GW of PV power, leading the world in installed PV capacity (see Exhibit 28), before being overtaken by Germany the following year.[92]

Exhibit 28

Photovoltaic Market in Japan



Source: Robert Foster, Japan Photovoltaics Market Overview, October 2005.

Biofuels: Because of a shortage of farm produce, Japan's ethanol production lags far behind that of the United States, Brazil, and Europe. Nevertheless, Japan plans to replace about 132 million gallons (500,000 kiloliters (kl)) of transportation fuel with biofuels by 2010.[93]

In 2006, the Ministry of Economy, Trade, and Industry introduced a new strategy to reduce fossil fuel dependence by raising the maximum percentage of ethanol mix in gasoline from 3% to 10% by 2020.[94] In 2007, the government removed the ¥53.8 per liter ($1.66 per gallon) distribution tax for ethanol blends.[95]

Japan's Ministry of Environment expects the country will only be able to meet 10% of the 132 million gallon target with domestic ethanol production.[96] Instead, Japan is importing ethanol from Brazil. In 2006, the two countries agreed that Brazil would supply 55 million gallons (210,000 kl) of sugar cane-based ethanol to Japan to be used for blends of high-octane fuel.[97]

Biodiesel production is essentially nonexistent. Although the government is considering standards for biodiesel, it has yet to set a time frame.[98]

Geothermal: Japan's volcanic activity is conducive to generating geothermal power. As of 2005, Japan ranked sixth in the world in geothermal capacity, with 535 MW in installed capacity.[99] Twenty geothermal power plants are currently in operation at 18 locations across Japan.[100] However, only one new plant has been constructed since the mid-1990s.

Brazil

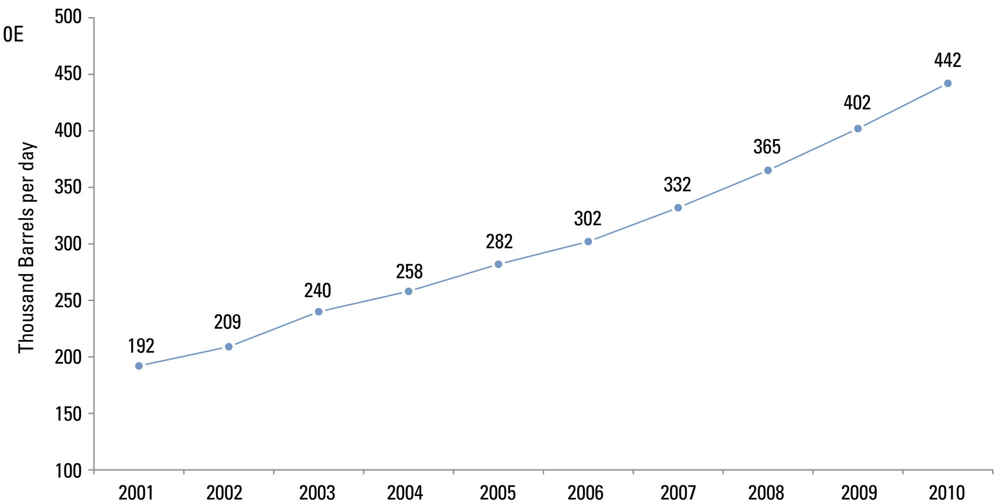
Brazil has the largest population and economy in Latin America, and is also the largest energy consumer in Latin America. Nevertheless, it has an ethanol trade surplus.[101] Brazil's sugar cane-based ethanol can be produced more efficiently and at a lower cost than the corn-based ethanol produced in the United States.

Brazil's large ethanol industry is a direct result of the oil crisis of 1973, which led the country to institute a national alcohol program ("Proálcool").[102] At the time, the country obtained 80% of its fuel from imported sources, and the economy was suffering a severe recession. In response, Brazil mandated that all gasoline be mixed with 10% ethanol.[103] Over the next five years, this percentage grew to 25%.[104] Today, more than 70% of Brazil's cars are flex-fuel.[105] It has been estimated that the government spent at least $16 billion on loans to sugar companies and price supports in the 20 years following 1979 (measured in 2005 US dollars).[106]

With gas prices again on the rise, however, Brazil's ethanol industry continues to grow, and new emphasis has recently been placed on biodiesel. The government, which started to allow B2 blending (2% blend of biodiesel fuel into petroleum diesel fuel) in 2005, will require the B2 for all diesel by 2008 and increase the mandate to 5% (i.e., B5) by 2013. See Exhibit 29 for the rise in Brazil's production of ethanol.

Exhibit 29

Brazil's Ethanol Production, 2000-2010E



Source: Brazil Ministry of Agriculture; EIA Short Term Energy Outlook; internal EIA estimates.

Renewables Regulation

In addition to the government's mandates regarding ethanol and biodiesel, the Brazilian Parliament passed legislation in April 2002 creating the Program of Incentives for Alternative Energy Sources (PROINFA).[107] Stage I mandated that 3,300 MW of renewable energy from biomass, wind, and small hydroelectric sources be grid-connected before the end of 2007 through a system of subsidies and incentives. Once the 3,300 MW objective has been met, Stage II aims to increase the share of the three renewable sources to 10% of annual electricity consumption within 20 years.

At a conference of World Bank officials, PROINFA was praised as offering "clear and stable regulatory frameworks, guaranteed 20-year power purchase contracts with the national utility ELECTROBRAS, and favorable financing terms with the Brazil National Development Bank (BNDES) of 20% equity, 80% debt, and 12-year financing." ELECTROBRAS purchases energy at preset preferential prices and then markets the renewable electricity. The subsidies and incentives granted under PROINFA are drawn from an Energy Development Account funded by end-use consumers through an increased energy bill. Low-income individuals are exempt from this increase.[108] The program is expected to create 150,000 jobs (direct and indirect), US$3.8 billion in total investment, diversification of producers and sources of energy, and estimated avoided emissions of 2.8 million metric tons of CO_2 per year.[109]

As of April 2006, only 37 of the 144 projects approved under PROINFA were under construction and scheduled to come online before the December 31, 2007, deadline.

India

India is currently the world's fifth-largest consumer of energy, accounting for 3.7% of worldwide energy consumption. Based on current growth projections, India is expected to overtake Japan and Russia and become the third-largest consumer of energy by 2030.[110]

India faces the challenge of meeting a rapidly rising energy demand with limited energy supply. To eradicate poverty and meet its economic and human development goals, India's economy needs to sustain an 8% to 10% growth rate by 2030. To realize this level of economic growth, however, India would need to grow its primary energy supply by 3 to 4 times and electricity supply by 5 to 7 times today's consumption. While the country's demand for oil alone is expected to increase at an average rate of 2.9% annually over the next 25 years, India has only 0.4% of the world's proven oil reserves.

Coal accounts for more than half of primary commercial energy consumption and oil accounts for nearly one-third.[111] At present rates of consumption, the country is projected to run out of coal within the next 40 years. Moreover, limited domestic reserves of oil and natural gas increase the importance of developing an effective alternative energy strategy.[112]

Importance of Alternative Energies

Given these limited domestic resources of conventional energy and the increasing cost of importing energy, alternative energy resources may play an important role in India's energy mix going forward.[113] Exhibit 30 charts the projected change, and demonstrates that excluding biomass, renewables comprise approximately 2% of the country's overall energy mix.*

** Biomass energy in India includes energy obtained from burning wood and forest products. Given the environmental impact of these processes, biomass is kept out of the renewables mix for the purposes of this subsection.*

Exhibit 30

Fuel-Mix in 2001-02 and Scenario for 2021-22

	2001-2002		2021-2022	
	MMTOE (tons of energy (mm)	%	MMTOE (tons of energy (mm)	%
Fossil Fuel-Total	285.8	65.3%	595	66.9%
Coal	151.6	34.6	250	28.1
Oil	107.5	24.6	220	24.7
Gas	26.7	6.1	125	14
Alternative Energy – Total	151.9	34.7	295	33.2
Nuclear	5.2	1.2	20	2.3
Renewable – Total	146.7	33.5	275	30.9
Hydro	7.6	1.7	30	3.4
Biomass	139	31.8	238	26.7
Solar	0	0	—	0
Wind	0.1	0	2	0.2
Biofuel	0	0	5	0.6
Total	438	100%	890	100%

Source: New and Renewable Energy Policy Statement, 2005.

Public Policy

Instead of a central ministry of energy (which was in place before 1992), various ministries and independent departments address energy issues at the federal level. Energy policy is also made at the state level, and the diffuse nature of India's energy policy-making presents a unique coordination challenge. In response to challenges to public policy-making, the prime minister set up the Energy Coordination Committee (ECC) in July 2005. The ECC is mandated to coordinate the government's policy response and address India's energy security concerns.[114]

India's Electricity Act of 2003 endeavored to catalyze the development of power generation from alternative sources to diversify the power supply. As a result, individual states are now requiring power distributors to purchase power generated from alternative sources.[115] In Karnataka, 5% to 10% of power must be derived from alternative sources. Maharashtra, Orissa, and Gujarat have also adopted renewables mandates.[116]

Most recently, the government has set out a "New and Renewable Energy Policy Statement 2005." This statement envisions requiring India to pursue all available fuel options and forms of energy, both conventional and non-conventional and from new and emerging technologies.

Highlights: Specific Energy Technologies

Wind: India already has one of the largest installed wind capacities globally. India was the world's fourth-largest producer in 2005, with a total installed capacity of 4,430 MW.[117] 2005 estimates project that an additional 3,000 MW of additional capacity of wind energy will be installed by 2007.[118]

Solar: India is considered to have one of the largest solar energy programs in the world. With approximately 300 sunny days each year, India has the potential to realize significant gains from solar energy.[119]

Biofuels: Indian energy policy is giving new attention to the role of ethanol in alleviating demand pressure on oil. As a result of policies encouraging investment in ethanol production plants, for example, ONGC-Mittal Energy Limited has established an ethanol refinery in which it has offered equity to Petrobras.[120] One-third of Indian states have used a 5% ethanol blend since 2004, and the government has recently announced plans for all refineries to produce such a blend.[121]

In legal proceedings, New Delhi and other cities have been ordered by the courts to use compressed natural gas (CNG) in public transportation, replacing diesel-fueled buses.[122]

There is also great deal of interest in Jatropha curcus, a type of shrub used in the production of biodiesel. The government is supporting a $10 million biodiesel production facility in the city of Mysore by making land available for the project, among other incentives. This facility is projected to produce 10 million liters per year of biodiesel made from Jatropha curcus.[123] In addition, there is a government proposal to cultivate 11 million hectares of Jatropha curcus to facilitate the production of biodiesel.[124]

Nuclear: The government is moving ahead with various plans to increase the country's nuclear energy capacity. The potential for development is underscored by a recent nuclear compact agreed between President George W. Bush and Prime Minister Manmohan Singh, allowing the sale or transfer of nuclear technology, equipment, and materials for India's civilian nuclear program. Based on this agreement, and anticipating various other international agreements, the prime minister has doubled the nuclear energy production target to 40,000 MW. Aiming for 25 to 28 more reactors, officials project a $40 billion investment in nuclear reactors over the next 15 years.[125]

China

China's energy demand is less than 10% of the world's total, but this share is quickly rising. Its oil market is now the second-largest in the world, and in less than 15 years, China has gone from energy self-sufficiency to importing one-half of its total energy supply.[126] Its focus on alternative energy is likewise increasing as its energy demands rise. In 2005, China had the world's largest total investment in alternative energy sources (excluding large scale hydropower plants), with expenditures of $6 billion dollars.[127]

To date, China's laws supporting investments in renewable energy have been focused on capacity targets, low interest loans and tax incentives. China's Renewable Energy Law became effective on January 1, 2006, with 17 proposed initiatives, including preferential tax treatment and subsidies. Pursuant to the Renewable Energy Law, China has committed to increase its alternative energy to 15% of the country's energy mix by 2020, and to invest approximately RMB1.5 trillion in renewable energy over that period.[128] Among other policy tools, feed-in tariffs have been incorporated and – where applicable – the grid operator must purchase all electricity produced by alternative energy generators that hold government permits.

In addition, the Renewable Energy Development Fund Proposal became effective in May 2006, and includes voluntary reimbursement as well as low interest short-term loans for the development of renewable energy. The updated targets for renewable energy in total power generation are 10%, 16%, and 30% for 2010, 2020, and 2040, respectively, up from 7.5% in 2005.[129]

More recently, in September 2007, the National Development and Reform Commission implemented the National Medium- and Long-Term Program for Renewable Energy (MLPRE), with the aim to raise consumption of electricity from renewable sources to 10% and 15% of total electricity consumption by 2010 and 2020, respectively, up from 7.5% in 2005. The government policy incentives will be introduced in the form of tax preferences and lending with interest subsidies. As it relates to prior legislation, the MLPRE provides a more detailed framework for the Renewable Energy Law.

Three state agencies – the Ministry of Science and Technology, the State Development and Planning Commission, and the State Economic and Trade Commission – are most actively involved in renewable energy development. Together, they have set major targets for fuel wood plantations, solar energy, wind power capacity and small hydro development. Besides these programs, the GEF/World Bank funds a program in China supporting the development of the wind and solar sectors, in addition to developing the business and project management skills of practitioners in the renewable energy field in China.

6 Conclusion

Public policy makers, industry, rate-paying customers and other stakeholders throughout the world are increasingly viewing renewable energy as an important component of strategies aimed at addressing the challenges associated with energy production and use. The principal challenges include the tradeoff between economic growth, environmental impacts, and national security. Driven by these combined pressures, a number of energy policies put in place around the world during the last decade have helped the renewable energy industry to grow significantly. Because most renewable energy technologies are not yet, in most regions, able to compete economically with fossil fuels, they will have to be supported by public policy interventions if renewable energy is to play a real near-term role in energy policy. Public policies are currently necessary to reduce the costs and improve the investment environment to enable significant and long-term growth in the use of renewable energy.

As illustrated by this paper, there is no single or best solution to the challenge of encouraging the use of renewable energy. Rather, picking the most effective options will depend on the specific conditions of each region and market, as well as the particular characteristics of each type of renewable energy. There are, however, a range of available policy options that have been tested in various places around the world. That base of experience should prove helpful for policy makers who wish to expand the use of renewable energy.

Glossary of Terms

BNDES: Brazilian National Development Bank.

BRICs: Brazil, Russia, India, and China make up a commonly discussed group of bourgeoning economies.

CAGR: a Compound Annual Growth Rate.

CO_2: Carbon dioxide.

DOE: United States Department of Energy.

EC: The European Commission; the Executive Branch of the European Union.

ECC: The Energy Coordination Committee in India; was created in July 2005 by the Prime Minister to coordinate the government's policy response and address India's energy security concerns.

EPA: Environmental Protection Agency.

ETS: Emissions Trading Scheme.

GEF: Global Environment Facility.

GHG: Greenhouse Gas emissions; pollution.

IBRD: International Bank for Reconstruction and Development.

IDA: International Development Association.

IEA: The International Energy Agency.

ITC: Investment tax credits; provide credits based on the amount of money invested in a project.

KGOE: KG (Kilogram) of oil equivalent.

kWh: Kilowatt hour; the unit by which energy consumption is measured.

MIGA: Multilateral Investment Guarantee Agency.

MLPRE: National Medium- and Long-Term Program for Renewable Energy, implemented in September 2007 by the National Development and Reform Commission.

MMTOE: Million tons of energy.

NIMBY: ''Not in my backyard"; the credo of citizens opposing a city's or a company's plan to install a factory, for example, in their community.

NRC: The Nuclear Regulatory Commission; it is working to improve and streamline the regulatory process to help catalyze the construction of nuclear plants in the United States.

OFGEM: The British Office of Gas and Electricity Markets; it requires suppliers to produce evidence of their compliance via Renewable Obligation Certificates.

OSEA: Ontario Sustainable Energy Association.

PPP: Purchasing Power Parity; the method of using the long-run equilibrium exchange rate of two currencies to equalize the currencies' purchasing power.

PROINFA: The Program of Incentives for Alternative Energy Sources; a policy created by the Brazilian Parliament in April 2002 to encourage usage of alternative energy.

PTC: Production tax credits; they provide credits based on the amount of energy produced each year.

PV: Photovoltaic Solar Energy; Solar PV utilizes silicon PV cells to produce energy generation. When light is absorbed by a solar cell, electrons are released and move according to the internal electric potential, and create energy.

REC: Renewable Energy Credits; they are a facet of RPS that are tradable certificates showing that one kilowatt hour of electricity has been generated by a renewable energy source.

REPI: Renewable Energy Production Incentive, of the 2005 Energy Policy Act.

RFS: The Renewable Fuels Standard; it mandates the use of an increasing volume of biofuel in the United States.

RO/ROC: Renewables Obligation/Renewables Obligation Certificate; a government-issued rule that suppliers must produce evidence that they derive a predetermined proportion of their power from renewable energy sources.

RPS: Renewable Portfolio Standards; they are prevalent in various US states and Japan. They require that a certain percentage of a utility's overall or new generating capacity or energy sales be derived from renewable resources in a certain year.

TW/GW/KW: Tera-Watt, Giga-Watt, Kilo-Watt, unit measures of energy; 1012 watts, 1 billion, and 1,000 watts, respectively.

UNDP: United Nations Development Programme.

UNEP: United Nations Environment Programme.

USDA: United States Department of Agriculture.

VEETC: The Volumetric Ethanol Excise Tax Credit in the United States; provides ethanol blenders/retailers with $0.51 per gallon tax credit, and a tax credit of up to 30% of the cost of alternative refueling.

WRCI: Western Regional Climate Initiative, launched in February 2007.

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