



# China and the United States—A Comparison of Green Energy Programs and Policies

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## Summary

China is the world's most populous country with over 1.3 billion people. It has experienced tremendous economic growth over the last three decades with an annual average increase in gross domestic product of 9.8% during that period. This has led to an increasing demand for energy, spurring China to add an average of 53 gigawatts (GW) of electric capacity each year over the last ten years to its power generation capabilities.

China essentially functions as a “command and control” economy. The national government owns or controls many of the country's industries and enterprises, and sets goals for economic development in the periodic Five Year Plans. China's industries and enterprises are expected to comply with the goals set in the national government's economic plan. China has set ambitious targets for developing its non-hydropower renewable energy resources with a major push of laws, policies, and incentives in the last few years. The wind power sector is illustrative of China's accomplishments, as installed wind power capacity has gone from 0.567 GW in 2003 to 12.2 GW in 2008. Plans already exist to grow China's wind power capacity to 100 GW by 2020. A similar goal exists for the solar photovoltaic power sector which China intends to increase generating capacity from 0.14 GW as of 2009 to over 1.8 GW by 2020. China recognizes that given the growing demand for energy at home, developing its domestic renewable energy industry and building manufacturing capacity can lead to advantages in future export markets.

However, energy efficiency and conservation are officially China's top energy priority. These are considered the “low-hanging fruit” in the quest to reduce energy use and cut demand. Energy conservation investment projects have priority over energy development projects under the Energy Conservation Law of 1997, with government-financed projects being selected on “technological, economic and environmental comparisons and validations of the projects.”

The key piece of legislation in recent years for advancing renewable electricity in China is the Renewable Energy Law of 2005. The law was designed to “promote the development and utilization of renewable energy, improve the energy structure, diversify energy supplies, safeguard energy security, protect the environment, and realize the sustainable development of the economy and society.” Renewable energy is subsidized by a fee charged to all electricity users in China of about 0.029 cents per kilowatt-hour (kwh). The fee was originally based on the incremental difference between coal and renewable energy (estimated in China at \$0.044 to \$0.059 per kwh), and goes to the companies which operate the electricity grid and must buy renewable power from project developers.

In contrast, the United States has largely a market-driven economy. Some argue that the United States does not have a comprehensive national policy in place for promotion of renewable energy technologies, with some observers saying that the higher costs of renewable electricity are not conducive to market adoption. However, the reasons for increasing the use of renewable energy are diverse, and include energy security, energy independence, cleaner air, and more recently anthropogenic climate change, sustainability concepts, and economic development. Such goals could reasonably be said to apply both to the United States and China. Pending legislation in the 111<sup>th</sup> Congress contains provisions which could serve to increase power generation from renewable energy by establishing market drivers (such as a national renewable electricity standard) which could catalyze U.S. renewable electricity development.

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## Introduction

China is the world's most populous country with over 1.3 billion people.<sup>1</sup> It has experienced tremendous economic growth over the last three decades with an average annual increase in gross domestic product (GDP) of 9.8% during that period.<sup>2</sup> This rapid economic growth has led to an increasing demand for energy, spurring China to add an average of 53 gigawatts (GW) of electric capacity each year over the last ten years to its power generation capabilities.<sup>3</sup>

China is also the world's largest producer and consumer of coal, with about half of its coal use being for electricity generation. In fact, coal provides over 70% of China's current electricity needs, and fuels much of the new power generation capacity being built.<sup>4</sup> While many of these new coal plants are among the most technically advanced in the world,<sup>5</sup> the burning of coal results in sulfur dioxide, nitrogen oxides, and particulate emissions which contribute to air pollution, and greenhouse gas<sup>6</sup> emissions linked to global climate change.<sup>7</sup> The potential environmental consequences of burning coal are a major reason China has been actively seeking to increase its renewable energy<sup>8</sup> capabilities. Limited domestic reserves of coal, natural gas, and oil (when current rates of use are considered) provides another impetus. However, China's announced intent to rely on domestic, sustainable solutions for its growing energy needs has led to a focus on developing "green" or renewable energy resources, an area in which China has great promise.<sup>9</sup>

China has set ambitious targets for developing its non-hydropower renewable energy resources with a major push of laws, regulations and incentives in the last few years. The wind power sector is illustrative of China's accomplishments, as installed wind power capacity has gone from 567 megawatts (MW) of in 2003 to 12,200 MW in 2008. Plans already exist to grow China's wind power capacity to 100 gigawatts (GW) by 2020. A similar goal exists for the solar photovoltaic (PV) power sector which China intends to increase capacity from 140 MW as of 2009 to over 1.8

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<sup>1</sup> Xinhua News Agency, *China to Keep Population Below 1.37b by 2010*, January 7, 2006, <http://www.china.org.cn/english/2006/Jan/154423.htm>.

<sup>2</sup> Roger Ballentine, *China Offers Tips on Using Energy More Efficiently*, Renewable Energy World.com, February 23, 2009, <http://www.renewableenergyworld.com/rea/news/article/2009/02/energy-efficiency-tips-from-china-54611>.

<sup>3</sup> EIA

<sup>4</sup> U.S. Energy Information Administration, *China Energy Data and Statistics*, July 2009, <http://www.eia.doe.gov/emeu/cabs/China/Background.html>.

<sup>5</sup> About 60% of China's new coal plants have a fuel conversion to energy efficiency of about 44%, as compared to the most efficient coal plants in the United States with an efficiency of about 40%. Keith Bradsher, *China Outpaces U.S. in Cleaner Coal-Fired Plants*, New York Times, May 10, 2009, [http://www.nytimes.com/2009/05/11/world/asia/11coal.html?\\_r=1](http://www.nytimes.com/2009/05/11/world/asia/11coal.html?_r=1).

<sup>6</sup> Greenhouse gases are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

<sup>7</sup> National Research Council, *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*, October 19, 2009, [http://www.nap.edu/catalog.php?record\\_id=12794#toc](http://www.nap.edu/catalog.php?record_id=12794#toc).

<sup>8</sup> Renewable energy resources are defined by the U.S. Department of Energy as energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include biomass, hydro, geothermal, solar, wind, ocean thermal, wave action, and tidal action. See [http://www.eia.doe.gov/glossary/glossary\\_r.htm](http://www.eia.doe.gov/glossary/glossary_r.htm).

<sup>9</sup> Jianxiang Yang, *China Speeds Up Renewable Energy Development*, Global Environmental Institute, October 26, 2006, <http://www.worldwatch.org/node/4691>.

GW by 2020.<sup>10</sup> Developing its domestic renewable energy resources also provides a growth opportunity for China's domestic renewable energy technology industries, and can serve to increase its domestic manufacturing capabilities.

This report will look at the laws, programs, and policies encouraging development of wind, solar, and biomass power in China and the United States as the major renewable energy technologies common to both countries. While hydropower is the most developed source of renewable energy in both China and the United States, additional development of conventional hydropower is not a major focus of U.S. or China's renewable energy policy and will not be featured in this discussion. The terms "green" and "renewable" energy are used interchangeably for purposes of this report.

## **Existing Laws, Programs, and Incentives**

Government incentives in the United States and China for renewable energy projects encompass a set of tools which generally depend on where a particular project is on a product development cycle. For example, direct subsidies are more often applied earlier in the timeline of research and development (R&D) projects, while tax incentives are generally made available later in a cycle to aid manufacturing ventures or to encourage consumers to adopt the technologies and help to build demand.

### **China<sup>11</sup>**

As a centrally planned economy with most companies in the energy sector being owned or managed by the national government, China is able to have a direct impact on the development and adoption of clean energy technologies. Most of the large industries in China (such as steel, petrochemicals, and power generation) are comprised of state-owned enterprises which are essentially run by the national government.

There are five power generation companies in China: Huaneng, Guodian, Datang, Huadian, Zhongdiantou. Two utility grid companies exist—the State Grid Corporation covering the 22 provinces in northern and western China, and the Southern Power Grid in the five provinces in southern China. For many years, the National Development and Reform Commission (NDRC) was the regulatory body in China with control over energy prices and project approval, and control over China's renewable energy development. As a result of recent reforms, energy policy strategy in China is now guided at the highest levels by the National Energy Commission (NEC) which is chaired by China's Premier Wen Jiabao.<sup>12</sup>

Large scale investment in clean energy technologies is a relatively recent undertaking for China, with air pollution concerns prompting the first forays into clean energy development. More recent attention to mitigating the perceived effects of global climate change have provided additional

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<sup>10</sup> Xinhua News Agency, *China to significantly raise its renewable energy targets*, May 5, p. 2009, <http://www.energy-enviro.fi/index.php?PAGE=2584>.

<sup>11</sup> Official Chinese government (English language) source documents are used when possible. Amounts quoted in dollars use currency conversions in reference documents, and are not adjusted for time-value of money.

<sup>12</sup> China Wind Power Center, *Wind Power Policy*, 2010, <http://www.cwpc.cn/cwpc/en/node/6547>.

momentum. Policies for encouraging renewable energy in China are largely driven by the central government, and enacted through national and provincial and local government programs. China led the world in 2009 in renewable energy investment, spending \$34.6 billion, with the United States second in clean energy spending, investing \$18.6 billion.<sup>13</sup>

## **Clean Energy Research and Development Programs<sup>14</sup>**

A series of programs promoting research and development of renewable energy technologies were established by China in the last quarter of the past century under the Ministry of Science and Technology. These included the following:

**Key Technology R&D Program:** Initiated in 1982 to address major science and technology issues in economic and social development, this was China's first national R&D program supporting innovation for environmental pollution control and efficient resource utilization for energy and water. Almost \$1 billion was invested between 2001 and 2005.<sup>15</sup>

**863 Program:** Known more formally as the "National High-Tech Development Plan," the 863 Program was created in March 1986 to develop a wide range of technology fields. The program focuses on boosting innovation in strategic high technology sectors so that China can gain a foothold in world markets. Its initial objective was to make China independent of financial obligations for foreign technologies, and diversification of research efforts away from purely military themes to civilian and dual-use technologies such as satellites, computers, robotics, biotechnology, energy, and space exploration. The program invested \$3 billion in research from 2001 to 2005, and another \$585 million was approved in 2008 jointly for the 863 and 973 R&D programs.<sup>16</sup>

**973 Program:** The National Basic Research Program focuses on fundamental, basic research and thus complements the 863 Program. Energy and sustainable development have been key features of the 973 Program since its founding at the third meeting of the National Science and Technology Committee in 1997. The program funded 382 projects between 1998 and 2008, with a total investment of \$1.3 billion.<sup>17</sup>

**Five Year Plans:** The 10<sup>th</sup> Five Year Plan (for 2001 to 2005) budgeted \$2.4 billion for the implementation of 12 "mega-projects" based on the 863 and National Key Technologies Programs aimed at achieving significant technological breakthroughs for China's industries. The 11<sup>th</sup> Five Year Plan (for 2006 to 2010) identifies energy technologies as a focus of the 863 Program, with hydrogen, fuel cells, energy efficiency, clean coal and renewable energy focus of \$172 million in funds. The 11<sup>th</sup> Five Year Plan has also made utility-scale renewable energy and new energy development the 973 Program's main focus.<sup>18</sup>

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<sup>13</sup> Pew Charitable Trusts, *Who's Winning the Clean Energy Race?*, March 2010, [http://www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Reports/Global\\_warming/G-20%20Report.pdf?n=5939](http://www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Reports/Global_warming/G-20%20Report.pdf?n=5939).

<sup>14</sup> [http://www.most.gov.cn/eng/programmes1/200610/t20061009\\_36224.htm](http://www.most.gov.cn/eng/programmes1/200610/t20061009_36224.htm).

<sup>15</sup> Center for American Progress, *Out of the Running?*, March 2010, [http://www.americanprogress.org/issues/2010/03/pdf/out\\_of\\_running.pdf](http://www.americanprogress.org/issues/2010/03/pdf/out_of_running.pdf). (CAP).

<sup>16</sup> CAP.

<sup>17</sup> CAP.

<sup>18</sup> "The Five-Year Plan for National Economic and Social Development, or the Five-Year Plan, mainly aims to arrange national key construction projects, manage the distribution of productive forces and individual sector's contributions to (continued...)"

The Five Year Plans are the guide to China's economic growth. Renewable energy is increasingly being linked to China's future wellbeing—both economically and environmentally. The next Five Year Plan will encompass 2011 to 2015, and will likely further formalize the link to green energy with deployment goals and investment.

## **Key Legislation Promoting Renewable Energy**

Renewable energy had been encouraged by a number of early laws in China, but these were intended more for rural development in distributed generation schemes. Many laws governing renewable energy do not have a lot of details prescribing how the legislation should be implemented. The laws generally state goals or what has to be accomplished, and lay out a framework. The details on how goals will be achieved are determined later, usually by the NDRC.

The main law governing China's power industry is the **Electricity Law of 1995**.<sup>19</sup> It was the first law to place legislative controls on the utility industry, centralizing control of existing regulatory agencies and restructuring state-owned electricity companies. The law was designed to promote the safe development of the electricity industry, and identified renewable energy as a means to develop electrification especially in rural areas.<sup>20</sup>

The **Energy Conservation Law of 1997** was enacted by the Standing Committee of the National People's Congress to guide the use of energy resources, promote energy-saving technologies, and protect the environment. The General Provisions state that "Energy conservation is a long-term strategy for national economic development," and the "state shall encourage and support research and popularization in the science and technology of energy conservation." While energy development and conservation are both being pursued, energy conservation investment projects are given priority over energy development projects under Article 10, with projects under the central government being selected on "technological, economic and environmental comparisons and validations of the projects." Article 11 then directs the State Council and provincial governments to "allocate energy conservation funds from both capital construction and technological restructuring investment funds to support rational energy utilization and development of new and renewable sources of energy." Article 38 of the Law requires government "at all levels" to utilize renewable energy resources sustainably, especially for rural areas. Article 39 focuses on improving energy efficiency in a variety of applications:

The State encourages the development of the following universal energy conservation technologies: (1) promote the wide use of cogeneration of heat and power and district heating, increase the utilization rate of heat and power units, develop heat-cascading technology, combined heat, power and cooling technology and combined heat, power and coal gas technology, and increase the efficiency of thermal energy application in an all-round way; (2) gradually achieve more-efficient operation of electric motors, fans, pumping equipment and systems; develop adjustable speed motor drives for energy conservation and electric-electronic power saving technology; develop, produce and disseminate the use of high-quality and low-cost energy-efficient appliances and equipment; and increase the

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(...continued)

the national economy, map the direction of future development, and set targets." See [http://english.gov.cn/2006-04/05/content\\_245556.htm](http://english.gov.cn/2006-04/05/content_245556.htm).

<sup>19</sup> See <http://fpc.org.uk/fsblob/448.pdf>.

<sup>20</sup> Article 48. See <http://www.lehmanlaw.com/resource-centre/laws-and-regulations/environment/electric-power-law-of-the-peoples-republic-of-china-1996.html>.

efficiency of electric power; (3) develop and disseminate the use of clean coal technologies, including fluidized bed combustion, smokeless combustion, and gasification and liquefaction, that are suited to domestic coals in order to increase coal utilization efficiency; and (4) develop and disseminate other universal energy-efficient technologies that are proved mature and yield remarkable benefits.

Article 40 directs all trades and professions to seek and disseminate energy-efficient technologies or solutions, and to replace outdated technologies and equipment.<sup>21</sup>

The Energy Conservation Law is generally written to consider sustainability while feeding the growth of the economy. Conservation and energy efficiency measures are seen as ways to lower the financial and environmental costs of funding China's growing economy. Demand-side management is also a key feature of China's 2007 Climate Change Program<sup>22</sup> in reducing the energy intensity<sup>23</sup> of the economy through:

... the development of specific energy conservation plans, the adoption and implementation of technology, economic, fiscal and management policies in favor of energy conservation, the development and application of energy efficiency standards and labeling, the encouragement of R&D, demonstration and diffusion of energy-saving technologies, the importing and absorbing of advanced energy-saving technologies, the creation and employment of new energy conservation mechanisms, and the promotion of key energy conservation projects.<sup>24</sup>

China's 11<sup>th</sup> Five Year Plan requires state-owned enterprises to reduce energy intensity by 20% overall from 2005 levels. Meeting this goal may prove to be a huge challenge. Although China has been able to reduce energy intensity 14.4% from 2005 to 2009, there has been an increase of 3.2% in energy intensity during the first quarter of 2010.<sup>25</sup>

China's **Law for Prevention and Control of Air Pollution of 2000** also looks to renewable energy as a means of preventing atmospheric air pollution. The law encourages the support and development of clean energy technologies for "solar energy, wind energy and water energy."<sup>26</sup>

However, the key piece of legislation in recent years for moving renewable energy deployment forward is the **Renewable Energy Law of 2005**.<sup>27</sup> The Law was based on goals to "promote the development and utilization of renewable energy, improve the energy structure, diversify energy supplies, safeguard energy security, protect the environment, and realize the sustainable development of the economy and society." The law has several key elements:

- Allows for middle and long-term national targets to be set for the total volume of renewable energy development (Article 7);

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<sup>21</sup> See <http://www.china.org.cn/english/environment/34454.htm>.

<sup>22</sup> See <http://www.china.org.cn/english/environment/213624.htm>.

<sup>23</sup> Energy intensity as consumption per unit of gross domestic product.

<sup>24</sup> National Development and Reform Commission of China, *National Climate Change Program*, June 4, 2007, <http://www.china.org.cn/english/environment/213624.htm>.

<sup>25</sup> XinHua News, *Stick to Energy Goals*, May 7, 2010, [http://news.xinhuanet.com/english2010/indepth/2010-05/07/c\\_13281612.htm](http://news.xinhuanet.com/english2010/indepth/2010-05/07/c_13281612.htm).

<sup>26</sup> Article 9. See <http://www.china.org.cn/english/environment/34422.htm>.

<sup>27</sup> See [http://www.renewableenergyworld.com/assets/download/China\\_RE\\_Law\\_05.doc](http://www.renewableenergyworld.com/assets/download/China_RE_Law_05.doc). (RELaw)



- Mandates connection with the grid and the purchase of electricity from licensed renewable energy generators (Article 14);
- Makes available preferential loans with subsidized interest rates (Article 25), and granted tax benefits (Article 26) for renewable energy projects.

While under the provisions of the Law, the “energy authorities of the State Council” are to implement its provisions both locally and nationally, the NDRC developed a **Medium and Long-Term Development Plan for Renewable Energy** (MLTPRE) in 2007 to implement the law. The MLTPRE established national deployment goals by technology to reach renewable energy as shown in **Table 1**. The “Guiding Principles” of the MLTPRE state that it focused on hydropower, wind, solar, and biomass energy development and deployment, coordinating renewable energy development with economic, social, and environmental objectives. Overall, the MLTPRE aimed at raising the share of renewable energy to 10% of total primary energy consumption by the end of 2010, and raising the share of renewable energy to 15% by 2020. The cost of renewable energy development and deployment in excess of conventional power (i.e., coal) is to be socialized by passing the expense to all customers as a surcharge to the retail price of power.

**Table 1. China—Renewable Energy Deployment Targets**  
(Capacities by Year)

Renewable Energy Source	2005	2010	2020
Hydropower	117 GW	190 GW	300 GW
Biomass Power	2 GW	5.5 GW	30 GW
Wind Energy	1.26 GW	5 GW	30 GW
Solar PV	0.07 GW	0.3 GW	1.8 GW
Bioethanol <sup>a</sup>	1.02 million tons	2 million tons	10 million tons
Biodiesel <sup>b</sup>	50,000 tons	200,000 tons	2 million tons

**Source:** Medium and Long-Term Development Plan (2007). National Development and Reform Commission (People’s Republic of China). See [http://en.chinagate.cn/reports/2007-09/13/content\\_8872839.htm](http://en.chinagate.cn/reports/2007-09/13/content_8872839.htm).

- Non-food grains used as feedstock.
- From waste and edible oil sources.

Mandates for market share under the MLTPRE require areas of China covered by large scale power grids to have non-hydropower renewable energy account for 1% of total power generation by 2010, and at least 3% by 2020. Power generators with installed capacities over 5 GW will be required to have non-hydropower renewable energy of 3% of total capacity by the end of 2010, and at least 8% by 2020.<sup>28</sup>

The national government recently added an incentive for the grid companies to connect to renewable energy projects. The Renewable Energy Law was amended in 2009 to require electricity grid companies to buy all the electricity produced by renewable energy generators.

<sup>28</sup> <http://www.chinaenvironmentallaw.com/wp-content/uploads/2008/04/medium-and-long-term-development-plan-for-renewable-energy.pdf> (MLTR).

Power companies refusing to comply will be fined an amount up to twice the “economic loss” of the renewable energy producer.<sup>29</sup>

## **Renewable Energy Focus**

### ***Biomass***

Biomass as a source of grid-connected electric power in China has yet to realize its full potential, with inefficiencies in transporting biomass feedstocks to centralized locations being a major hurdle. Biomass is widely used in China’s rural areas where over 80% of the population live.<sup>30</sup> When biomass is used in biogas digesters, the resulting biogas mixture can be up to 70% methane.<sup>31</sup> Biogas produced from livestock manure is a major resource in rural areas for household cooking and heating.<sup>32</sup> Biogas methane can also be used to fuel engine generators and to produce electricity for households. Larger biogas projects from collectives can operate cogeneration facilities providing thermal energy for heating or hot water.

Biomass-fueled electricity is generally considered to be carbon-neutral, but biomass is a very small part of China’s overall centralized electricity production. Development of biomass projects connected to the grid are expected to be limited to areas with abundant biomass resources in order to promote direct-fired biomass electric power generation plants. As of 2006, biomass electric power capacity was about 2,200 MW.<sup>33</sup> Biomass power projects are eligible for a feed-in tariff<sup>34</sup> (FIT) which was raised to \$0.051 per kilowatt-hour in 2008.<sup>35</sup> A production subsidy was authorized of \$19 to \$22 per ton of biomass pellets produced from agricultural or forestry residues.<sup>36</sup> Biomass energy is also viewed as a part of the solution to arrest desertification in China, with programs to plant willow trees springing up in affected regions. Willow trees grow quickly, and are harvested for energy. For example, a power plant in Inner Mongolia burns as much as 200,000 tons of willow annually, producing 210 million kwh of electricity, thus

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<sup>29</sup> China Economic Net, *China adopts amendment to renewable energy law*, December 26, 2009, [http://en.ce.cn/National/Politics/200912/26/t20091226\\_20695325.shtml](http://en.ce.cn/National/Politics/200912/26/t20091226_20695325.shtml) (CENet).

<sup>30</sup> <http://www.cite-sciences.fr/france-chine/en/chinaworld/2/c15.html>.

<sup>31</sup> Methane digesters convert manure or other organic matter into biogas through a process called anaerobic digestion. In this process, bacteria decompose the organic matter in the absence of oxygen, producing a gas composed of 60% to 70% methane and 30% to 40% carbon dioxide—biogas. See <http://www.cleanenergyresource teams.org/technology/biogas-digesters>.

<sup>32</sup> By the end of 2005, there were more than 17 million household biogas digesters producing 6,500 million cubic meters of biogas annually. Over 1,500 large-and medium-scale digester projects facilities generate around 1500 million cubic meters of biogas annually. See <http://www.china.org.cn/english/environment/213624.htm>.

<sup>33</sup> Renewable Energy Policy Network for the 21<sup>st</sup> Century, *Recommendations for Improving the Effectiveness of Renewable Energy Policies in China*, October 2009, [http://www.ren21.net/pdf/Recommendations\\_for\\_RE\\_Policies\\_in\\_China.pdf](http://www.ren21.net/pdf/Recommendations_for_RE_Policies_in_China.pdf). (RECREN)

<sup>34</sup> “A feed-in tariff is an energy-supply policy focused on supporting the development of new renewable power generation. ... The FIT contract provides a guarantee of payments in dollars per kilowatt hour for the full output of the [renewable energy] system for a guaranteed period of time (typically 15-20 years).” Karlynn Cory, Toby Couture, and Claire Kreycik, *Feed-in Tariff Policy: Design, Implementation, and RPS Policy Interactions*, National Renewable Energy Laboratory, NREL/TP-6A2-45549, March 2009. (FITP)

<sup>35</sup> RECREN.

<sup>36</sup> RECREN.

displacing power from coal-based generation. The cinders left over from the combustion process can be used for fertilizer.<sup>37</sup>

With China's domestic oil reserves dwindling, biofuels are considered a supplement to enhance China's transportation energy supplies, and reduce air emissions. Over \$290 million was allocated for research, development, and demonstration of biofuels. China is the world's third largest producer of ethanol, following the United States and Brazil. While biofuels can be made from a variety of biomass sources, China's MLTPRE focuses on using marginal lands and non-food crops for biofuels production,<sup>38</sup> with specific targets for bioethanol and biodiesel (see **Table 1**). It should also be noted that China has become a net food importing country which makes food security a priority, and is a likely reason for China's focus on non-food crop sources of bioethanol.<sup>39</sup>

## **Solar**

China is the world's largest producer of solar photovoltaic (PV) panels. As of 2008, China had installed about 140 Megawatts of PV capacity.<sup>40</sup> But with the global economic downturn came a slowdown in orders for PV panels, and China began to look at developing the solar power domestic market.

China's initial goal for solar power was established in 2007 at a modest 1.8 GW, but this target is in the process of being revised upward to perhaps 20 GW.<sup>41</sup> A "Golden Roofs" initiative announced in March 2009 provides a subsidy of \$2.93 per watt for roof-mounted PV systems over 50 kilowatts (kw) which could cover over half of a system's installation cost. A feed-in tariff of \$0.16 per kilowatt-hour (kwh) was also established for PV power projects at the same time. Encouragement for larger utility scale solar projects was announced in July 2009 under the "Golden Sun" program, which provides for up to 50% of project costs (including transmission or distribution lines to connect to the grid), and up to 70% of such costs for projects in more remote areas (such as the Western Region). The Golden Sun program is for projects of 300 MW capacity and above, which are in service for a minimum of 20 years.<sup>42</sup>

Provinces also provide local incentives for solar development. For example, the Jiangsu provincial government established a FIT for solar power from ground-based solar farms, rooftop, or building integrated PV systems installed in 2009 with respective rates of \$0.31, \$0.54, and

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<sup>37</sup> Zhang Qi, *Burning willows to stop desertification*, China Daily, May 11, 2009. [http://www.chinadaily.com.cn/bw/2009-05/11/content\\_7761535.htm](http://www.chinadaily.com.cn/bw/2009-05/11/content_7761535.htm).

<sup>38</sup> The potential land area for cultivating oilseed plants and energy crops (including jatropha curcas, rapeseed, ricinus communis, lacquer tree, Chinese goldthread tree, and sweet sorghum) is estimated to meet the annual feedstock requirements of 50 million tons of liquid biofuel. China has banned the use of grain for ethanol production. RECREN.

<sup>39</sup> Jonathan Lynn, *China Became Net Food Importer In 1<sup>st</sup> Half*, Reuters, August 22, 2008, <http://www.planetark.com/dailynewsstory.cfm/newsid/49900/story.htm>.

<sup>40</sup> <http://earth2tech.com/2009/06/24/is-china-on-the-cusp-of-becoming-a-huge-solar-panel-market/>

<sup>41</sup> Breakthrough Institute and the Information Technology and Innovation Foundation, *Rising Tigers, Sleeping Giant*, November 2009, [http://thebreakthrough.org/blog/Rising\\_Tigers.pdf](http://thebreakthrough.org/blog/Rising_Tigers.pdf). (RISING TIGERS)

<sup>42</sup> China also announced several utility-scale renewable energy projects in 2009, including the world's largest wind farm, a 10 GW "Three Gorges of Wind Power" project in Gansu Province, and a 2 GW solar power plant in Northern China using Arizona-based First Solar's thin-film solar PV panels. See [http://switchboard.nrdc.org/blogs/bfinamore/china\\_records\\_its\\_climate\\_acti.html](http://switchboard.nrdc.org/blogs/bfinamore/china_records_its_climate_acti.html).

\$0.63 per kwh of electricity generated.<sup>43</sup> There has since been discussion of establishing a national feed-in tariff for solar power projects. However, solar power may be in competition for national government funding with wind power (which is seen by the central government leadership as a better option for China) for such consideration, making a solar FIT unlikely in 2010.<sup>44</sup>

## *Wind*

Domestic wind power turbine technology and electricity production have grown tremendously in China since the turn of the century. National government support for Wind Power in China began in 2001 with a 50% cut in value added taxes for power generated by wind. This was followed in 2003 with a push for wind power development from the Chinese government with the institution of a concession tendering program.<sup>45</sup>

The process for wind farm development usually begins with the NDRC conducting wind resource assessments for prospective areas prior to arranging for a concession for a wind power project. Projects below 50 MW do not require competitive bidding, and so may be developed by local authorities. Wind power projects over 50 MW are approved by the NDRC, which also sets prices for the electricity generated by these projects. While wind projects under 50 MW can be approved by local governments, prices for wind power are generally subject to final approval by the NDRC.<sup>46</sup> The regional grid power company would enter into a long-term power purchase agreement to buy electricity from the project over the life of the project, with the national government guaranteeing the power purchase. The bidding process would determine the in-grid tariff, with the agreement specifying how much electricity the bidder would provide to the grid. The goal of the program was to achieve economies of scale by producing a large capacity and thereby produce a low price for grid-connected wind power. Additionally, it was thought that foreign companies would be attracted by the long-term purchase power agreement to invest in China's wind energy sector.<sup>47</sup>

Mixed results came from the tenders received, with many being structured on impractically low power prices. Winning bids were thus often too low to make the projects economically viable. This prompted the government to change the weight of power prices in its process of evaluating the bids.<sup>48</sup>

The 2005 Renewable Energy Law established a purchase system for renewable electricity, but the process of requesting bids for tenders continued for grid-connected wind power projects. In 2007, a target of 15% of China's total energy consumption from renewable energy was set for 2020.

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<sup>43</sup> Yotam Ariel, *Incentives, Falling Cost and Rising Demand in China's PV Market*, Renewable Energy World, November 13, 2009. <http://www.renewableenergyworld.com/rea/news/article/2009/11/incentives-falling-cost-and-rising-demand-in-chinas-pv-market>.

<sup>44</sup> See <http://chinasolarenergy.blogspot.com/2010/04/ndrcs-zhang-guobao-and-feed-in-tariff.html>.

<sup>45</sup> Competitive bids for concessions with a goal of reducing the price of wind power projects. See <http://www.gwec.net/index.php?id=125>.

<sup>46</sup> With the exception of Guangdong Province which approves its own projects and prices. RECREN.

<sup>47</sup> See <http://www.ecoworld.com/energy-fuels/wind-power-in-china.html> CHINA.

<sup>48</sup> RECREN.

The law required the grid company to purchase the full amount of power generated by wind power projects with the tariff for all projects being set by the winning bid.<sup>49</sup>

In 2009, the NDRC replaced the public bidding process and instituted FITs for wind power, scaled according to the available wind resource and construction conditions in the various regions of China.<sup>50</sup> As more projects were installed, the understanding of the dynamics between localized wind resources and resulting power production led to more rational prices for wind power.<sup>51</sup>

As of 2009, China's Meteorological Administration estimated China's developable wind power resources at over 250 million kilowatt-hours.<sup>52</sup> By the end of 2009, China's installed wind power capacity had reached 25.8 GW.<sup>53</sup> Officials in China expect to surpass the official target of 30 GW for installed wind power by 2020, with estimates of 100 GW of wind power capacity predicted. China also expects to surpass the installed capacity target for solar power of 1,800 MW, with 10,000 MW seen as possible. The revised expectations have yet to be formally endorsed by the NDRC.<sup>54</sup> However, China's wind resources and increasing demand for electric power are now being matched by the industrial capability to build wind turbines and solar panels which can meet the resource potential.

Offshore wind is another as yet "untapped" resource in China, one which the government expects to begin development of very soon. China's offshore wind power potential is estimated at more than 750 million kilowatt-hours, which is more than twice the estimate of exploitable wind power resources onshore. As with onshore wind, offshore concessions would be put up for tender offers with price offers to send electricity to the grid. Developers must be Chinese-funded enterprises, or Sino-foreign joint ventures with majority Chinese ownership. The process of establishing concession areas has already begun with China's National Energy Bureau, and the State Oceanic Administration jointly issuing an "Interim Measure" in 2010 concerning regulations for developing offshore capacity.<sup>55</sup>

## **Incentives, Subsidies and Procurement Programs**

Financial support for renewable energy in China involves subsidies, tax policies, pricing mechanisms, and a reward scheme for green production. Subsidy support is extended to overhead costs of programs (i.e., administrative, operational, and other expenses for government renewable energy agencies), renewable energy technology research and development, and provincial or local electrification projects. Tax incentives can come from the central or local governments, and can

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<sup>49</sup> RELaw.

<sup>50</sup> Tariff levels ranged from \$0.07 to \$0.09 per kwh. RISING TIGERS.

<sup>51</sup> GWEC.

<sup>52</sup> Zhang Qi, *Wind can power up entire Nation*, China Daily News, June 18, 2009, [http://www.chinadaily.com.cn/bizchina/2009-06/18/content\\_8296706.htm](http://www.chinadaily.com.cn/bizchina/2009-06/18/content_8296706.htm).

<sup>53</sup> New York Times, *Gains in Global Wind Capacity Reported*, February 15, 2010, <http://green.blogs.nytimes.com/2010/02/15/gains-in-global-wind-capacity-reported/>.

<sup>54</sup> *China to triple wind goal to 100,000 MW by 2020*, May 6, 2009, <http://climateprogress.org/2009/05/06/energy-and-global-warming-news-china-solar-wind/>.

<sup>55</sup> China.Org. Cn, Xinhua, *China speeds up offshore wind power construction*, March 20, 2010, [http://www.china.org.cn/business/2010-03/20/content\\_19647071.htm](http://www.china.org.cn/business/2010-03/20/content_19647071.htm).

be technology specific. Pricing for renewable energy is not standardized, and is set by contracts negotiated between projects and utilities.<sup>56</sup>

Renewable energy is subsidized by a fee charged to all electricity users in China of about 0.029 cents per kwh.<sup>57</sup> Electricity customers in China pay rates according to customer class.<sup>58</sup> The fee was originally based on the incremental difference between coal and renewable energy (estimated in China at \$0.044 to \$0.059 per kwh).<sup>59</sup> The fee goes to the companies which operate the electricity grid and must buy the renewable power from project developers. The fee for industrial users of electricity recently doubled in 2009 to about 0.8% of their electricity bill.<sup>60</sup>

As China's technological capabilities improve, it will use more of its own industrial capacity to meet domestic clean energy needs, and rely less on imported equipment. China has embraced an array of incentives, subsidies, and procurement policies to encourage such development. Interest rates as low as 2% for bank loans enable the financing of renewable energy projects.<sup>61</sup> Preferences were established with the Government Procurement Law of 2002, which specified the government shall procure domestic goods, construction, and services, unless availability or other conditions exist to impair such procurement.<sup>62</sup>

Application of domestic content rules for renewable energy projects were formalized in 2005 by the NDRC's "Notice of Requirements for the Administration of Wind Power Construction." At least 70% of Wind Power equipment is required to be produced in China. The determination of domestic content is based on the percentage of total components in a wind turbine manufactured and assembled in China, regardless of the level of Chinese ownership in the producing factory. Wind farms which fail to comply do not receive approval for construction permits. Authorities in China are reportedly considering dropping the domestic content requirement, when objectives of establishing the domestic wind turbine industry and supply chain are considered met.<sup>63</sup> Under the Wind Power Concession Project, the NDRC is "overseeing construction" of a series of wind farms of at least 10 GW generating capacity.<sup>64</sup>

Financial incentives for other renewable energy projects in China are available from both the national and provincial governments. The central government offers an investment subsidy of 50% for solar power projects under the Golden Sun program. For biomass power projects, a \$0.04 per kwh subsidy is offered, along with incentives such as risk reserves and tax breaks, and the

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<sup>56</sup> See <http://www.nrel.gov/docs/fy04osti/36045.pdf>.

<sup>57</sup> The original surcharge of 0.014 cents per kwh was increased to 0.029 cents per kwh in 2007. RECREN.

<sup>58</sup> For example, electricity for residential use in Beijing was 49 fen per kwh (about \$0.07), while that for agricultural use was around 52 fen per kwh, for secondary industry use 76 fen per kwh and for commercial use 79 fen per kwh, according to Beijing Electric Power Corporation. One yuan is 100 fen. See [http://news.xinhuanet.com/english/2009-11/19/content\\_12492364.htm](http://news.xinhuanet.com/english/2009-11/19/content_12492364.htm).

<sup>59</sup> RECREN.

<sup>60</sup> Keith Bradsher, *China Leading Global Race to Make Clean Energy*, New York Times, January 30, 2010, <http://www.nytimes.com/2010/01/31/business/energy-environment/31renew.html>. (NYT1)

<sup>61</sup> NYT1.

<sup>62</sup> Article 10. See [http://english.gov.cn/laws/2005-10/08/content\\_75023.htm](http://english.gov.cn/laws/2005-10/08/content_75023.htm).

<sup>63</sup> See [http://www.chinadaily.com.cn/bizchina/2009-11/24/content\\_9033778\\_3.htm](http://www.chinadaily.com.cn/bizchina/2009-11/24/content_9033778_3.htm).

<sup>64</sup> See <http://www.nftc.org/default/Press%20Release/2010/China%20Renewable%20Energy.pdf>. China's Promotion of the Renewable Electric Power Equipment Industry. (CPRE).

government has established at least one joint venture to demonstrate and deploy biomass power technology at a reported 40 plants.<sup>65</sup>

Incentives for non-food sourced biofuels production are available to farmers and biofuel producers. Ethanol production in 2006 was 1.56 million tonnes compared to 0.19 million tonnes for biodiesel, with subsidies for ethanol at \$115 million with no subsidies for biodiesel in that year. In 2007, flexible subsidies were made available to biofuels producers to make up for losses on crops due to low crude oil prices (though the Chinese government wants to encourage enterprises to reserve funds to offset such risks). Farmers were authorized a subsidy of \$405 for each hectare of forest used for biofuels production, and a subsidy of \$365 for each hectare growing biofuel crops.<sup>66</sup> China controls transportation fuel prices, and sets the price of ethanol at approximately 91% of the price of gasoline. The five licensed producers of ethanol in China are eligible for support in the form of direct output-linked subsidies, tax exemptions and low-interest loans, and they are the beneficiary of mandatory blending programs for ethanol with gasoline in ten provinces. Contrary to the highly controlled ethanol industry, the biodiesel industry is dominated by small scale producers who use waste cooking oil and animal fats as feedstock. Producers sell biodiesel direct to users without taxation or direct fuel subsidies. Total support for ethanol and biodiesel is expected to rise to \$1.2 billion by 2020, excluding the subsidy support to farmers mentioned earlier.<sup>67</sup>

Under the economic stimulus plan designed to help China recover from the current global financial crisis, the national government allocated over 210 billion yuan (about \$31 billion), or 5.3% of its entire stimulus package, for environmental protection and energy conservation.<sup>68</sup>

## United States

Some argue that the United States does not have a comprehensive national policy in place for promotion of renewable energy technologies. Federal policies exist providing corporate tax incentives for renewable electricity, but these are generally authorized for short periods and must be periodically reauthorized. Even when the programs are authorized for longer terms, they are not always fully funded in appropriations legislation. Most federal grant and loan programs are short-term in funding duration, being authorized by the American Recovery and Reinvestment Act of 2009. An exception, however, is biofuels which do have significant federal government support in the form of the Renewable Fuel Standard (RFS). The RFS mandates minimum goals for blending quantities of renewable fuels with gasoline and diesel through 2022.<sup>69</sup>

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<sup>65</sup> The national government established the National Bio Energy Company, Limited, as a joint venture between the State Grid Corporation of China and the Dragon Power Company, Ltd. CPRE.

<sup>66</sup> Xinhua, *China to offer incentives for non-food biofuels*, November 7, 2007, [http://www.chinadaily.com.cn/china/2007-12/07/content\\_6306076.htm](http://www.chinadaily.com.cn/china/2007-12/07/content_6306076.htm).

<sup>67</sup> See Global Subsidies Initiative of the International Institute for Sustainable Development, *Biofuels—At What Cost? Government Support for Ethanol and Biodiesel in China*, December 2008, [http://www.globalsubsidies.org/files/assets/China\\_Biofuels\\_Subsidies.pdf](http://www.globalsubsidies.org/files/assets/China_Biofuels_Subsidies.pdf).

<sup>68</sup> Zhu Shaobin, *China's Economic Stimulus Plans Benefit Environment*, Xinhua, March 3, 2009, [http://news.xinhuanet.com/english/2009-03/10/content\\_10986048.htm](http://news.xinhuanet.com/english/2009-03/10/content_10986048.htm).

<sup>69</sup> CRS Report R40155, *Selected Issues Related to an Expansion of the Renewable Fuel Standard (RFS)*, by Randy Schnepf and Brent D. Yacobucci.

Much of the U.S. renewable energy installed capacity is a result of state deployment initiatives<sup>70</sup> rather than federal programs, with 30 states having a renewable portfolio standard (RPS) in place to encourage deployment.<sup>71</sup> However, the availability of federal tax incentives have aided deployment in recent years, with the Investment Tax Credit<sup>72</sup> (ITC) being key to many corporate decisions to invest in renewable energy.

## **Clean Energy Research and Development Programs**

The history of energy research and development in the United States in the closing quarter of the last century can be characterized as being driven by energy prices, causing shifts in the direction of policies, programs, and levels of program funding. During this period, the U.S. Department of Energy (DOE) has been the key agency involved in energy R&D in the United States according to a 2001 report from the National Research Council:

From 1978 through 1999, the federal government expended \$91.5 billion (2000 dollars) on energy R&D, mostly through DOE programs. This direct federal investment constituted about a third of the nation's total energy R&D expenditure, the balance having been spent by the private sector. Of course, government policies—from cost sharing to environmental regulation to tax incentives—influenced the priorities of a significant fraction of the private investment. On balance, the government has been the largest single source and stimulus of energy R&D funding for more than 20 years.<sup>73</sup>

DOE continues to be responsible for the largest share of federal energy-related research dollars, and administers the national laboratories and technology centers which are key to the execution of U.S. national energy research strategies. The modern history of energy research can be traced to the 1977 Department of Energy Organization Act (P.L. 95-91) which dismantled the predecessor agency (the Energy Research and Development Administration) and created the agency.

## **Key Legislation Promoting Renewable Energy**

The **National Energy Act of 1978** followed the formation of DOE, and was largely focused on conservation of fossil fuels in reaction to the 1973 energy crisis. The Public Utility Regulatory Policies Act (PURPA) (P.L. 95-617) encouraged generation of electricity from renewable sources by requiring electric utilities to purchase electricity from qualifying small power and cogeneration facilities.<sup>74</sup>

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<sup>70</sup> The Union of Concerned Scientists projects that state Renewable Portfolio Standard programs will support 76,750 MW of new renewable power by 2025—an increase of 570% over total 1997 U.S. levels (excluding hydro). [http://www.ucsusa.org/assets/documents/clean\\_energy/RES\\_in\\_the\\_States\\_Update.pdf](http://www.ucsusa.org/assets/documents/clean_energy/RES_in_the_States_Update.pdf).

<sup>71</sup> <http://www.ferc.gov/market-oversight/othr-mkts/renew/othr-rnw-rps.pdf>.

<sup>72</sup> See business energy tax credit discussion at [http://www.dsireusa.org/incentives/incentive.cfm?Incentive\\_Code=US02F&re=1&ee=1](http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US02F&re=1&ee=1).

<sup>73</sup> National Academy of Sciences, *Energy Research at DOE: Was It Worth It? Energy Efficiency and Fossil Energy Research 1978 to 2000*, Washington, DC, 2001, [http://www.nap.edu/catalog.php?record\\_id=10165](http://www.nap.edu/catalog.php?record_id=10165).

<sup>74</sup> Qualifying Facility (QF): A cogeneration or small power production facility that meets certain ownership, operating, and efficiency criteria established by the Federal Energy Regulatory Commission (FERC) pursuant to the Public Utility Regulatory Policies Act (PURPA). See [http://www.eia.doe.gov/glossary/glossary\\_q.htm](http://www.eia.doe.gov/glossary/glossary_q.htm).



It was the **Energy Security Act of 1980** (ESA) (P.L. 96-294) which largely brought renewable energy and renewable technologies into the forefront of public policy. ESA consisted of six major acts<sup>75</sup> and provided funding for research in areas such as renewable energy and biofuels.

The **Energy Policy Act of 1992** (EPACT) (P.L. 102-486) was wide-ranging legislation addressing topics of energy efficiency and conservation, natural gas supplies, alternative fuels and alternative fuel vehicles. EPACT set goals for energy management,<sup>76</sup> and authorized subsidies for wind and other alternative energy technologies (i.e., the Renewable Energy Production Incentive discussed later in this report). EPACT also established the Production Tax Credit<sup>77</sup> (PTC).

The **Energy Policy Act of 2005** (EPACT5) (P.L. 109-58) continued the focus on energy supply and demand policies. EPACT5 extended the PTC for wind and qualifying biomass technologies. The law also authorized funds for developing renewable energy technologies and loan guarantees for renewable energy deployment, and required electric utilities to offer net metering on request to customers. EPACT5 also created the Renewable Fuel Standard with requirements for blending 7.5 billion gallons of renewable fuel with gasoline by 2012.

This was followed by the **Energy Independence and Security Act of 2007** (EISA) (P.L. 110-140) which was largely focused on energy security and energy efficiency. EISA also provided funds to accelerate R&D for renewable energy particularly solar and geothermal power, and energy storage technologies. EISA also extended the RFS program with a mandate to blend 36 billion gallons of renewable fuel with gasoline and diesel fuel by 2022.

The **American Recovery and Reinvestment Act of 2009** (ARRA) (P.L. 111-5) was enacted as a stopgap measure in response to the current financial crisis to aid economic recovery.

More than \$45 billion was appropriated for energy efficiency and renewable energy programs across federal government programs, most of which was to be obligated before the end of FY2010. Almost \$8 billion was provided for energy and other R&D programs, \$2.4 billion for energy technology and facility development grants, and \$14 billion for electric power transmission grid infrastructure development and energy storage development (including \$6 billion for loan guarantees). Another \$14.1 billion was provided for renewable energy tax incentives, with an additional \$2.3 billion for energy efficiency tax incentives.<sup>78</sup>

ARRA also included a temporary provision allowing projects eligible for the Investment Tax Credit to receive a grant covering 30% of project costs.

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<sup>75</sup> Under the Energy and Security Act of 1980 were the following: U.S. Synthetic Fuels Corporation Act, Biomass Energy and Alcohol Fuels Act, Renewable Energy Resources Act, Solar Energy and Energy Conservation Act and Solar Energy and Energy Conservation Bank Act, Geothermal Energy Act, and the Ocean Thermal Energy Conversion Act.

<sup>76</sup> See <http://www1.eere.energy.gov/femp/regulations/epact1992.html#wc>.

<sup>77</sup> The renewable electricity Production Tax Credit is a per-kilowatt-hour tax credit for electricity generated by qualified renewable energy technologies and sold by the taxpayer to an unrelated party during the taxable year. See CRS Report R40913, *Renewable Energy and Energy Efficiency Incentives: A Summary of Federal Programs*, by Richard J. Campbell, Lynn J. Cunningham, and Beth A. Roberts.

<sup>78</sup> CRS Report R40412, *Energy Provisions in the American Recovery and Reinvestment Act of 2009 (P.L. 111-5)*, coordinated by Fred Sissine.

## Renewable Energy Focus

### *Biomass*<sup>79</sup>

Biomass for electric power is arguably the most conventional of all renewable electricity technologies, and is the largest source of renewable electricity in the United States. Approximately 53% of all renewable energy comes from biomass, represented by biofuels, landfill gas, biogenic municipal solid waste, wood, wood-derived fuels and other biomass such as switchgrass and poplars.<sup>80</sup> Agricultural wastes (such as corn stover) are another potential feedstock. Biomass combustion is a relatively mature technology but it is not widely used and is generally not very efficient unless it is used in a combined heat and power application. Large scale co-firing of biomass with coal is a higher efficiency, lower per unit cost application. Technologies for biomass gasification could result in higher efficiencies when used to produce synthesis gas or hydrogen for heat and/or power production. Demonstration and deployment of newer industrial gasification technologies is needed to scale-up plants and provide economical designs with high degrees of availability. Wood-burning stoves and solar water heaters are the most common applications of residential renewable energy. With wood and biomass net summer capacity reported at 7 Gigawatts (GW) for 2007, DOE estimates that 41 GW of domestic biomass generation could be available by 2030.<sup>81</sup> The RFS is a significant factor in biofuels policy, which has largely focused on corn-based ethanol.<sup>82</sup> But increasing scrutiny on the effects of ethanol production on global food prices and production practices has pushed researchers to focus more on non-food cellulosic sources production of ethanol.<sup>83</sup>

### *Wind*

Wind power projects have been growing at a faster rate than natural gas-fueled electric power production in the United States, with over 9,922 MW of capacity installed in 2009. The total installed and grid-connected wind power capacity as of 2009 in the United States was approximately 35 GW.<sup>84</sup> DOE estimates that domestic wind power could reach a capacity of 61 GW or greater by 2030.<sup>85</sup> A major federal government incentive for wind power has been the Production Tax Credit (PTC), which originated in the Energy Policy Act of 1992 as aid to facilities in operation. Currently, an income tax credit of \$0.021 per kwh is available for electricity produced from utility-scale wind turbines under the PTC. However, the PTC has expired three times in the last decade only to be restored. The importance of the PTC to the industry is apparent as installations of wind power have consistently fallen in the year following the lapse of the tax credit.<sup>86</sup> The American Recovery and Reinvestment Act of 2009 (ARRA) (P.L. 111-5) extended the Section 45 Production Tax Credit “placed in service” date for wind to the end

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<sup>79</sup> CRS Report R40833, *Renewable Energy—A Pathway to Green Jobs?*, by Richard J. Campbell and Linda Levine.

<sup>80</sup> AEO 2009.

<sup>81</sup> U.S. Department of Energy, Energy Information Administration (AEO 2009), *Annual Energy Outlook 2009*, Table D10, [http://www.eia.doe.gov/oiaf/aeo/pdf/0383\(2009\).pdf](http://www.eia.doe.gov/oiaf/aeo/pdf/0383(2009).pdf).

<sup>82</sup> CRS Report R41282, *Agriculture-Based Biofuels: Overview and Emerging Issues*, by Randy Schnepf

<sup>83</sup> <http://www.nrel.gov/biomass/pdfs/40742.pdf>.

<sup>84</sup> Global Wind Energy Council, *Global Wind 2009 Report*, March 2010, [http://www.gwec.net/fileadmin/documents/Publications/Global\\_Wind\\_2007\\_report/GWEC\\_Global\\_Wind\\_2009\\_Report\\_LOWRES\\_15th.%20Apr..pdf](http://www.gwec.net/fileadmin/documents/Publications/Global_Wind_2007_report/GWEC_Global_Wind_2009_Report_LOWRES_15th.%20Apr..pdf).

<sup>85</sup> CRS Report R40833, *Renewable Energy—A Pathway to Green Jobs?*, by Richard J. Campbell and Linda Levine.

<sup>86</sup> [http://www.windpoweringamerica.gov/pdfs/2007\\_annual\\_wind\\_market\\_report.pdf](http://www.windpoweringamerica.gov/pdfs/2007_annual_wind_market_report.pdf).

of 2012, and allowed PTC-eligible facilities placed in service from 2009 and 2012 to choose a 30% ITC in place of the PTC, or to receive a 30% grant.

Offshore wind power in the United States is a fledgling industry, having just received federal authority in 2010 to go ahead with the first U.S. offshore wind farm in Nantucket Sound, off the Massachusetts coast. Known as the Cape Wind project, it will involve 130 turbines (from the German firm, Siemens AG) with a total capacity of 420 MW.<sup>87</sup> The overall potential for U.S. offshore wind power production capacity was estimated at 908 GW in 2005.<sup>88</sup>

## **Solar**

As of 2008, the total capacity of the grid-connected solar power industry in the United States was 8,775 MW.<sup>89</sup> Solar PV represented about 800 MW of that capacity, with solar thermal installations making up the rest. Solar power, like wind power, is considered a variable resource but solar power technologies can generate most power at peak energy demand times when the weather is hot and sunny. Concentrating solar power thermal plants with heat storage capacity are being increasingly considered for large central station generating plants in the sun-rich areas of the western United States. Solar thermal hot water heating is a small but growing application in the United States whose deployment prospects may be enhanced by a recent focus on energy efficiency and conservation. For the solar power industry, the key federal incentive of recent years has been the Investment Tax Credit which allowed businesses to invest in solar power projects and receive a tax credit for up to 30% of the expense. As a short-term remedy to the almost annual reauthorization quest for the ITC, the Emergency Economic Stabilization Act of 2008 extended the 30% solar investment tax credit for eight years to 2016, and removed the prohibition against utility company use of the ITC thus allowing them to take advantage of the credit.

## **Incentives, Subsidies and Procurement Programs**

Government incentives, subsidies, and procurement requirements exist at both the federal and state government levels in the United States. The federal government is the largest single consumer of energy in the United States, and has defined procurement goals for the use of renewable energy:

EPACT5 required federal agencies to increase their purchase of renewable energy to a minimum of 7.5% of overall energy purchases by 2013. Agencies receive double-credit for renewable energy generated on their facility sites. Presidential Executive Order (EO) 13423 required that at least one-half of the EPACT renewable energy requirement come from “new” (i.e., put in service after January 1, 1999) renewable energy sources, preferably sited on agency property for agency use. EO 13423 also allowed agencies to use new “non-electric” renewable energy sources to meet the requirement for new renewable energy. Examples of non-electric renewable energy include thermal energy from solar ventilation

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<sup>87</sup> Reuters, *Cape Wind, first U.S. offshore wind farm, approved*, April 28, 2010, <http://www.reuters.com/article/idUSTRE63R42X20100428>.

<sup>88</sup> Walt Musial, *Offshore Wind Energy Potential for the United States*, National Renewable Energy Laboratory, May 2005. [http://www.windpoweringamerica.gov/pdfs/workshops/2005\\_summit/musial.pdf](http://www.windpoweringamerica.gov/pdfs/workshops/2005_summit/musial.pdf).

<sup>89</sup> Reuters, *U.S. installed solar capacity up 17 percent in 2008*, March 20, 2009, <http://www.reuters.com/article/idUSTRE52J5VW20090320>.

pre-heat systems, solar heating and cooling systems, solar water heating, ground source heat pumps, biomass-fueled heating and cooling, thermal uses of geothermal and ocean resources. However, these non-electric renewable energy sources cannot apply to meeting the EPACT renewable federal electricity purchase requirement. In 2010, an agency could use non-electric renewables equal to 2.5% of its electricity to satisfy EO 13423, and then use old renewable energy sources for 5% of its use to satisfy EPACT, for a total equivalent of 7.5% of its electricity use from renewable energy.<sup>90</sup>

The Renewable Energy Production Incentive (REPI) was established by EPACT to provide incentive payments for new projects generating and selling renewable electricity. Eligible renewable energy technologies include solar, wind, and biomass (excluding municipal solid waste). The payment of \$0.015 per kwh (in 1993 dollars, indexed for inflation) was for the first 10 years of a facility's operation, but is subject to availability of annual appropriations in each federal fiscal year of operation.<sup>91</sup> REPI was reauthorized by EPACT5 for FY2006 through FY2026. REPI program funding is determined under the DOE budget process, and employs a tiered decision process as to which projects have priority for payments.<sup>92</sup>

Under the Food, Conservation and Energy Act of 2008 (2008 Farm Bill) (P.L. 110-234), the U.S. Department of Agriculture runs a grant program for developing renewable energy and energy efficiency projects under the Rural Energy for America Program (REAP). REAP is intended to encourage the adoption of renewable energy and energy efficiency technologies by rural small businesses and farmers largely through the competitive issuance of grants and loan guarantees. The program also funds energy audits and provides other renewable energy technology assistance. The 2008 Farm Bill provided for base funding of REAP at \$55 million for FY2009, \$60 million for FY2010, \$70 million for FY2011, and \$70 million for FY2012.<sup>93</sup>

## Discussion

China essentially functions as a “command and control” economy. The national government owns or controls many of the country's industries and enterprises, and sets goals for economic development in the periodic Five Year Plans. China's industries and enterprises are expected to comply with the goals set in the national government's economic plan. China has been described as a developing country going through its industrialization phase, and has developed capabilities in industrial sectors such as steel and petrochemicals. But China is also focused on developing new industries which can feed into the future growth of its economy. One such sector is renewable energy, and in the last five years, China has developed its manufacturing capabilities in wind turbines and solar panels and is using these capabilities to serve its own needs to produce renewable electricity. China recognizes that given the growing demand for energy at home,

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<sup>90</sup> CRS Report R41040, *Identifying Incentives and Barriers to Federal Agencies Achieving Energy Efficiency and Greenhouse Gas Reduction Targets*, by Anthony Andrews and Richard J. Campbell.

<sup>91</sup> <http://apps1.eere.energy.gov/repi/about.cfm>.

<sup>92</sup> The current payment under REPI is \$0.021 per kwh. If there are insufficient appropriations to make full payments for electricity production from all qualified systems for a federal fiscal year, 60% of the appropriated funds for the fiscal year will be assigned to facilities that use solar, wind, ocean, geothermal, or closed-loop biomass technologies; and 40% of the appropriated funds for the fiscal year will be assigned to other eligible projects. Funds will be awarded on a pro rata basis, if necessary. See [http://www.dsireusa.org/incentives/incentive.cfm?Incentive\\_Code=US33F&re=1&ee=1](http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US33F&re=1&ee=1).

<sup>93</sup> See [http://www.dsireusa.org/incentives/incentive.cfm?Incentive\\_Code=US05F&State=Federal&currentpageid=1](http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US05F&State=Federal&currentpageid=1).

developing its domestic renewable energy industry and building manufacturing capacity can lead to advantages in future export markets.

Officially, energy efficiency and conservation are China's top energy priority. These are considered the "low-hanging fruit" in the quest to reduce energy use and cut demand. Energy efficiency benchmarks have been established for China's top 1,000 energy consuming industries (which accounted for 33% of national and 47% of industrial energy usage in 2004) with energy reduction goals set for each enterprise.<sup>94</sup> China is the world's largest market for new construction with approximately 2 billion square meters of floor space added annually. China's existing building codes (for both residential and public buildings) focuses on heating, ventilation and air conditioning, as well as lighting, hot water, and power use. New standards have been in development since 2005 with national energy design criteria for residential buildings.<sup>95</sup> Energy efficient building codes are a key tool in establishing passive measures for energy savings in new future housing stock. Similarly, in the power generation sector, smaller, less energy efficient coal-fired power plants have been targeted for closure as China aims for efficiencies of scale in building larger, state-of-the-art, more efficient coal power generation.

However, renewable energy development is a rising priority for power generation in China. In late 2009, the Standing Committee of the National People's Congress affirmed its support of the development of the renewable power industry by building China's domestic capacity. Grid companies were directed to purchase all renewable electricity generated, with the State Council to determine the proportion of renewable electricity to overall generating capacity in order to meet national goals.<sup>96</sup>

The weak link in these plans is transmission. Targets have been set for building renewable electric power generation without similar planning for accomplishing grid connection and integration, especially for remote wind power. China's grid companies must accept subsidized wind power, but costs of building transmission lines to connect to wind farms (especially those in remote regions) are not subsidized. As a result, as much as one-third of wind power generation in China is not connected to the grid due to a lack of transmission capacity. When combined with low tariffs, this likely means that China's wind power sector has been operating at a loss.<sup>97</sup> To help remedy the imbalance, the State Grid Corporation has begun to build a pilot "Smart Grid" in China's larger cities to help integrate renewable energy sources. Goals for a Smart Grid are expected to be incorporated into China's next Five Year plan, with a "unified strong and smart grid" to be built nationwide by 2020.<sup>98</sup>

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<sup>94</sup> Lynn Price, Xuejun Wang, and Jiang Yun, *China's Top-1000 Energy-Consuming Enterprises Program: Reducing Energy Consumption of the 1000 Largest Industrial Enterprises in China*, Ernest Orlando Lawrence Berkeley National Laboratory, LBNL-519E, June 2008.

<sup>95</sup> B. Shui, M. Evans, and H. Lin, et al., *Country Report on Building Energy Codes in China*, Pacific Northwest National Laboratory, April 2009, [http://www.energycodes.gov/implement/pdfs/CountryReport\\_China.pdf](http://www.energycodes.gov/implement/pdfs/CountryReport_China.pdf).

<sup>96</sup> CENet.

<sup>97</sup> China's wind power sector is expected to be operating at a loss for some time to come, largely due to the practice of awarding concessions to the bids with the lowest tariff and awarding contracts for the life of a project. As such, higher government subsidies may be required for wind farm profitability, and building transmission infrastructure will still be needed on a massive scale to bring this power to market. See Guardian.co.uk, *Wind Power Growth in China's Deserts Ignored Financial Risks*, May 14, 2010, <http://www.guardian.co.uk/environment/2010/may/14/wind-power-china-desert>.

<sup>98</sup> The "Smart Grid" is an intelligent system capable of seamlessly integrating renewable energy sources like solar and wind power into the electricity network. See Xinhua News, *China Sets to Build Smart Grid to Tap Renewable Energy*, (continued...)

China today is dealing with some of the same issues that the United States is likely to face as it considers building the infrastructure to take advantage of potentially huge wind and solar resources of the west and southwest. China's transmission system (like that of the United States) is mostly regional in functionality, and could benefit from improved connectivity across regions if renewable resources in remote areas are to be more fully harnessed. The cost of developing the transmission system will be great in both countries, but China has begun to build efficient ultra-high voltage (UHV) transmission lines (i.e., voltages of 1,000 kilovolt (KV) alternating current, or higher, and 800 KV direct current, or higher). UHV can reduce transmission line losses and transmit more power over longer distances.<sup>99</sup> China's State Grid Corporation plans to invest \$88 billion through 2020 to build UHV lines.<sup>100</sup>

In contrast to China's centrally controlled economy, the United States has largely a market-driven economy. Some observers argue that the current higher costs of renewable electricity do not favor market adoption.<sup>101</sup> However, the goals for increased use of renewable energy are diverse, and include energy security, energy independence, cleaner air, and more recently anthropogenic climate change, sustainability concepts, and economic development. Goals for reducing pollution have been enforced by government regulations requiring changes in the fuels used for power generation, and are often buttressed by requirements to install equipment to reduce particular types of emissions. Such goals could reasonably be said to apply to both the United States and China.

Pending legislation in the 111<sup>th</sup> Congress<sup>102</sup> contains provisions which could serve to increase power generation from renewable energy by establishing market drivers (such as a national renewable electricity standard<sup>103</sup> or other measures to build demand) which could catalyze U.S. renewable electricity development, encouraging venture capital and private sector investment. However, it is noted that the United States and the United Kingdom are the only major nations relying on significant venture capital investment for clean energy technology development.<sup>104</sup> Venture capital has driven much energy innovation in the United States in the past and will undoubtedly play a role in the future in funding the next generations of clean energy technologies. But developing a renewable energy industry in the United States without large scale imports of major parts and equipment from overseas will likely continue to mean major investments from

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(...continued)

March 13, 2010, [http://news.xinhuanet.com/english2010/china/2010-03/13/c\\_13209617.htm](http://news.xinhuanet.com/english2010/china/2010-03/13/c_13209617.htm).

<sup>99</sup> International Electrotechnical Commission, *Energy efficient Ultra High Voltage: the future of electricity transmission*, March 2007, <http://electronics.ihs.com/news/articles/iec-uhv-electricity-transmission.htm>.

<sup>100</sup> Julian Wong and Andrew Light, *China Begins Its Transition to a Clean-Energy Economy*, Center for American Progress, June 4, 2009, [http://www.americanprogress.org/issues/2009/06/china\\_energy\\_numbers.html](http://www.americanprogress.org/issues/2009/06/china_energy_numbers.html).

<sup>101</sup> Jerry Taylor and Peter Van Doren, *Evaluating the Case for Renewable Energy: Is Government Support Warranted?*, CATO Institute, Policy Analysis no. 422, January 10, 2002, [http://www.cato.org/pub\\_display.php?pub\\_id=1281](http://www.cato.org/pub_display.php?pub_id=1281).

<sup>102</sup> Several bills currently pending in Congress for climate change mitigation and clean energy seek to establish a federal renewable energy (or electricity) standard (RES). These include H.R. 2454, the American Clean Energy and Security Act of 2009, and S. 1462, the American Clean Energy Leadership Act of 2009. Under current proposals, the RES would require retail electric suppliers to obtain increasing percentages of renewable electricity for the power they provide to customers. CRS Report R41089, *Small Hydro and Low-Head Hydro Power Technologies and Prospects*, by Richard J. Campbell.

<sup>103</sup> A renewable electricity standard would require retail electricity providers to supply a minimum percentage of electricity from renewable energy sources, such as solar and wind.

<sup>104</sup> Pew Charitable Trusts, *Who's Winning the Clean Energy Race?*, March 2010, [http://www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Reports/Global\\_warming/G-20%20Report.pdf?n=5939](http://www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Reports/Global_warming/G-20%20Report.pdf?n=5939).

the federal government to help create a domestic manufacturing capacity. Such an effort may have to go beyond tax credits and loan guarantees which have been used to this point in time if the development of renewable energy technology manufacturing capacity and “green jobs” creation are goals. In some countries, these policies can be instituted at the discretion of a central government. The massive allocation of government-funded resources by countries seeking to build renewable energy technology leadership and global market share is an indication of the greater reliance these nations expect to have on the renewable energy industry. The potential for product and equipment sales is key to their belief that such a transition should be accelerated.

China has chosen to implement a Renewable Energy Law mandating minimum deployment levels for renewable electricity technologies (in terms of gigawatts of capacity by a target date), and to support these deployment goals with a complementary, national feed-in tariff for selected technologies. If increased deployment of renewable electricity technologies is a U.S. policy goal, a recent analysis by the National Renewable Energy Laboratory suggests that the United States could also implement both a renewable electricity standard and a FIT.<sup>105</sup>

The United States has traditionally relied primarily on market forces and tax incentives to encourage the development and deployment of new technologies. This would be the “business as usual” model. However, several forces are in play that call the “business as usual” model for innovation and deployment of renewable energy technologies into question: for example, investment dollars are scarce at this time, as the nation struggles to emerge from a recession; and other nations have aggressively used governmental powers to channel resources into renewable energy programs that have permitted them to establish renewable energy industries whose products and productivity often exceed those of the United States. Further, many believe that the U.S.’s existing (mostly non-renewable) low-cost energy system limits market opportunities in the short term, despite potential opportunities in the longer term or abroad. As a result, numerous observers and pundits have argued for more aggressive governmental intervention to bolster and accelerate U.S. activities relating to renewable energy. This is the backdrop for President Obama’s declaration of a U.S. policy to invest in clean energy jobs.

While the PTC and ITC are considered important to industry investment in renewable energy deployment, plans to make these tax incentives applicable over the long-term have yet to eventuate. One option of a model for the future could be the Obama Administration’s inclusion in the FY2010 budget of \$75 billion to make permanent the Internal Revenue Code Section 41, Research and Experimentation tax credit.<sup>106</sup> The credit, which expired at least eight times, was designed to help businesses develop new and improved products and processes.

Like China, the United States relies most on coal for electric power generation with that fuel providing about half of the U.S. power generation.<sup>107</sup> Clean coal is seen as a part of China’s clean energy future, and an opportunity exists for China and the United States to work together to develop clean coal technology.<sup>108</sup> However, China has decided that renewable electricity will also be a significant part of that energy future, with current plans for renewable energy sources to

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<sup>105</sup> FITP.

<sup>106</sup> [http://www.whitehouse.gov/the\\_press\\_office/Fact-Sheet-A-Historic-Commitment-To-Research-And-Education/](http://www.whitehouse.gov/the_press_office/Fact-Sheet-A-Historic-Commitment-To-Research-And-Education/).

<sup>107</sup> U.S. Energy Information Administration, *Net Generation by Energy Source: Total (All Sectors)*, May 14, 2010, [http://www.eia.doe.gov/cneaf/electricity/epm/table1\\_1.html](http://www.eia.doe.gov/cneaf/electricity/epm/table1_1.html).

<sup>108</sup> See [http://www.energy.gov/news2009/documents2009/US-China\\_Fact\\_Sheet\\_Coal.pdf](http://www.energy.gov/news2009/documents2009/US-China_Fact_Sheet_Coal.pdf).

contribute 15% of its primary energy needs by 2020. Targets, planning, and investment have all followed to further China's renewable energy goals.

Unconventional sources of natural gas, such as coalbed methane and gas shales, may be resources that both the United States and China can develop.<sup>109</sup> Recent technological developments have raised the potential for natural gas to be produced in abundance especially from tight, impermeable shale formations. The outlook for renewable energy development could be affected if these unconventional natural gas sources can be developed and economically produced in an environmentally acceptable manner.<sup>110</sup>

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<sup>109</sup> See [http://www.adv-res.com/pdf/Kuuskras%20Condensed%20Worldwide%20Uncon%20Gas%202012\\_12\\_09.pdf](http://www.adv-res.com/pdf/Kuuskras%20Condensed%20Worldwide%20Uncon%20Gas%202012_12_09.pdf).

<sup>110</sup> CRS Report R40894, *Unconventional Gas Shales: Development, Technology, and Policy Issues*, coordinated by Anthony Andrews.