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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 approximately 1.4 billion people. 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. This has led to an increasing demand for energy, spurring China to more than double its electric power generating capacity in each of the last three decades, growing from 66 GigaWatts (GW) installed in 1980 to 1,100 GW installed as of 2011. Coal currently fuels about 66% of China's electricity generation. However, the reduction of air pollution (caused in part by the burning of coal for electric power) has become a major public policy focus in China.

China has set ambitious targets for developing its 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 91 GW in 2013; China surpassed the United States in 2010 with over 41 GW of installed wind power capacity. Notably, however, approximately 18% of that capacity was not yet connected to the power grid in 2013. Plans already exist to grow China's wind power capacity to 200 GW by 2020. A similar goal exists for the solar photovoltaic (PV) power sector. Installed solar PV capacity rose from 0.14 GW as of 2009 to over 19 GW in 2013, with goals reported for 50 GW of solar PV capacity by 2020. Also, a hold on large- and medium-scale hydropower project development has been lifted, with a virtual doubling of hydropower capacity from approximately 200 GW of capacity to 380 GW planned by 2020. The 12th Five-Year Plan (FYP) encompassing the years 2011 to 2015 has further formalized the link to green energy with specific deployment goals and investment. China recognizes that developing its domestic renewable energy industry and building its manufacturing capacity will help it meet energy demands at home and potentially win advantages in future export markets.

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, and was originally based on the incremental cost difference between coal and renewable energy power generation.

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." China is the world's largest market for new construction, and new building standards have been in development since 2005 with national energy design criteria for residential buildings. In the power generation sector, many smaller, less efficient coal-fired power plants have been closed. The 11th FYP targeted a 20% overall reduction in the energy intensity (i.e., energy consumption per unit of GDP) of the economy. The 12th FYP builds upon this goal, aiming to reduce energy intensity an additional 16% by 2015.

In contrast to China, 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, for both countries, 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, and economic development.

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Introduction

China is the world's most populous country with approximately 1.4 billion people. 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.[1] This rapid economic growth has led to an increasing demand for energy, spurring China to more than double its electric power generating capacity in each of the last three decades, growing from 66 GigaWatts (GW) installed in 1980 to 1,100 GW installed as of 2011.[2]

China is also the world's largest producer and consumer of coal.[3] According to the U.S. Energy Information Administration (EIA), coal currently fuels about 66% of China's electricity generation.[4] However, the reduction of air pollution caused in part by the burning of coal for electric power has become a major public policy focus in China.[5] While many of China's new coal plants are among the most technically advanced in the world,[6] burning coal results in sulfur dioxide, oxides of nitrogen, and particulate emissions which contribute to air pollution, and greenhouse gas[7] emissions linked to global climate change.[8] The current and potential future environmental consequences of burning coal are a major reason China has been decreasing the use of coal,[9] and actively seeking to increase its renewable energy[10] capabilities. When current rates of use are considered, limited domestic reserves of coal, natural gas, and oil provide another impetus for change. 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.[11]

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1 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.

2 Energy Information Administration, "International Energy Statistics: Total Electricity Installed Capacity," http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=2&pid=2&aid=7.

3 World Coal Association, "Coal Statistics," 2012, http://www.worldcoal.org/resources/coal-statistics/.

4 Energy Information Administration, "China—Overview," February 4, 2014, http://www.eia.gov/countries/cab.cfm?fips=CH.

5 Lucy Hornby, "China Pollution: Trouble in the Air," *Financial Times*, February 26, 2014, http://www.ft.com/intl/cms/s/0/c8d06578-98d8-11e3-8503-00144feab7de.html#axzz2zYnYdFCA.

6 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.

7 Greenhouse gases are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

8 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.

9 Coal-fired electricity was reported by EIA to be 70% of China's generation capacity as of 2009.

10 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.

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

Figure 1. Map of China

Administrative Regions and Provinces

Source: http://www.nationsonline.org/maps/china-provinces-map-855.jpg.

China has ambitious targets for developing both its hydropower and non-hydropower renewable energy resources with a major push of laws, regulations and incentives in the last few years. Development of large- and medium-sized hydropower projects had previously been at a standstill with environmental impact and population displacement issues presenting major obstacles.[12] The wind power sector is illustrative of China's accomplishments, as installed wind power capacity has gone from 567 MegaWatts (MW) in 2003 to 75,000 MW in 2012.[13] Developing its domestic

[12] Xie Liangbing and Chen Yong, *Making Up for Lost Time: China's Hydropower Push,* Economic Observer, January 24, 2011, http://www.eeo.com.cn/ens/Industry/2011/01/24/192214.shtml. (CHHYDP).

[13] Global Wind Energy Council, *Global Wind Report—2012*, 2012, http://www.gwec.net/wp-content/uploads/2012/06/ (continued...)

renewable energy resources also provides a growth opportunity for China's domestic renewable energy technology industries, and serves to increase its domestic manufacturing capabilities.

This report will look at the laws, programs, and policies encouraging development of wind, solar, hydropower, and biomass power in the China and the United States as the major renewable electricity technologies common to both countries.

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, and will be the focus of this report. 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[14]

Most of the large industries in China (such as steel and petrochemicals) are comprised of state-owned enterprises which are essentially run by the national government. The five large power generation companies in China are also government entities: 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 (see **Figure 1**). 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).[15]

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 has provided additional momentum.[16] Policies for encouraging renewable energy in China are largely driven by the central government, and enacted through national and provincial and local government programs.

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Annual_report_2012_LowRes.pdf.

[14] 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.

[15] The highest level body coordinating energy policy in China is the National Energy Commission established in January 2010. It is tasked with formulating energy development strategy, reviewing major issues related to energy security and energy development, and coordinating energy exploitation and international cooperation on energy issues. Its members include the heads of ten government ministries, several quasi-ministries and regulatory commissions, the governor of the Central Bank, a deputy chief of the People's Liberation Army, and other power figures. "China's National Energy Commission Is Established," *China People's Daily online*, January 27, 2010, http://english.peopledaily.com.cn/90001/90778/90862/6880658.html.

[16] "China bound its commitment domestically through a State Council decision even before last year's Copenhagen meeting, and it has said that the 40-45% carbon intensity reduction target will also be incorporated into its 12th Five-
(continued...)

China led global investment in 2013 with $61.3 billion in clean energy funding, but that amount was down 4% from the $63.8 billion invested in 2012. This represented the first decline in China's clean energy spending in over a decade.[17]

Clean Energy Research and Development Programs[18]

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.[19]
>
> **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 to diversify 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.[20]
>
> **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.[21]
>
> **Five-Year Plans**: The Five-Year Plans (FYP) are the guide to China's economic growth. The 10th FYP (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 11th FYP (for 2006 to 2010) identifies energy technologies as a focus of the 863 Program, with hydrogen, fuel cells,

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Year Plan to be adopted by its National People's Congress in March 2011." See Deborah Seligsohn, *Cancún Climate Change Summit: China's Journey from Copenhagen*, Guardian Environmental Network, WRI, November 1, 2010, http://www.guardian.co.uk/environment/2010/dec/01/cancun-climate-change-summit-china.

[17] Bloomberg New Energy Finance, "Clean Energy Investment Falls for Second Year," press release, January 15, 2014, http://about.bnef.com/press-releases/clean-energy-investment-falls-for-second-year/.

[18] Ministry of Science and Technology of the People's Republic of China, *Key Technologies R&D Program*, http://www.most.gov.cn/eng/programmes1/200610/t20061009_36224.htm.

[19] Center for American Progress, *Out of the Running?*, March 2010, http://www.americanprogress.org/issues/2010/03/pdf/out_of_running.pdf. (CAP).

[20] CAP.

[21] CAP.

energy efficiency, clean coal and renewable energy a focus of $172 million in funds. The 11th FYP has also made utility-scale renewable energy and new energy development the 973 Program's main focus.[22] Renewable energy was increasingly being linked to China's future wellbeing—both economically and environmentally.

The 12th FYP will encompass the period from 2011 to 2015, and was formally announced in March, 2011. Energy efficiency and renewable energy continue as a focus of China's government as part of seven new "Strategic Emerging Industries."[23] China will likely follow the plan with specific investment goals (through preferential tax, fiscal and procurement tools) in biotechnology, new energy (i.e., nuclear, solar, wind power, biomass), High-end Equipment Manufacturing, Energy Conservation and Environmental Protection (i.e., energy efficiency, advanced environmental protection, recycling), Clean-Energy Vehicles, New Materials, and Next-Generation Information Technology. These industries are expected to become the "backbone of China's economy" in the near future, offering inroads to global markets.[24]

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**.[25] 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.[26]

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

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

[23] HSBC Global Research, *China's Next 5-Year Plan—What It Means for Equity Markets*, October 6, 2010, http://www.research.hsbc.com/midas/Res/RDV?p=pdf&key=DRpq0Zsciy&n=279532.PDF.

[24] APCO Worldwide, *China's 12th Five-Year Plan—How It Actually Works and What's in Store for the Next Five Years*, December 10, 2010, http://www.apcoworldwide.com/content/PDFs/Chinas_12th_Five-Year_Plan.pdf.

[25] Angie Austin, *Energy and Power in China: Domestic Regulation and Foreign Policy*, The Foreign Policy Centre, April 2005, http://fpc.org.uk/fsblob/448.pdf.

[26] Electric Power Law of the People's Republic of China, Article 48, http://www.lehmanlaw.com/resource-centre/laws-and-regulations/environment/electric-power-law-of-the-peoples-republic-of-china-1996.html.

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 use 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 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. [27]

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 in reducing the energy intensity[28] 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.[29]

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."[30]

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[27] See Law of the People's Republic of China on Conserving Energy, http://www.china.org.cn/english/environment/34454.htm.

[28] Energy intensity as consumption per unit of gross domestic product.

[29] National Development and Reform Commission of China, *National Climate Change Program*, June 4, 2007, http://www.china.org.cn/english/environment/213624.htm.

[30] Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution, Article 9, http://www.china.org.cn/english/environment/34422.htm.

However, the key piece of legislation in recent years for moving renewable energy deployment forward is the **Renewable Energy Law of 2005**.[31] 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. It:

- Allows for middle and long-term national targets to be set for the total volume of renewable energy development (Article 7);
- Mandates connection with the grid and the purchase of electricity from licensed renewable energy generators (Article 14); and
- 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**[32] (MLTPRE) in 2007 to implement the law. The MLTPRE established national deployment goals by technology to reach renewable energy. 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 15% by 2020. The cost of renewable energy development and deployment in excess of conventional power (e.g., coal) is to be socialized by passing the expense to all customers as a surcharge to the retail price of power.

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 are required to have non-hydropower renewable energy of 3% of total capacity as of the end of 2010, and at least 8% by 2020.[33]

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. Power companies refusing to comply are to be fined an amount up to twice the "economic loss" of the renewable energy producer.[34]

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[31] Renewable Energy World, *Authorized Release: The Renewable Energy Law. The People's Republic of China,* http://www.renewableenergyworld.com/assets/download/China_RE_Law_05.doc. (RELaw).

[32] National Development and Reform Commission, People's Republic of China, *Medium and Long-Term Development Plan for Renewable Energy in China*, Abbreviated English Language version, September 2007, http://www.chinaenvironmentallaw.com/wp-content/uploads/2008/04/medium-and-long-term-development-plan-for-renewable-energy.pdf.

[33] Ibid.

[34] China Economic Net, *China Adopts Amendment to Renewable Energy Law*, December 26, 2009, http://en.ce.cn/National/Politics/200912/26/t20091226_20695325.shtml. (CENet).

China's pledge for 15% of total energy consumption to come from nonfossil fuel sources by the year 2020 made ahead of the 2009 climate talks in Copenhagen[35] was reiterated by the National Energy Administration[36] at a Beijing national work conference in January 2011.[37] The 11th FYP targeted a 20% overall reduction in the energy intensity[38] of the economy. The 12th FYP builds upon this goal, aiming to reduce energy intensity an additional 16% by 2015.[39]

Renewable Energy Focus

China's renewable energy development goals are shown in **Table 1**. The major renewable energy technologies are described in the following paragraphs. Since China considers hydropower to be renewable energy, it is also included in the section.

Table 1. China—Renewable Energy Deployment Targets

(Capacities by Year)

Renewable Energy Source	2005	2010	2020
Hydropower	117 GW	200 GW[a]	380 GW[b]
Biomass Power	2 GW	5.5 GW	30 GW[b]
Wind Energy	1.26 GW	42 GW[a]	200 GW[b]
Solar PV	0.07 GW	0.6 GW[a]	50 GW[b]
Bioethanol[c]	1.02 million tons	2 million tons	10 million tons
Biodiesel[d]	50,000 tons	200,000 tons	2 million tons

Source: Compiled by CRS from various sources.

Notes: GigaWatts (GW)

a. Actual installed capacity for 2010.

b. Reported new target.

c. Non-food grains used as feedstock.

d. From waste and edible oil sources.

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[35] Peta Hodge, "China's Emissions Pledge Shows Commitment to Copenhagen," *Green Business News*, November 26, 2009, http://www.greenwisebusiness.co.uk/news/chinas-emissions-pledge-shows-commitment-to-copenhagen-936.aspx.

[36] The National Energy Administration (NEA) was created in March 2008 as part of the general reforms of the Chinese energy sector by the Congress of the Communist Party of China. The NEA is a semiautonomous body under the NDRC responsible for energy planning and development, drafting of energy laws, and international energy cooperation. See http://ec.europa.eu/energy/international/bilateral_cooperation/china/stakeholders_en.htm.

[37] Barbara Finamore, *Staff Blog—China's Announcements on Energy and Climate in Advance of Presidential Summit*, Natural Resources Defense Council, January 18, 2011, http://switchboard.nrdc.org/blogs/bfinamore/chinas_announcements_on_energy.html.

[38] The amount of energy used in producing a given level of output or activity. It is measured by the quantity of energy required to perform a particular activity (service), expressed as energy per unit of output or activity measure of service. See http://www1.eere.energy.gov/analysis/eii_trend_definitions.html.

[39] Center for Climate and Energy Solutions, *Energy and Climate Goals of China's 12th Five-Year Plan*, March 2011, http://www.c2es.org/international/key-country-policies/china/energy-climate-goals-twelfth-five-year-plan.

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 electric production was estimated to have reached 5,500 MW in 2010, and is expected to increase to 30,000 MW by 2020.[40] Biomass is widely used in China's rural areas where over 80% of the population lives.[41] When biomass is used in biogas digesters, the resulting biogas mixture can be up to 70% methane.[42] Biogas produced from livestock manure is a major resource in rural areas for household cooking and heating.[43] Biogas methane can also be used to fuel internal combustion engine generators 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 is 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.[44] Biomass power projects are eligible for a feed-in tariff[45] (FIT) which was raised to $0.051 per kilowatt-hour in 2008.[46] A production subsidy was authorized of $19 to $22 per ton of biomass pellets produced from agricultural or forestry residues.[47] 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 kiloWatt-hours (kWh) of electricity, thus displacing power from coal-based generation. The ashes left over from the combustion process can be used for fertilizer.[48]

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[40] David DuByne, "Biogas? China Size It," *Science Alert*, May 9, 2008, http://www.sciencealert.com.au/opinions/20080905-17301.html.

[41] http://www.cite-sciences.fr/france-chine/en/chinaworld/2/c15.html

[42] 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.cleanenergyresourceteams.org/technology/biogas-digesters.

[43] 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.

[44] Renewable Energy Policy Network for the 21st 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. (RECREN).

[45] "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).

[46] RECREN.

[47] RECREN.

[48] Zhang Qi, "Burning Willows to Stop Desertification," *China Daily*, May 11, 2009, http://www.chinadaily.com.cn/bw/2009-05/11/content_7761535.htm.

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. 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,[49] 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.[50] As of 2009, China was the world's third largest national producer of ethanol, following the United States and Brazil.[51]

Hydropower

China is now the world's largest hydropower producer with over 229 GW of installed capacity.[52] That capacity is expected to increase to 290 GW by 2015, according to goals announced by China's National Energy Administration, with major new dams to be installed on the Huanghe, Jinshangjiang,Yalongjhiang, Daduhe, Nujiang, and Lancangjiang rivers.[53] With the lifting of the effective "ban" on large- and medium-scale hydropower development, [54] China now reportedly plans to virtually double its hydropower capacity to 380 MW by 2020.[55] China's overall potential for "technically developable" hydropower is estimated to be 542 GW, with over 400 GW of that capacity seen as "economically developable." Past dam-building booms created many water resource and environmental problems, but China's government has passed a variety of water-protection laws and regulations over the last 20 years which it hopes will reduce environmental impacts of the current dam-building cycle.[56]

Solar

China's initial goal for solar power was established in the 2007 MLTPRE at 1.8 GW. A "Golden Roofs" initiative announced in March 2009 provided a subsidy of $2.93 per Watt for roof-mounted solar photovoltaic[57] (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 kWh was also established for PV power projects at the same time. Encouragement for larger utility scale solar projects was

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[49] 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.

[50] Jonathan Lynn, "China Became Net Food Importer in 1st Half," *Reuters*, August 22, 2008, http://www.planetark.com/dailynewsstory.cfm/newsid/49900/story.htm.

[51] Renewable Fuels Association, *World Ethanol Production*, 2014, http://ethanolrfa.org/pages/World-Fuel-Ethanol-Production.

[52] Jonathan Moch, *Renewable Energy in China: An Overview*, World Resources Institute, 2013, http://www.chinafaqs.org/library/chinafaqs-renewable-energy-china-overview-0.

[53] Energychinaforum.com, "NEA Outlines Key Tasks For Energy Sectors, To Benefit Related Listed Firms," January 20, 2011, http://www.energychinaforum.com/news/46032.shtml.

[54] See CHHYDP.

[55] Includes 330 GigaWatts (GW) conventional hydropower, and 50 GW of pumped storage. See http://www.electricityforum.com/news/sep10/Chinesehydropowertoreach380GWby2020.html.

[56] Peter Bosshard, "Dam Nation," *Foreign Policy*, March 8, 2011, http://www.foreignpolicy.com/articles/2011/03/08/dam_nation.

[57] Solar energy is converted directly into electricity using photovoltaic cells which capture photons.

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 was for projects of 300 MW capacity (and above) which are in service for a minimum of 20 years.[58] 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 $0.63 per kWh of electricity generated.[59]

A national solar FIT was initiated in 2011 at 1.15 yuan ($0.19) per kWh for ground-based, utility-type systems, but the subsidy was lowered that year to 1 yuan ($0.16) per kWh. China announced a new FIT policy in 2013, extending the program to cover distributed generation (DG) including rooftop systems. The subsidy was changed to 0.9 yuan ($0.14) per kWh generated for ground systems, with 0.95 yuan ($0.15) per kWh or 1 yuan ($0.16) per kWh possible based on solar radiation levels where the solar plant is located. DG PV systems are eligible for 20 years to receive a subsidy of 0.42 yuan ($0.07) per kWh generated.[60] Distributed systems may also get the coal-fired electricity price of a further 0.20 to 0.36 yuan ($0.03 to $0.06) per kWh for surplus electricity sent back to the grid.

As of 2011, manufacturers in China accounted for 63% of global solar photovoltaic (PV) panel production.[61] Installed capacity in China has grown more slowly than production, with a total of 0.6 GW of solar PV installed as of 2010.[62] With the global economic downtown came a slowdown in overseas orders for PV panels, and so China began to look at developing the domestic solar market. China increased its goals for domestic solar PV capacity, with installed capacity rising to 19 GW in 2013,[63] following through with a policy to move away from coal for electric power generation.[64] Plans have now been reported for increasing installed capacity to as much as 50 GW by 2020.

Pilot plants for large scale concentrating solar power[65] (CSP) facilities were proposed for Gansu (300 MW) and Shaanxi (92 MW), with discussions for a demonstration plant in Inner Mongolia

[58] 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.

[59] 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.

[60] Xie Yu, "New Policy Boosts Construction of Solar Plants," *China Daily*, September 13, 2013, http://www.chinadaily.com.cn/business/2013-09/13/content_16968866.htm.

[61] David L. Chandler, *Solar-Cell Manufacturing Costs: Innovation Could Level the Field*, Massachusetts Institute of Technology, MITNews, September 5, 2013, http://web.mit.edu/newsoffice/2013/solar-cell-manufacturing-costs-0905.html.

[62] Energychinaforum.com, *India and China to Benefit As Global Solar PV Returns to Pre-Recession Growth,* March 8, 2011, http://www.energychinaforum.com/news/47839.shtml.

[63] Bloomberg New Energy Finance, *China Overview*, 2013, https://www.newenergyfinance.com/core/country-profiles/chn.

[64] Jennifer Duggan, "China Sets New World Record for Solar Installations," *The Guardian News*, January 30, 2014, http://www.theguardian.com/environment/chinas-choice/2014/jan/30/china-record-solar-energy.

[65] Solar energy is converted into heat energy using fields of lenses and mirrors focused on a pipe carrying a fluid (solar troughs), or aimed at a tower (i.e., a power tower). The heat produces a temperature sufficient to turn water into steam (continued...)

(50 MW).[66] China now reportedly has a goal of developing 3 GW of CSP by 2015, growing to 10 GW by 2020.[67]

Wind

China's installed wind capacity was reported to be 91 GW as of 2013, and plans have been reported to increase wind capacity to 200 GW by 2020.[68] The official MLTPRE target for 30 GW of installed wind power by 2020 has long been surpassed. China became the world's leader with almost 42 GW of installed wind power capacity in 2010. However, the United States still led in total electrical energy produced from wind power, because China's grid-connected capacity lagged behind its installed capacity by over 30% at that time.[69] As of the end of 2012, China was reported to have 75 GW of installed capacity, meaning that about 17% of wind capacity was not connected to the grid.[70] China plans to increase investment in its transmission system to connect the remote regions where wind farms are being built to population centers where the power can be used.

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 introduction of a tender process for award of concessions for wind power projects.[71]

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. [72]

The regional grid power company would enter into a long-term power purchase agreement to buy electricity from the selected bidder over the life of the wind project, with the national government guaranteeing the power purchase. The bidding process would also determine the in-grid tariff,

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(...continued)

and drive a turbine just as in a thermal power station.

[66] Helios CSP, "China Moves Toward Concentrating Solar Power Plants," February 23, 2011, http://helioscsp.com/noticia.php?id_not=221.

[67] John A. Mathews, Mei-Chih Hu, and Ching-Yan Wu, "Concentrating Solar Power: China's New Solar Frontier," *Asia-Pacific Journal*, Vol. 11, Issue 21, No. 2, May 27, 2013, http://www.japanfocus.org/-Ching_Yan-Wu/3946.

[68] SustainableBusiness.com News, "China Leads Wind Industry Growth for 2013," February 10, 2014, http://www.sustainablebusiness.com/index.cfm/go/news.display/id/25506.

[69] Whats On Xiamen, Inc., "China Overtakes US as World's Largest Wind-Power Installer," January 14, 2011, http://www.whatsonxiamen.com/tech625.html.

[70] Global Wind Energy Council, *Global Installed Wind Power Capacity in 2013—Regional Distribution*, 2013, http://www.gwec.net/global-figures/graphs/.

[71] Li Junfeng, Shi Jingli, and Xi Hongwen, et al., *A Study on the Pricing Policy of Wind Power in China, Chinese Renewable Energy Industries Association, Greenpeace*, Global Wind Energy Council, October 2006, http://gwec.net/wp-content/uploads/2012/06/Report-wind-power-price-policy-china.pdf.

[72] With the exception of Guandong Province which approves its own projects and prices. RECREN.

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.[73] Initially, mixed results came from the tenders received with many being structured on impractically low power prices. Winning bids were often too low to make the projects economically viable. This prompted the government to change the weighting of power prices in its process of evaluating the bids.[74]

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. 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.[75]

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.[76] 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. As of 2009, China's Meteorological Administration estimated China's developable wind power resources at over 250 million kWh,[77] with a potential onshore capacity of between 700 GW and 1,200 GW.

Offshore wind is a largely untapped resource in China. 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.[78] As of 2012, China's offshore installed capacity is about 260 MW, which accounts for only about 0.5% of installed wind capacity.[79] China has an ambitious goal of 30 GW of installed offshore wind capacity for 2020.

[73] "Wind Power in China," *Ecoworld*, July 2006, http://www.ecoworld.com/energy-fuels/wind-power-in-china.html.

[74] RECREN.

[75] RELaw.

[76] Tariff levels ranged from $0.07 to $0.09 per kWh. Rob Atkinson, Michael Shellenberger, and Ted Nordhaus, et al., *Rising Tigers, Sleeping Giants*, The Breakthrough Institute and the Information and Technology Innovation Foundation, November 2009, http://thebreakthrough.org/blog/Rising_Tigers.pdf.

[77] 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.

[78] "China Speeds Up Offshore Wind Power Construction," China.Org.Cn, Xinhua, March 20, 2010, http://www.china.org.cn/business/2010-03/20/content_19647071.htm.

[79] Global Wind Energy Council, *Global Offshore: Current Status and Future Prospects*, 2014, http://www.gwec.net/global-offshore-current-status-future-prospects/.

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 be technology specific. Pricing for renewable energy is not standardized, and is set by contracts negotiated between projects and utilities.[80]

Renewable energy is subsidized by a rate fee charged to all electricity users in China.[81] Electricity customers in China pay rates according to customer class.[82] The fee was originally based on the incremental cost difference between coal and renewable energy (which was estimated in China at $0.044 to $0.059 per kWh).[83] 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 doubled in 2009 to about 0.8% of their electricity bill.[84]

However, reported problems with levels of payments into the renewable energy fund led to delays in reimbursing generators of renewable energy.[85] To address the issue, the NDRC shifted the burden of renewable energy funding to the industrial sector in 2013 by doubling the industrial surcharge to 0.015 yuan ($0.25) per kWh, while keeping the fee levied on other electricity customers at a rate of 0.008 yuan ($0.13) per kWh.[86]

Under the economic stimulus plan designed to help China recover from the 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.[87]

China is now using more of its own domestic manufacturing capacity to meet domestic clean energy needs, and relying 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 enabled the financing of renewable energy projects.[88] Preferences were established with the Government Procurement Law of 2002, which specified government

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80 National Renewable Energy Laboratory, *Renewable Energy in China—Financial Incentives*, NREL/FS-710-36045, April 2004, http://www.nrel.gov/docs/fy04osti/36045.pdf.

81 The original surcharge of 0.014 cents per kWh was increased to 0.029 cents per kWh in 2007. See RECREN, p. 23.

82 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.

83 RECREN.

84 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).

85 Michael Davidson, *Transforming China's Grid: Sustaining the Renewable Energy Push*, The Energy Collective, September 24, 2013, http://theenergycollective.com/michael-davidson/279091/transforming-china-s-grid-sustaining-renewable-energy-push.

86 Ibid.

87 Zhu Shaobin, "China's Economic Stimulus Plans Benefit Environment," *Xinhua*, March 3, 2009, http://news.xinhuanet.com/english/2009-03/10/content_10986048.htm.

88 NYT1.

procurement of domestic goods, construction and services, unless availability or other conditions existed to impair such procurement.[89]

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." Under the Wind Power Concession Project, the NDRC is "overseeing construction" of a series of wind farms of at least 10 GW generating capacity.[90] The determination of domestic content was 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. As much as 70% of wind power equipment was required to be produced in China until 2009, when local content requirements were abolished with the introduction of the wind power FIT.[91]

Financial incentives for other renewable energy projects in China are available from both the national and provincial governments. The central government offered an investment subsidy of 50% for solar power projects under the Golden Sun program in 2009. However, subsidies for solar PV projects for the developer's own use were reduced (e.g., grid-connected rooftop solar) from 7 yuan ($1.11) per Watt to 5.5 yuan per Watt due to the drop in solar PV panel prices. For biomass power projects, a $0.04 per kWh subsidy was offered, along with incentives such as risk reserves and tax breaks, and the government has established at least one joint venture to demonstrate and deploy biomass power technology at a reported 40 plants.[92]

Incentives for non-food sourced biofuels production are available to farmers and biofuel producers. Ethanol production in 2006 was 1.56 million tons compared to 0.19 million tons for biodiesel, with subsidies for ethanol at $115 million and 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.[93] 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

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[89] The Government Procurement Law of the People's Republic of China (Order of the President No. 68), Article 10, http://english.gov.cn/laws/2005-10/08/content_75023.htm.

[90] See *China's Promotion of the Renewable Electric Power Equipment Industry*, http://www.nftc.org/default/Press%20Release/2010/China%20Renewable%20Energy.pdf. (CPRE).

[91] "In China, all wind turbine generator manufacturers were required to use respectively 40% (before 2003), 50% (2003) and 70% (until 2009) of domestic components in the manufacturing of wind turbines." Jan-Christoph Kuntze and Tom Moerenhout, *Local Content Requirements and the Renewable Energy Industry—A Good Match?,* International Centre for Trade and Sustainable Development, June 2013, http://unctad.org/meetings/en/Contribution/DITC_TED_13062013_Study_ICTSD.pdf.

[92] 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.

[93] "China to Offer Incentives for Non-Food Biofuels," *Xinhua*, November 7, 2007, http://www.chinadaily.com.cn/china/2007-12/07/content_6306076.htm.

biodiesel is expected to rise to $1.2 billion by 2020, excluding the subsidy support to farmers mentioned earlier.[94]

China provides substantial domestic subsidies to its green energy industries in support of its deployment goals. However, in the wake of complaints in the United States (principally by the United Steelworker's Union) that China was illegally subsidizing its wind power and solar PV exports in violation of World Trade Organization (WTO) obligations, the U.S. Trade Representative announced an investigation in 2010 of China's support for makers of wind power, solar energy, advanced batteries, and energy-efficient vehicles.[95]

China's export restrictions on rare-earth elements[96] (REEs) were described by the United Steelworkers Union as an example of China's unfair trade practices, as China produced 97% of the world's REEs and charged a 10% export tariff. China cut its exports of REEs by 40% in July 2010, causing global demand to exceed supplies for the first time.[97] The WTO issued a report in 2011, which stated that Chinese restrictions on its exports of nine raw materials were inconsistent with WTO rules, which induced WTO members to bring a similar case against China over its export restrictions on REEs.[98] China's government denied the allegations of unfair trade practices, pointing to proposed federal incentives for the U.S. clean energy industry as comparable subsidies.[99] The WTO ruled against China for a second time in 2013, judging that China's export restrictions on REEs were incompatible with WTO rules.[100]

United States

Some observers would argue that the United States does not have a comprehensive national policy in place for promotion of renewable energy technologies. Others might say that federal policies exist, providing corporate tax incentives for renewable electricity, even though the incentives are generally authorized for short periods, and have been periodically reauthorized. And even when such renewables incentives 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, with the programs authorized by the American Recovery and Reinvestment Act of 2009 being an example. An exception, however, is biofuels which do have significant federal government support in the form

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[94] 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.

[95] Sewell Chan and Keith Bradsher, "U.S. to Investigate China's Clean Energy Aid," *New York Times*, October 15, 2010, http://www.nytimes.com/2010/10/16/business/16wind.html.

[96] A group of 17 elements consisting of scandium, yttrium, and the 15 lanthanides. Rare-earth elements are vital to many electronic and renewable energy technologies. See CRS Report R41347, *Rare Earth Elements: The Global Supply Chain*, by Marc Humphries.

[97] Robert F. Service, "Chinese Policies Could Pinch U.S. Efforts to Make Electric Vehicles," *Science*, vol. 329, no. 5990, p. 377, July 23, 2010, http://www.sciencemag.org/content/329/5990/377.1.short.

[98] John Miller and James Areddy, "Trade Judges See Flaw in China Policies: Preliminary WTO Report Finds No Case for Some of Beijing's Export Restrictions," *Wall Street Journal*, February 18, 2011.

[99] Michael Wines and Xiyun Yang, "China Rips US Complaint on Clean Energy Aid," *New York Times*, October 18, 2010, http://www.boston.com/news/world/asia/articles/2010/10/18/china_rips_us_complaint_on_clean_energy_aid/.

[100] Lucy Hornby and Shawn Donnan, "WTO Rules Against China on Rare Earths Export Quotas," *Financial Times*, October 29, 2013, http://www.ft.com/intl/cms/s/0/486d5c68-40b5-11e3-ae19-00144feabdc0.html#axzz2tEc5AsoQ.

of the Renewable Fuel Standard (RFS). The RFS mandates minimum goals for blending quantities of renewable fuels with gasoline and diesel through 2022.[101]

Much of the U.S. renewable electricity installed capacity is a result of state deployment initiatives[102] rather than federal programs, with 30 states having a renewable portfolio standard (RPS) in place to encourage deployment.[103] However, the availability of federal tax incentives has aided deployment in recent years, with the Investment Tax Credit[104] (ITC) being key to much of the investment in solar PV installations.

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 could 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 federal 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.[105]

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 U.S. 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

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[101] CRS Report R40155, *Renewable Fuel Standard (RFS): Overview and Issues*, by Randy Schnepf and Brent D. Yacobucci.

[102] 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). Union of Concerned Scientists, "Renewable Electricity Standards at Work in the States: Fact Sheet," http://www.ucsusa.org/assets/documents/clean_energy/RES_in_the_States_Update.pdf.

[103] See map of states with renewable portfolio standards at http://www.eia.gov/todayinenergy/detail.cfm?id=4850.

[104] See business energy tax credit discussion at http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US02F&re=1&ee=1.

[105] 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.

by requiring electric utilities to purchase electricity from qualifying small power and cogeneration facilities.[106]

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[107] 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,[108] and authorized subsidies for wind and other alternative energy technologies (e.g., the Renewable Energy Production Incentive discussed later in this report). EPACT also established the Production Tax Credit[109] (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 financial crisis of 2007 to 2008 in order 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.[110]

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[106] 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.

[107] 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.

[108] See http://www1.eere.energy.gov/femp/regulations/epact1992.html#wc.

[109] 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 Lynn J. Cunningham and Beth Cook.

[110] CRS Report R40412, *Energy Provisions in the American Recovery and Reinvestment Act of 2009 (P.L. 111-5)*, (continued...)

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

Renewable Energy Focus

The principal U.S. renewable energy sectors are described in the following paragraphs. Hydropower is not viewed by all U.S. experts as renewable energy, but since China has significant goals for hydroelectric development, a summary of U.S. hydropower is included.

Biomass

Biomass for electric power is arguably the most conventional of all renewable electricity technologies. Approximately 23.5% of non-hydropower renewable electricity produced in the United States came from biomass in 2010.[111] 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, and is categorized usually under coal power generation. 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 residential renewable energy applications. With wood and biomass electric power net summer generating capacity reported at 7.7 GW for 2012, DOE estimates that 11 GW of biomass capacity could be available by 2030.[112] The RFS is a significant factor in biofuels policy which has largely focused on corn-based ethanol[113] but is shifting to cellulosic and other advanced feedstocks.[114] 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.[115]

Hydropower

While only about 2,400 of the existing 80,000 dams in the United States produce power, many of the non-powered dams have a significant hydropower potential. A DOE study in 2011 indicated that enhancing existing hydro facilities, by adding turbines to dams without any hydro capacity or enhancing existing structures, is relatively inexpensive and could present a further opportunity as

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coordinated by Fred Sissine.

[111] U.S. Energy Information Administration, *Annual Energy Outlook 2014*, Renewable Energy Generating Capacity and Generation, April 2014, http://www.eia.gov/forecasts/aeo/tables_ref.cfm. (AEO 2014).

[112] Ibid.

[113] CRS Report R41282, *Agriculture-Based Biofuels: Overview and Emerging Issues*, by Randy Schnepf.

[114] CRS Report RL34738, *Cellulosic Biofuels: Analysis of Policy Issues for Congress*, by Kelsi Bracmort et al.

[115] See National Renewable Energy Laboratory, "Research Advances Cellulosic Ethanol, NREL Leads the Way," http://www.nrel.gov/biomass/pdfs/40742.pdf.

much as 12GW of capacity.[116] The opportunity is however concentrated at the top 100 non-powered dam sites.

However, a previous DOE's Idaho National Laboratory assessed the potential for developing small and low-head hydroelectric generation in the United States.[117] A set of feasibility criteria was established for "developable resources, and identified approximately 5,400 with the potential for small hydro projects (e.g., providing between 1 MW and 30 MW of annual mean power). DOE estimated these projects (if developed) could result in a greater than 50% increase in total U.S. hydroelectric power generation.

Solar

As of 2012, the net summer grid-connected solar power industry in the United States was approximately 7.7 GW of capacity, representing both solar PV and solar thermal capacity. DOE estimates that approximately 29 GW could be available by 2030.[118] Solar power, like wind power, is considered a variable resource but solar power technologies can produce its highest output at peak energy demand times when the weather is hot and sunny. Concentrating solar power thermal plants with heat storage capacity are being 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 (ITC) 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.

Wind

The net summer wind power capacity in the United States was approximately 59 GW in 2012.[119] However, DOE estimates that domestic wind power could reach a capacity of 77 GW or greater by 2030.[120] 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 $0.023 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.[121] The

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[116] Boualem Hadjerioua, Yaxing Wei, and Shih-Chieh Kao, *An Assessment of Energy Potential at Non-Powered Dams in the United States, DOE Wind and Water Power Program*, ED 19 07 04 2, April 2012, http://nhaap.ornl.gov/system/files/NHAAP_NPD_FY11_Final_Report.pdf.

[117] U.S. Department of Energy—Idaho National Laboratory, Feasibility Assessment of the Water Energy Resources of the United States for New Low Power and Small Hydro Classes of Hydroelectric Plants, DOE-ID-11263, January 2006, http://hydropower.inel.gov/resourceassessment/pdfs/main_report_appendix_a_final.pdf.

[118] AEO 2014.

[119] AEO 2014.

[120] CRS Report R40833, *Renewable Energy—A Pathway to Green Jobs?*, by Richard J. Campbell and Linda Levine.

[121] See Ryan Wiser and Mark Bolinger et al., "Annual Report on U.S. Wind Power Installation, Cost, and Performance (continued...)

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 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.

The PTC was scheduled to expire at the end of 2012, but was extended for one year, through 2013, as part of the American Taxpayer Relief Act (ATRA; P.L. 112-240). In addition to extending the PTC for wind, provisions in ATRA changed the credit expiration date from a placed-in-service deadline to a construction start date for all qualifying electricity-producing technologies.[122]

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 with a total capacity of up to 468 MW.[123] The overall potential for U.S. offshore wind power production capacity was estimated at 908 GW in 2005.[124]

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 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.[125]

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Trends: 2007," National Renewable Energy Laboratory, May 2008, http://www.nrel.gov/docs/fy08osti/43025.pdf.

122 CRS Report R43453, *The Renewable Electricity Production Tax Credit: In Brief*, by Molly F. Sherlock.

123 Cape Wind Associates, "Frequently Asked Questions: Cape Wind Basics," 2014, http://www.capewind.org/faqs/cape-wind-basics.

124 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.

125 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.

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.[126] 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.[127] However, the program has not been funded since 2010.[128]

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 2014 Farm Bill extended the REAP program through FY2018, with mandatory funding of $50 million for FY2014 and each fiscal year thereafter.[129]

Discussion

China

With the process of urbanization continuing in China, a further 200 million to 300 million people are expected to move to urban areas over the next 20 years. This shift in population is seen as a driving force behind the change in focus from increasing GDP to increasing domestic consumption in the 12th Five-Year Plan. [130] The national government still owns or controls many of the country's large industries and enterprises, and sets goals for economic development in the periodic Five-Year Plans. As such, China's industries and enterprises are still encouraged to meet goals set in the national government's economic plan. But today's China also has a large and growing private sector, and improving the employment and income prospects for its citizens

[126] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Renewable Energy Production Incentive*, April 10, 2007, http://apps1.eere.energy.gov/repi/about.cfm.

[127] The payment under REPI was $0.021 per kWh. If there were 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 were to be awarded on a pro rata basis, if necessary. See http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US33F&re=1&ee=1.

[128] CRS Report R40913, *Renewable Energy and Energy Efficiency Incentives: A Summary of Federal Programs*, by Lynn J. Cunningham and Beth Cook.

[129] CRS Report R43076, *The 2014 Farm Bill (P.L. 113-79): Summary and Side-by-Side*, coordinated by Ralph M. Chite.

[130] S. Klamp, "Chinese 12th 5-Year Plan—New Energy, New Energy Cars," CITE Investments, November 8, 2010, http://cleaninvest.wordpress.com/2010/11/08/chinese-12th-5-year-plan-new-energy-new-energy-cars/.

appears to be behind a shift to a market focus in many areas of China's "socialist market economy."[131]

The 12th Five-Year Plan emphasizes the development 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, developing its domestic renewable energy industry and building manufacturing capacity can lead to advantages in future export markets. 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.[132] 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.

Officially, however, energy efficiency and conservation remain China's top energy priority. These are considered the "low-hanging fruit" in the quest to reduce energy use and cut demand. Energy efficiency in China's larger firms is approaching levels in Western countries. The 11th FYP saw China's energy consumption per unit of GDP (i.e., energy intensity) drop by 19.6%.[133] The 12th FYP may not result in the energy savings seen in the previous five years, since many small power plants, less energy efficient coal-fired power plants, and steel mills were shut down. Few if any of these less efficient producers remain open.[134] Most of the energy savings in the 12th FYP are expected to come from structural changes in China's economic structure and technological improvements.[135] 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.[136] 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) focus 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.[137] Energy efficient building codes are a key tool in establishing passive measures for energy savings in new future housing stock.

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[131] CRS Report RL30519, *The Growth of the Private Sector in China and Implications For China's Accession to the World Trade Organization*, by Wayne M. Morrison.

[132] CENet.

[133] Liu Jianqiang, *Reining in China's Energy Targets*, Chinadialogue, March 2, 2011, http://www.chinadialogue.net/article/show/single/en/4138-Reining-in-China-s-energy-targets.

[134] "China Small Power Plants Closures Ahead of Schedule," *Reuters*, July 3, 2010, http://in.reuters.com/article/2010/07/03/idINIndia-49857620100703.

[135] Yang Fuqiang, Hu Yangli, and Li Jingjjng, "China Needs Higher Targets," *Chinadialogue.net*, March 3, 2011, http://www.chinadialogue.net/article/show/single/en/4140—China-needs-higher-targets-.

[136] 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.

[137] 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.

The "weak link" in China's electricity planning has been transmission. Targets have been set for building renewable electric power generation without effective measures 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.[138] 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. Formal goals for a Smart Grid are expected to be incorporated into China's 12th Five-Year Plan, with a "unified strong and smart grid" to be built nationwide by 2020.[139] The lack of grid integration for wind has improved only slightly in the last few years, with curtailment of wind capacity (due to inadequate transmission capacity) being especially acute in the less populous northern western provinces of China.[140]

China today is dealing today 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 U.S. 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 (e.g., 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.[141] China's State Grid Corporation plans to invest $88 billion through 2020 to build UHV lines.[142]

United States

In contrast to China's socialist market economy, the United States has overall a market-driven economy. Some observers argue that the current higher costs of renewable electricity do not favor market adoption.[143] However, the goals for increased use of renewable energy are several, and

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[138] 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 "Wind Power Growth in China's Deserts Ignored Financial Risks," *The Guardian*, May 14, 2010, http://www.guardian.co.uk/environment/2010/may/14/wind-power-china-desert.

[139] The "Smart Grid" is an intelligent system capable of seamlessly integrating renewable energy sources like solar and wind power into the electricity network. See "China Sets to Build Smart Grid to Tap Renewable Energy," *Xinhua News*, March 13, 2010, http://news.xinhuanet.com/english2010/china/2010-03/13/c_13209617.htm.

[140] Micahel Davidson, "Spilled Wind: An Update on China's Wind Integration Challenges," *The Energy Collective*, March 4, 2014, http://theenergycollective.com/michael-davidson/346951/spilled-wind-update-china-s-wind-integration-challenges.

[141] 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.

[142] 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.

[143] 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.

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 both to the United States and China.

In the United States, while individual states may have renewable electricity mandates, there is no federal law driving development of renewable energy. Many observers believe that renewable energy technologies need a federal policy driver which creates a national demand for renewable electricity if it is to be a "significant" contributor to domestic power generation picture. This opinion is largely based on the view that renewables are not "mature" technologies, since renewable electricity technologies are largely intermittent or variable resources, requiring fossil resources to make renewables dispatchable (i.e., providing power on demand). 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.[144] Others believe that renewable energy technologies should rely on venture capital and private sector investment alone, and the market alone should dictate whether they are employed. However, it is noted that the United States relies more on investment from venture capitalists for clean energy technology development than the rest of the world combined.[145] 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.

Creation of green jobs by developing a globally competitive renewable energy technology manufacturing industry has been described as a cornerstone of U.S. economic policy. Developing such a capability in the United States will likely require major investments from the federal government. Such an effort may have to go beyond tax credits and loan guarantees as 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.

The United States has traditionally relied primarily on market forces and tax incentives to encourage the deployment of new technologies. This would be the "business as usual" model. However, several factors exist that call into question the "business as usual" model for innovation and deployment of renewable energy technologies. For example, investment dollars are scarce at this time, as the nation is still emerging 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 have

[144] FITP.

[145] "The United States continues to hold an overwhelming advantage in the area of venture capital/private equity investment, accounting for 73 percent of the G-20 total in 2010." Pew Charitable Trusts, *Who's Winning the Clean Energy Race*?, March 2011, http://www.pewenvironment.org/uploadedFiles/PEG/Publications/Report/G-20Report-LOWRes-FINAL.pdf.

exceeded 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. With recent environmental regulatory measures to reduce air emissions coming into effect,[146] the opportunity for clean technologies may be increasing. But some observers have argued for more aggressive governmental intervention to bolster and accelerate U.S. activities relating to renewable energy.

Concluding Comments

China's 11th FYP required state-owned enterprises to reduce energy intensity by 20% overall from 2005 levels. While China was able to reduce energy intensity 14.4% from 2005 to 2009, there was an increase of 3.2% in energy intensity during the first quarter of 2010.[147] Meeting these energy intensity goals proved to be a challenge.[148]

China pledged in the 12th FYP to cut energy consumption per unit of GDP by 16% and cut carbon emissions by 17% in the period from 2011 to 2015. But meeting the 16% drop in energy intensity in the 12th FYP may be a greater challenge if total GDP is larger. The NDRC recently stated that during the first two years of the 12th FYP, "China's aggregate energy consumption per unit of GDP dropped by 5.5%, only meeting 32.7% of the Five-Year Plan target.... To realize the 12th Five-Year Plan goal, China must reduce its annual energy consumption by 3.84% ... over the next three years."

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.[149] Clean coal technologies are 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 these technologies.[150] 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 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.[151] Recent technological developments have raised the potential for natural gas to be produced in abundance especially from tight shale gas

[146] CRS Report R42895, *Clean Air Issues in the 113th Congress: An Overview*, by James E. McCarthy.

[147] "Stick to Energy Goals," *XinHua News*, May 7, 2010, http://news.xinhuanet.com/english2010/indepth/2010-05/07/c_13281612.htm.

[148] "According to reports submitted by each province to this year's parliamentary sessions in Beijing, only Xinjiang admitted it had failed to hit its 11th FYP target—achieving a 10.2% cut against a target of 20%. Of the 30 other provinces, eight said they had either hit their targets earlier than required or exceeded them, while four—Anhui, Fujian, Jiangxi and Qinghai—gave ambiguous responses. Anhui, for example, said it "expected to be able to hit" its target, while Fujian said it "will hit" its target. The remainder all said they had fully met their emissions-reduction obligations." Yuan Duanduan and Feng Jie, "Behind China's Green Goals," *ChinaDialogue*, March 24, 2011, https://www.chinadialogue.net/article/show/single/en/4181-Behind-China-s-green-goals.

[149] 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.

[150] See http://www.energy.gov/sites/prod/files/edg/news/documents/US-China_Fact_Sheet_Coal.pdf.

[151] Vello Kuuskraa and Scott Stevens, *Worldwide Gas Shales and Unconventional Gas—A Status Report*, Advanced Resources International, December 12, 2009, http://www.adv-res.com/pdf/Kuuskraa%20Condensed%20Worldwide%20Uncon%20Gas%2012_12_09.pdf.

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.

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