Renewable Energy Development in China

A 40-Year China-World Bank Partnership

WORLD BANK GROUP

Photo credits. Front Cover: Christophe de Gouvello

Renewable Energy Development in China

A 40-Year China-World Bank Partnership[1]

1 This paper was prepared by a World Bank team led by Christophe de Gouvello, Coordinator of the World Bank-China Energy Team, and Yanqin Song, World Bank Senior Energy Specialist, under the guidance of Jie Tang, World Bank Energy Practice Manager for East Asia and Pacific. The main international expert and international contributor was Noureddine Berrah, who worked for more than 30 years with the World Bank and the China energy sector authorities on the development of the China energy sector, in particular on the development of renewable energy.

1818 H Street NW

Washington DC 20433

Telephone: 202-473-1000

Internet: www.worldbank.org

Contents

Renewable Energy Development

A 40-Year China-World Bank Partnership

1. China's remarkable economic growth required dramatic growth of energy consumption and continuous changes in the nation's energy economy. The World Bank supported the efforts of the Chinese government to develop and revitalize the country's energy sector to meet the daunting challenges it faced while continuously warning that the unrestrained reliance on coal would lead to unsustainable stress on the local and global environment. In mid-1980s, the Chinese government and the World Bank embarked on a long and arduous journey to develop renewable energy (RE) to lessen the impacts on the environment and avoid excessive reliance on coal to alleviate the debilitating power shortages that constrained the economy:

    - In the early 1980s, the first project supported by the World Bank after China joined the Bretton Woods family was a large hydropower plant, the Lubuge Hydropower project in Yunan Province. With modern procurement and project management practices and state-of-the-art engineering, the Lubuge project was transformational in modernizing and building a solid base for unprecedented large hydropower development in the next decades.

    - By the late 1990s, as coal had become pervasive in the energy sector, accounting for about 80 percent of the installed generation capacity, and local pollution had begun to erode the momentous gain of the unprecedented economic growth, the World Bank secured Global Environment Facility (GEF) funds and engaged the Chinese authorities to initiate and strengthen the development of wind and photovoltaic (PV) development. The China Renewable Energy Development Project (REDP) is credited by many Chinese experts as the catalyst for PV development in China.

    - In the 2000s, the first phase of the China Renewable Energy Scale-up Program (CRESP) made significant contributions to the legal, regulatory, and policy framework for scaling up renewable energy in China. Chinese authorities labeled CRESP as "for the time being, the largest international technical assistance program in China." The issuance of the 'Renewable Energy Law' in 2006 opened the door to the boom of RE as the proportion of RE in the energy mix increased constantly for the next decade, making a significant dent in coal's long-reigning supremacy and contributing to the expansion of China's RE industrial base and economic development. In 2017, with US$132.6 billion of investment, China's RE development program became the largest in the world.

    - In the 2010s, the second phase of CRESP focused on efficiency improvement and reduction of incremental costs to sustain the RE scale-up. Indeed, China's RE development program began facing serious challenges, including (a) low efficiency of existing wind and PV assets evidenced by low capacity factors (see Figure 5.2), (b) ballooning subsidies as feed-in tariffs remained high despite a significant decrease in wind power equipment and a sudden and substantial decrease in PV system costs, and (c) lack of inter-provincial trading leading to development of sites with poor resources to meet RE provincial targets.

    - Recently, the Chinese government took two major commitments at the highest level to implement an 'Energy Revolution' and achieve carbon neutrality by 2060. The Energy Revolution asserts the priority of RE development, defining more ambitious RE development targets and transitioning toward a lesser coal-dependent economy in a new strategy backed by first-order legal instruments. It revisits and completes current policies governing the energy sector to promote more market-oriented and

decentralized RE development and pilot the Energy Revolution in coal-dependent provinces. The Chinese government and the World Bank are currently reshaping the investment program and policy dialogue to meet these new challenges and put the country on track to meet its transformational carbon neutrality target.

2. This paper focuses on the more than 40-year partnership with the World Bank along China's long journey to develop a large-scale, efficient, and competitive RE industry in the country and globally. While the projects supported by the World Bank and their role are highlighted in this paper, this support should only be seen as a catalyst. The remarkable development of renewable energy in China was primarily guided by the multiple Chinese authorities at the national, provincial, and county levels, implemented by the many public and private companies, and fueled by local financing institutions. The paper is structured along the four stages of RE development in China, which are detailed in a companion report.[2] It highlights the key milestones of this partnership, its achievements, and challenges, detailing World Bank support and main activities that contributed to China's rise from a lagger to a leader.

From Lagger to Leader

3. Despite the overall dominance of coal in the China energy system, RE development has been remarkable, including the growth of its share in the overall country energy matrix and the unprecedented increase of installed power generation capacity:

    - China's total commercial RE utilization increased from only 24 million tons of coal equivalent (tce) in 1980, about 4 percent of the total primary energy consumption, to 582 million tce in 2018, about 12.5 percent of the country's primary energy consumption (see Figure 1). This contributed to achieving the 15 percent of nonfossil fuel share in the primary energy consumption target set for the 13th Five-Year Plan (FYP) (2016–2020), more than two years ahead of schedule. China's RE utilization is dominated by hydropower, which accounted in 2018 for about 64 percent of the total, followed by wind for about 19 percent, solar for about 9 percent, and others for about 8 percent.

Figure 1: Commercial RE Utilization and Share of Primary Energy Consumption

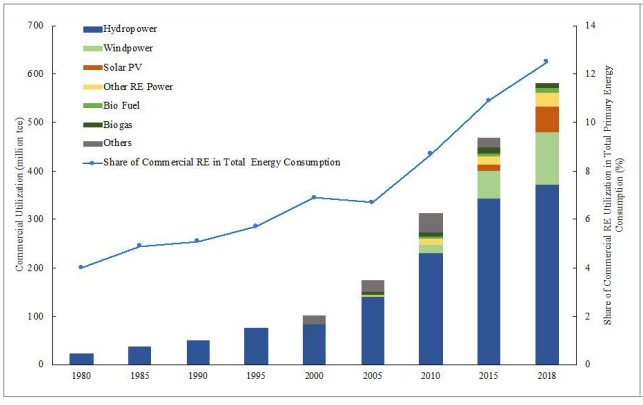
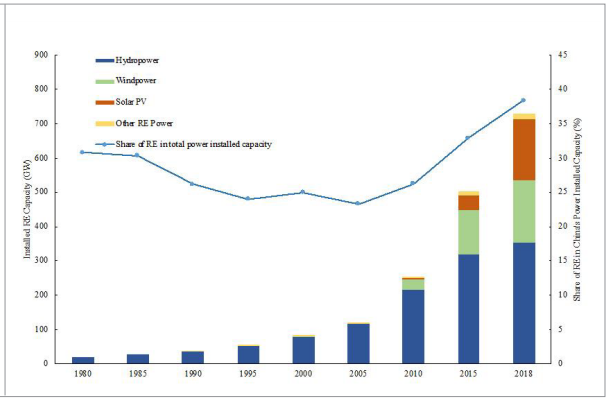


Figure 2: RE Installed Capacity and Share in Total Installed Capacity in China



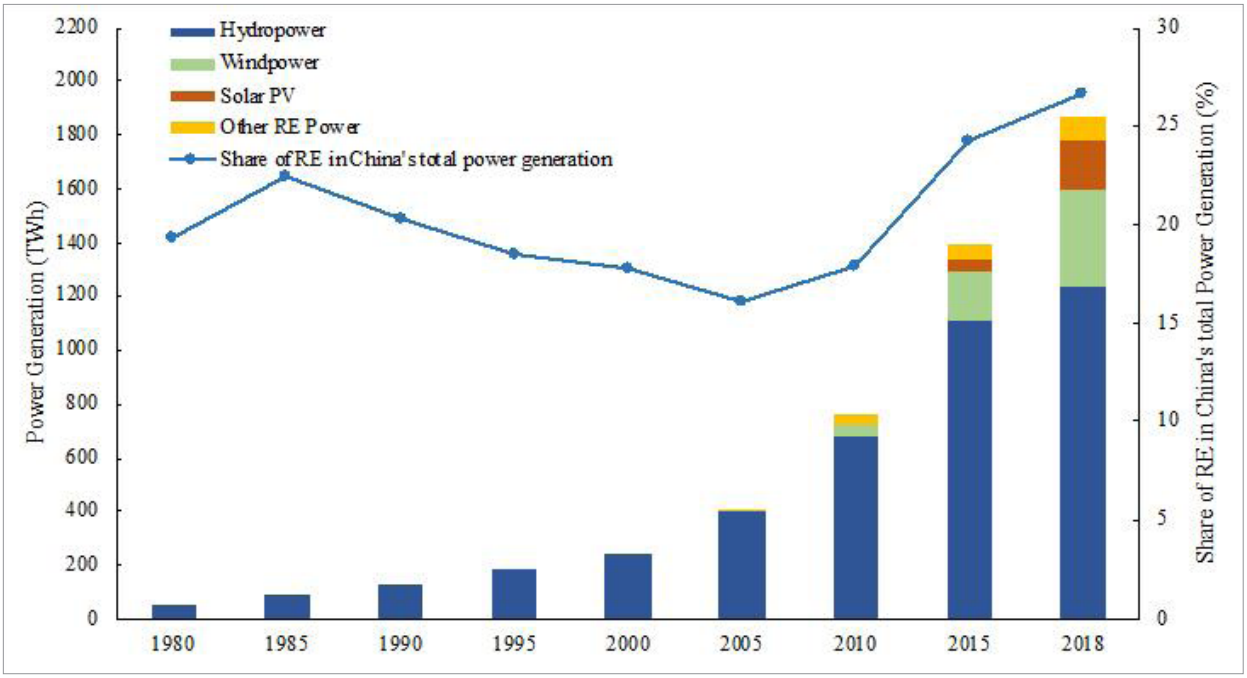
Source: The study team based on China Energy Statistical Yearbook 2018, China Renewable Energy Data Book.

2 A detailed analysis of these four stages, in particular the policies and measures adopted by China at each stage and the lessons for other countries that can be drawn from the Chinese experience, has been presented in a separate report: China: 40-Year Experience in Renewable Energy Development.

- The installed capacity of RE power generation increased from slightly more than 20 GW in 1980 to about 730 GW in 2018, representing 38.4 percent of China's generation capacity (with hydropower 352 GW, followed by wind 184 GW, solar 175 GW, and others 19 GW) (see Figure 2). This is the largest capacity in the world, accounting for more than 29 percent of the global installed capacity. It surpassed the combined capacity installed in the United States, Brazil, and Germany by 46 percent.[3]

- RE power generation increased from 58 terawatt-hours (TWh) in 1980, essentially from hydropower, to 1,867 TWh in 2018, accounting for about 27 percent of the country's total power generation. It exceeded by about 15 percent the combined RE power generation of the United States, Brazil, and Canada.[4] In 2018, hydropower accounted for 17.6 percent of China's power generation, followed by wind 5.2 percent, solar 2.5 percent, and other technologies 1.3 percent (see Figure 3).

Figure 3: Number and Share of RE in Total Power Generation

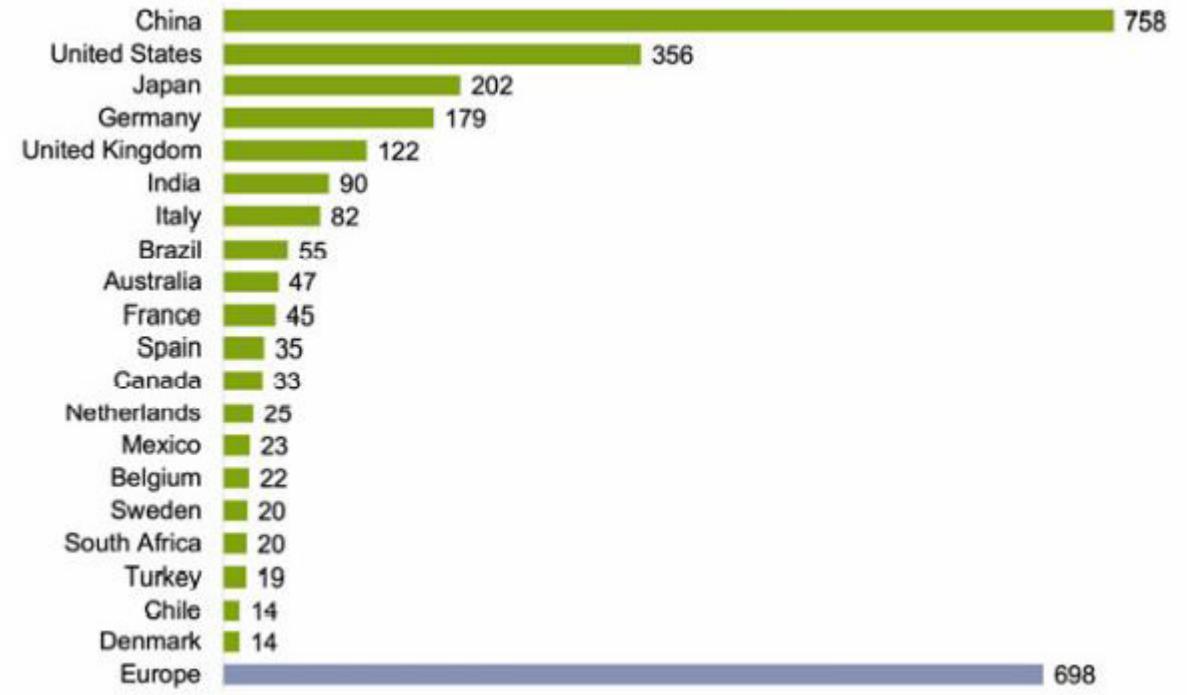


Source: The study team based on the China Electricity Council's Statistical List of Power Basic Data.

4. While hydropower has been the dominant renewable energy for four decades, in recent years, the development of new forms of renewable energy, in particular solar PV and wind energy, has also been remarkable. From 2010 to mid-2019, China's RE investment, excluding large hydro, amounted to US$758 billion, slightly higher than combined investments in the United States, Japan, and Germany (see Figure 4).

3 Source: Renewable Energy Statistics 2019, IRENA
4 Source: Renewable Energy Statistics 2019, IRENA

Figure 4: RE Investment in Selected Countries (2010 to the first half of 2019) (US$, billions)



Source: UNEP and Bloomberg NEF. 2019. Global Trends in Renewable Energy Investment 2019.

5. This impressive development of RE brought about significant social, economic, and environmental benefits to the Chinese society:

   - In 2016, the entire country had access to electricity. In recent years, 'PV poverty alleviation' programs increased the annual income of 2.24 million poor households by at least CNY 3,000 (about US$450 per household), amounting to about 8 percent of the average income of rural households.
   - China's RE industry is currently among the global leaders, especially in wind and solar PV, providing about 5 million jobs.
   - It contributed significantly to curbing the momentous air pollution of the 2010s and mitigating climate change impacts. Avoided annual SO_2 emissions amounted to 2.24 million tons, ash emissions to 224 million tons, and CO_2 emissions to 1.53 billion tons in 2018,[5] amounting to about 16 percent of total CO_2 emissions in 2018.

5 The avoided emissions were calculated comparing the actual emissions to a hypothetical case where RE consumption is replaced by standard coal consumption (commercial RE consumption in tce times standard coal's emission factors). Source: Chinese Academy of Engineering, Renewable Energy Law Implementation Assessment Report 2018.

The Long Journey

6. China's RE development can be divided into four stages by three major milestones (see Figure 5).

   (a) China's 'Agenda 21', adopted in 1994, identified, for the first time, RE as an independent energy subsector[6] and one of China's main development anchors. This marked the beginning of China's planned implementation of RE development.

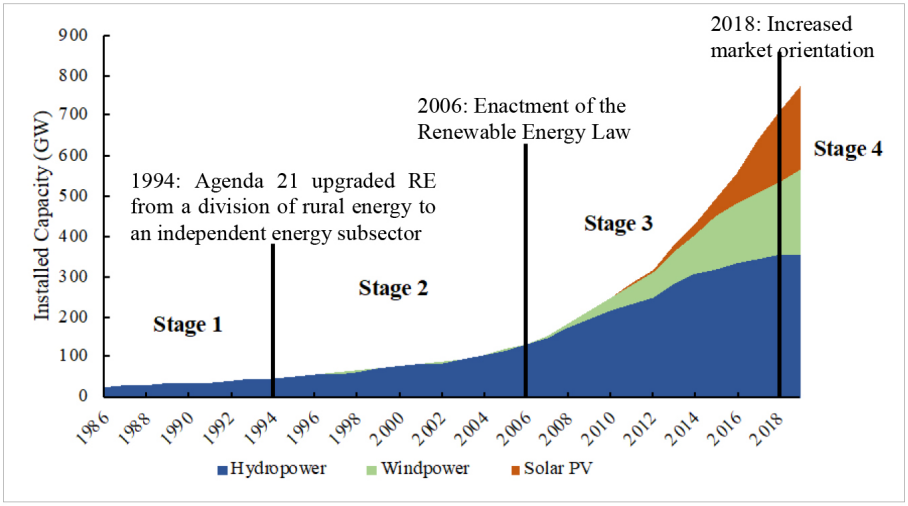
   (b) The issuance of the Renewable Energy Law, which established five basic measures to promote the development of non-hydro RE in China:

   - The announcement of ambitious overall, and later technology-specific, RE targets for the medium and long term that provided clear signals to developers and investors and all market players about the expected growth of the RE market
   - The legal obligation of all power grid companies to purchase the full amount of the on-grid RE electricity and ease access of RE electricity to the systems
   - The assurance that the 'on-grid prices' of RE electricity would provide investors and developers adequate returns on investments for the development and utilization of RE. The prices were differentiated by region and evolved over time to sustain the unprecedented development of RE in the country.[7]
   - The 'Price Compensation' measure shared the burden on electricity consumers by adding a fee (surcharge) on each kWh of the total electricity consumption
   - The establishment of a Special Fund,[8] supplied by the consumer fees, to provide subsidies that made RE electricity more attractive to investors.

   (c) The 'Notice on matters related to photovoltaic power generation' in 2018 was issued following the unprecedented decrease of the cost of PV systems. It initiated a new era of China's RE development characterized by the phasing-out of subsidies, increased market orientation, and increased efficiency of wind and PV installed capacities.

6 Before the adoption of Agenda 21, RE developed was supervised by rural energy departments at different administrative levels.
7 The success of China's RE drive fully illustrates the effectiveness of China's on-grid tariff subsidies. The advantage of the on-grid tariff policy—through which the government can make RE production more competitive and attractive to businesses and investors—is that it anchors the revenue of power generation throughout the life cycle. In this way, it conveys a clear price signal to investors and can effectively support the early stages of RE development.
8 The Special Fund was also supplied by the financial resources, and this part of the Special Fund was dedicated to demonstration projects, research and development (R&D) programs, resource census projects, standard setting projects, and remote area electrification projects.

Figure 5: Major RE Installed Capacity and milestones



Source: Study team.

7. These three major milestones can be seen as pivotal moments to define four successive stages of RE development in China, as detailed in the 'China: 40-Year Experience in Renewable Energy Development' report. In this paper, we analyze the role of the World Bank partnership along these four stages of RE development in China.

8. The rest of the present paper focuses on detailing the progress achieved by China during the four stages, stressing the main events, policies, and triggers that led to the deployment of RE technologies and highlighting the World Bank's support to and cooperative efforts with concerned Chinese institutions.

Stage 1 (up to 1994): The Early Years

9. During this stage, China managed to maintain a quasi-energy autarky and faced acute insufficiency of energy supply, especially power, to support the fast-growing economy and the needs of the rural population. This led to increased reliance on coal, deforestation, and indoor pollution due to extensive use of coal and wood. To address these issues, China mainly focused its efforts on (a) decentralized RE, including small hydropower, to meet the energy needs of the rural areas and build the foundation for a more ambitious renewable energy development and (b) developing large hydropower to ease power shortages constraining economic growth.

Decentralized RE for a Better Life in Rural Areas

10. The development of small hydropower, biogas and the deployment of efficient stoves, solar water heaters, and, to a lesser extent, wind and PV contributed significantly to improving clean energy supply to rural areas during this stage. By the end of the first stage,

    - More than half of rural households used biomass energy-saving stoves, which contributed to saving one-third to half of fuel consumption;
    - 5.25 million biogas digesters were built nationwide to produce 1.3 billion m^3 of biogas annually;

- 60,000 small hydropower stations, amounting to about 16 GW, were constructed and most of them were managed at the county or prefecture level; and
- 2.3 million m^2 of water heaters were installed nationwide.

11. Policy efforts relating to these technologies focused on coordinating the concerned ministries and establishing the research and technical institutes to promote and support the development of renewable energy.

12. Major efforts deployed after the open door policy, especially during three FYPs,[9] covering the end of stage 1, led to
    - Significant progress in research and demonstration projects in line with China's prudent and gradual approach to test policies and development approaches before deploying them at a large scale and
    - A good foundation for development and utilization of non-large hydropower RE at a larger scale despite the limited development of wind and solar power. By the end of this stage, (a) installed capacity of wind power amounted to 26 MW and (b) solar PV started to be deployed in remote and nomadic areas with about 5 MW installed capacity.

13. Learning from the failure of the development of biogas during the 1960s and 1970s that damaged the reputation of digesters among rural households,[10] the World Bank focused, beginning in 1988, on assisting the Ministries of Water Resources and Agriculture in jointly launching pilot comprehensive rural energy planning projects and developing local energy systems to provide cleaner energy to the rural population in 100 counties (extended to 200 counties in 1991).

14. The activities developed under this stage were funded by grants from the Energy Sector Management Assistance Program (ESMAP) and focused on
    - Comprehensive rural energy planning in selected counties to increase access of the rural population to non-power clean energy and electricity. The methodologies and approaches were then disseminated to the pilot counties by the ministries;
    - On-the-job training on technical issues related to biomass energy-saving stoves and design of dissemination programs;
    - Introduction to international best practices through lectures by visiting international experts and visits to developed countries;
    - Extensive training programs on economic evaluation of energy projects; and
    - Experience sharing with countries facing the same issues, especially in Africa.

15. During the implementation of the ESMAP TA program, the Ministry of Water Resources stressed that 1,500 counties relied on small hydropower plants (SHPs) for more than 50 percent of their power supply. Power systems in these counties were managed by power utilities at the county level under the supervision of the ministry. They requested a specific ESMAP activity to build their capacity in planning,

9 Sixth, Seventh, and Eighth FYPs (1981–1995).

10 In the 1960s, China launched an important program to meet rural energy needs with biogas in a short time and installed a large number of digesters, which all had to be scrapped after few years of operation and some even before commissioning. In the 1970s, history repeated itself and China installed 7 million digesters in rural households but 3 million failed to operate adequately.

engineering, and operation capabilities. ESMAP responded positively to the request and the 'Support to Decentralized Power Companies' was designed and focused on

- Least cost development of local power systems;
- Design of SHPs to better take into account the characteristics of the sites rather than using generic designs provided by the ministry;
- Design of distribution system and loss reduction studies using state-of-the-art software;
- Technical workshops during the visits of international experts of technical issues such as efficiency and flexibility in powerhouse design of different turbine types, especially for low-head sites;
- On-the-job training for use of software to optimize the design of local distribution networks;
- Experience sharing through lectures provided by members of the ESMAP power and loss reduction team and involvement of staff from countries, such as Kenya, that successfully completed ESMAP loss reduction studies; and
- Provision of personal computers and software to streamline optimized power distribution design.

16. These pilot programs were successful and replicated in other counties and contributed to the deployment of small hydropower in 1,500 counties which provided cleaner energy for cooking and heating and increased access to electricity. By the end of 1994, 87 percent of the rural population had basic access to electricity.

17. The training courses improved project designs and economic justification, construction methods and equipment production of small hydropower units, efficient stoves, and biogas digesters.

Large Hydropower for Easing Power Shortages

18. Furthermore, during this stage, large hydropower (more than 50 MW installed capacity) increased from about 6 GW in 1970 to 26 GW by 1986 and to about 33 GW by 1994, the end of the first stage of development. Despite this important increase, the share of hydropower in total installed generation capacity receded during this stage from about 31 percent in 1980 to 30 percent in 1985 to 24 percent by the end of 1994. The share of hydropower in overall generated electricity increased from 19 percent in 1980 to 32 percent in 1985 but then decreased to 20 percent in 1990 and about 18 percent by the end of 1994.

The Transformational 'Shock Wave' of the Lubuge Hydropower Project

19. During the three decades preceding the open door policy in the 1980s, several large-scale hydropower special projects were launched and contributed to (a) strengthening hydropower station design, construction, and equipment manufacturing and (b) building the technical and engineering capacity of personnel involved in these projects. However, these projects suffered from insufficient government financing and experienced extended construction periods due to inefficient use of resources and inadequate project management. After the 'open door policy', China's hydropower industry sought and benefitted from extensive support provided by the international community, including developed countries such as the European Union, Japan, Australia, and Canada and international organizations

such as the United Nations Development Programme (UNDP), GEF, and the World Bank. However, the Lubuge hydropower project in Yunan Province, the first World Bank loan to China, brought about a transformational shock wave that modernized and built a solid base for large hydropower development in more than the next three decades.

20. In 1984, China signed the 'Agreement on the use of a US$154 million loan from the World Bank for the Lubuge Hydropower Station'. In line with this agreement, China conducted an international tender for the construction of the diversion tunnel. The Japanese company which won the bid completed the project in October 1986, five months ahead of the expected schedule, based on Chinese experience. The realization that "China still lagged behind developed countries due to a lack of technology, investment, and similar aids" despite its long history in water conservancy and dam construction[11] sent a shock wave through the Chinese hydropower industry.

21. The 'project-based schedule management' method especially surprised Chinese experts and Vice Premier Li Peng demanded that construction companies start trial implementation of advanced foreign management methods. During the preparation of Lubuge and later hydropower projects, the World Bank promoted needed technical transfer for interpretation of geological data, judgment of foundation excavation, design for sophisticated structures and construction management, and adoption of the largest possible generating unit sizes, in view of the large scale of development at future sites.

22. The World Bank also successfully promoted nontechnical solutions such as co-financing arrangements including export credits for the major electrical and mechanical equipment and bilateral grants for engineering services; introduced international competitive bidding for civil works and modern construction techniques for a rock fill dam, power tunnel, and underground powerhouse; and enhanced the financial autonomy of the Yunnan Provincial Electric Power Bureau (YPEPB). The training component under the project included training of staff of the Kunming Hydroelectric Investigation and Design Institute, the Lubuge Construction Management Bureau, and YPEPB in the areas of design, construction management, quality control, accounting, and cost control through technical assistance and the upgrading and equipping of an electrical training school in Kunming. Training activities were part of all the following hydropower projects and included establishment of specialized training institutes, on-the-job training within the country, and training in utilities and institutions abroad.

23. The Lubuge project was followed up by the initiation, during this stage, of (a) 7 hydropower power projects bringing the total hydropower capacity started during this period to more than 8 GW, of which the 1,800 MW Tianhuangping pumped storage project to increase the East China power system flexibility to meet peaking load; and (b) two major transmission projects to connect the hydroelectric capacity to load centers. "With Bank assistance, the Government has already developed interim guidelines for procurement of civil works through ICB. Use of ICB for both equipment and civil works will continue to be expanded as the Chinese gain more experience."[12]

24. Knowledge transfer and capacity-building activities were included in all projects and financed through bilateral grants and concessional funds from the International Development Association (IDA) for project preparation to introduce modern design and construction management approaches. As an example, during preparation of Ertan, the design was reviewed to economically optimize the project by increasing the water head from 150 m in earlier designs to 165 m, which increased the rated output from 3,000 MW

11 "While history does not record the construction of the earliest dam, it is acknowledged that China, India, Iran, and Egypt are the pioneer countries of dam construction. Records indicate that only three dams higher than 30 m existed before anno Domini (AD) 1000, among which the highest was the Fushan Weir earth dam in China (48 m in height)." Source: Jia, Jinsheng. 2016. "A Technical Review of Hydro-Project Development in China." Engineering 2 (3): 302–312. https://doi.org/10.1016/J.ENG.2016.03.008.

12 World Bank. 1984. Staff Appraisal Report - China: Lubuge Hydroelectric Project.

to 3,300 MW and added 840 GWh of generated electricity per year. Furthermore, it included transfer of knowledge on least-cost investment programming, load dispatching, and the application of computers, which appeared, despite the progress already made, to be behind the prevailing levels in developed countries. The age profile of the engineering staff was striking at that time; most of them were in their 50s and 60s. Strenuous efforts were needed to replenish the gap by training young graduates then emerging from universities. This involved the setting up of specialized training institutes, on-the-job training within the country, and training in utilities and institutions abroad. Training components were included in all loans to assist beneficiaries to improve their training programs and facilities.

Stage 2 (1995–2005): The Takeoff

Power Sector Reform Technical Assistance: Loosening the Grip of Monopolistic Utilities on the Sector

25. The second stage of RE development was preceded in 1993 by a major technical assistance activity that paved the way for the development of renewable energy as the pollution ensuing the massive coal generation development worsened and monopolistic utilities resisted change.

26. The reforms of the 1980s went a long way to loosen the centralized management of the power sector, mobilize and diversify financial sources, and improve cost recovery through higher tariffs. However, the sector was still struggling to cope with the tremendous growth and by the early 1990s, "Many of Chinese leading officials recognized that coping with the tremendous growth (of the power sector) requires an urgent and wholesale reform agenda to improve efficiency at all levels of the industry (investment, production and consumption) through introduction of market-based policies, further opening of the sector to domestic and foreign investors, and sound environmental policy to minimize adverse impacts of large coal-fired and hydro power plants."[13]

27. The Ministry of Electric Power (MoEP) requested World Bank assistance to initiate structural reform in the power sector. The World Bank raised a grant from its Institutional Development Fund and launched a technical assistance activity including a high-level workshop to present international experience and discuss issues and constraints facing the power sector and a joint study with Chinese experts and MoEP staff to develop guiding principles for the 1990s' reforms. One of the major topics discussed and agreed upon was that: "China's legal tradition was short. The power sector was still governed by a complex array of laws, provisions, administrative rules, regulations and policy circulars. Most of the laws and regulations, enacted under the 'command and control' economy, fail to support structural changes and, sometimes, hinder the smooth functioning of the emerging market economy and further involvement of private investors in the sector." The workshop concluded that: "the Government should put more focus on the design and implementation of a legal and regulatory framework."[14]

28. The policy dialogue initiated during the preparation of the technical assistance report (see footnote 15) led to the enactment of the first Electricity Law in China in 1995. The law transformed incumbent national and provincial power utilities from monopoly holders to single buyers and allowed entry of nonutility generators to ease the financial constraints facing the power sector. This favored mainly the development of hydropower during this stage but opened the door to future development of wind and PV bases.

---

13 World Bank. 1994. *China - Power Sector Reform: Towards Competition and Improved Performance*. World Bank.
14 World Bank 1994.

29. Renewable energy was a critical component of China's long-term rural development strategy. China has strongly supported small hydropower, biogas, and small wind turbines from the early 1950s to the end of the first stage. They succeeded in providing energy and electricity to isolated rural populations. The 1995 Electricity Law extended support of the Government of China (GoC) to solar PV, wind, geothermal, and biomass energy for power. By the mid-1990s, during the preparation of the REDP, the GoC confirmed its commitment to renewable energy in the New and Renewable Energy Development Program, 1996–2010, developed by the State Economic and Trade Commission (SETC) and the former State Planning Commission (SPC) and the State Science and Technology Commission (SSTC). This program aimed at improving the efficiency of RE technology applications, lowering production costs, and broadening the contribution of renewable energy in meeting the growing overall energy needs of the country.

30. In the second half of the 1990s, the GoC, with World Bank/GEF assistance, undertook sectoral analyses which included, but were not limited to, (a) a strategy document,[15] which concluded that China needed a market-driven approach and incentives to develop renewable energy; (b) an international workshop on financial incentives;[16] and (c) an assessment of RE resources in Northwest China, the region to be covered by the PV component in the REDP.[17] Then, the SETC and World Bank embarked on the preparation of the REDP, and in 2000, the World Bank followed up by assisting the government during the preparation of the 10th FYP (2001–2005) and recommended to replace supply-driven by market-driven incentives for RE development.

31. During 1995–2005, renewable energy in China developed rapidly as significant progress was made in the utilization of hydropower, biogas, and bioliquid. By the end of this stage, wind and solar power contributions were still modest, but a consensus was emerging in the country that wind and solar power have an immense potential to further the development of renewable energy in the country. Decision-makers came to the conclusion that like in Germany and Spain, the "important key to successful adoption of renewable energy generation in China is a political initiative establishing a steady market pull sufficient to motivate entrepreneurs to develop an indigenous industry."[18]

32. Renewable energy, especially hydropower, made a remarkable contribution to the country's energy supply. By 2005, RE development and utilization (excluding the traditional way of using biomass energy) reached 166 million tce, accounting for about 7.5 percent of the total primary energy consumption.

Remarkable Achievement in Non-Power RE

33. From 2003 to 2005, the national debt fund[19] invested CNY 1 billion annually to promote biogas. Rural biogas construction began to develop rapidly. By the end of 2005, (a) more than 18 million household biogas digesters had been installed, (b) about 1,500 large-scale livestock and poultry farm biogas projects had been completed, and (c) annual utilization of biogas reached about 8 billion m^3. These achievements provided cleaner fuel for nearly 70 million rural people. The development of biogas became an important component of rural development and ecological protection. The programs were based on local expertise, manufacturing, and operation. Technical institutes gradually improved the design and

15 China: A Strategy for International Assistance to Accelerate Renewable Energy Development, 1998. http://documents1.worldbank.org/curated/en/254061468770423918/pdf/multi-page.pdf, December 2000.
16 Financial Incentives for Renewable Energy Development: Proceedings from an International Workshop February 13–21, 1997. http://documents1.worldbank.org/curated/en/333351468771719399/pdf/multi-page.pdf
17 Assessing Markets for Renewable Energy in Rural Areas of Northwest China, 2000. https://openknowledge.worldbank.org/bitstream/handle/10986/20316/multi_page.pdf?sequence=1&isAllowed=y
18 Issues and Options for Localization of Wind Turbine Manufacturing in China. Consultant Report by Garrad Hassan America Inc, for CRESP (2004).
19 The national debt fund refers to the Special Financial Fund established in 1998 by the central government and endowed by the issuance of long-term national bonds mainly for infrastructure development.

manufacturing as competition increased in a thriving market. Developers accumulated vast experience in construction and training centers built local workers' skills and capacity. These actions laid a solid foundation for the Chinese biogas industry.

34. The total number of installed solar water heaters covered 80 million m^2 and geothermal deployed for heating was about 2 million tce. However, the main focus was on development of RE for power generation as coal dominance in the power sector caused serious concerns about the local and global environment.

Hydropower

35. By the end of the second phase, the installed capacity of hydropower reached 117 GW (including about 7 GW of pumped storage power stations), accounting for 23 percent of the total installed capacity of power generation. In 2005, electricity generation amounted to about 395 TWh, accounting for 16 percent of the total electricity generation.

36. **Substituting small hydropower for fossil fuel.** In 2003, the government initiated a program to substitute small hydropower for fossil fuels to address fossil fuel shortages and reduce local pollution in rural areas of the mid- and up-stream of the Yangtze and the Yellow Rivers. The program was implemented in 26 counties and cities located in Sichuan, Guizhou, Yunnan, and Shanxi Provinces and Guangxi Zhuang Autonomous Region. By the end of 2005, the program benefited 200,000 people, avoided 160,000 tons of firewood consumption, and allowed transformation of 20,000 ha of farmland to forest and the protection of 104,000 ha of forest.

37. **Building recognized expertise in large hydropower development.** The large hydropower stations put into operation during the 10th FYP (2001–2005) included the units of the left bank of the Three Gorges Project, amounting to 9.8 GW in Hubei Province, the 1,350 MW Dachaoshan hydropower station in Yunnan Province, and the 1,500 MW Gongboxia hydropower station in Qinghai Province. Several large-scale hydropower projects have also been started, including the Lancang River power station and the Xiaowan hydropower station totaling 4,200 MW in Yunnan Province and the 4,200 MW Longtan hydropower station on the Hongshui River in Guangxi Province. The total capacity of hydropower projects under construction during this stage was about 80 GW. The construction of these large-scale projects eased the power shortages and contributed to a more reliable power supply. They consolidated the experience and advanced construction methods of the early cooperation programs with advanced countries and provided experience to a large pool of hydropower experts. These led to noticeable cost reduction that allowed a faster development of hydropower in the country and built the base for global recognition of leadership of the Chinese hydropower industry and massive exports. In the last years of the second phase, World Bank support focused on technical assistance to secure financing of larger hydropower projects,[20] development of hydropower in poor counties through the financing of the 248 MW Hubei Hydropower Development Project in Poor Areas (2003), and rehabilitation and development of small hydropower in Zhejiang in CRESP I (2005).

Emerging Power Technologies

38. **Biomass.** By the end of stage 2, the total installed capacity of biomass-based power generation in China was about 2 GW, including 1,700 MW of bagasse power generation capacity, 200 MW of municipal solid

20 Trembath, Barry. 1997. "Constraints to Hydropower Development in a Privatizing Sector." Paper presented at the World Bank's Energy Week. Washington, DC. March 13–14, 1997.

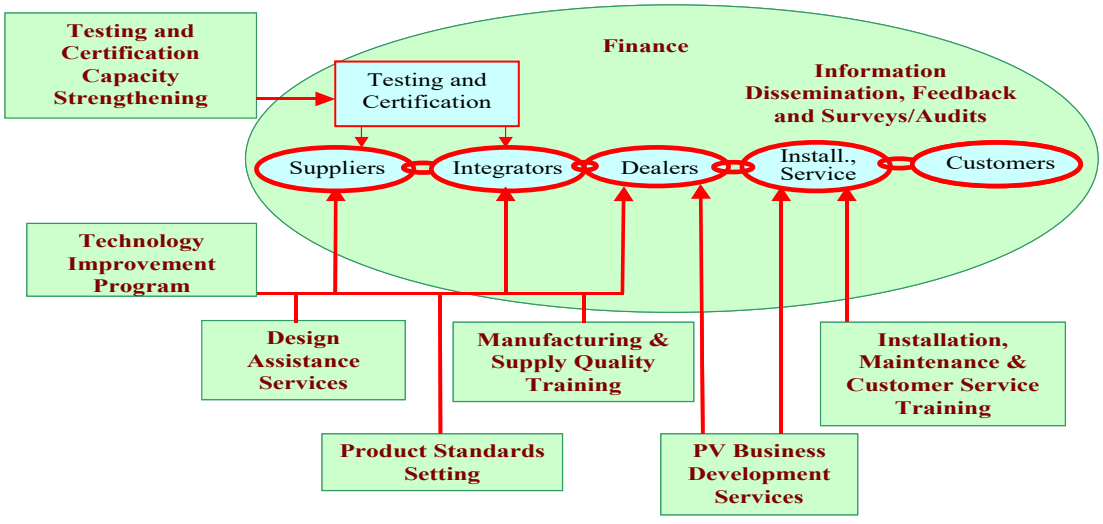
waste power generation capacity, and about 100 MW of power generation capacity fueled by gasified agricultural and forestry wastes, such as rice husk and biogas.

39. **Great potential for wind and solar power.** During this stage, several wind and, to a lesser extent, solar demonstration and testing projects and a wind concession program were initiated. By the end of the stage, (a) more than 60 grid-connected wind farms were commissioned, with a total installed capacity of 1,260 MW, laying the foundation for the large-scale development of wind power—in addition, there were about 250,000 small independently operated wind turbines in remote areas, with a total capacity of about 50 MW, and (b) the total capacity of PV power generation reached 70 MW. Non-grid-connected PV stations were built in 12 counties and more than 700 towns, and more than 500,000 household PV systems were installed to provide access to electricity to the poor population in remote areas.

REDP: Focusing on Solar and Wind[21]

40. As China was on its way to become one of the hydropower industry leaders, the Chinese government and World Bank decided to extend World Bank support to the two emerging technologies with great development potential, that is, wind and solar PV energy. After extensive consultations with government institutions and all market players, it was agreed that the REDP, approved by the Board in 1999, should (a) focus on promoting commercial or near-commercial applications; (b) combine international advances in technology with demonstrated Chinese low-cost production capabilities; and (c) tap the large potential demand by lowering costs and improving products, system reliability, and consumer service.

Figure 6: REDP-Comprehensive Support throughout the Supply Chain to Improve Quality and Reduce Cost



41. The World Bank proposed to include a component for the development of 190 MW wind farms in four sites. However, the three largest ones, including the 100 MW wind farm and the first 50 MW wind farm, did not secure government approval because of unclear delineation of approval responsibilities between the SETC and SPC.[22] Despite the small size of the wind component (20 MW in two sites), the Shanghai wind farms demonstrated the commercial viability of well-designed, procured, and constructed wind

21 Most of the following paragraphs are borrowed from the Implementation Completion Results and Report (ICR) of the REDP. World Bank, May 2, 2009.

22 The two institutions were later merged to form the National Development and Reform Commission (NDRC).

farms. These wind farms have become a model for procurement[23] and operation of wind farms. The operator of these wind farms, Long Yuan, a shareholder in Shanghai Wind Power Company, became one of the largest and most successful wind power developers.

42. The PV component achieved its expected outputs and development objectives: (a) the REDP's verified sales exceeded 400,000 units with an aggregate capacity of 11.1 MWp compared with the objective of 350,000 systems and a capacity of 10 MWp; (b) it helped establish a sustainable PV market in the northwestern region of China; (c) the technology improvement exceeded its output indicators; (d) technical standards developed by the project were strictly enforced—74 component manufacturers involved in the project met them and 18 companies offered PV systems that met international standards; and (e) the testing capacity developed under the project contributed greatly to the quality of PV equipment and integrators were supported to develop better-quality and novel products.

43. The project PV standards were adopted as national standards, before the country opted for international standards. The REDP supported the establishment of the 'Golden Sun Certification System'[24] operated by the China General Certification Center (CGCC). PV standards developed in the REDP were adopted as GB/T 19064 in 2003 and International standard IEC 61215 adopted in 2005. Four institutes supported by the REDP were accredited and upgraded to ISO 17025 for testing—one center (for modules) in 2005 and three in 2006 (balance of system, batteries, and PV systems) three years later than expected. The Tianjin Institute of Power Sources (TIPS) is one of the four institutes.

44. Furthermore, in 2005, the World Bank/REDP partnered with the German Agency for International Cooperation (*Deutsche Gesellschaft für Internationale Zusammenarbeit*, GIZ)[25] to upgrade TIPS testing capabilities of PV modules up to international standards. By the end of the activity, TIPS stated that: "Before 2005, there were only a few module manufacturers in China. Our testing capacity were limited to electrical performance tests. With the support of the REDP, we have, since 2006, conducted tests not only for more than 200 modules by domestic manufacturers but also for foreign manufacturers. Well-known manufacturers such as Wuxi Suntech, NEPV, Changzhou Trina and Solarfun are now our customers."

45. The REDP Project Appraisal Document (PAD) noted that the project, if successful, could affect PV prices globally—a statement that was contested during the review process of the project but accepted by management. In hindsight, it has been achieved as the Chinese PV sector has undergone a transformation during project implementation. In the following years, according to the project ICR, many of the REDP-supported companies contributed to the following:

    - Some of beneficiaries of the TI grant have become major players in the international market. Some are listed on stock exchanges in Europe and the United States and are operating in markets in Europe, Japan, and the United States. At the closing of the REDP (2008), China was the second largest producer of PV equipment in the world and the third largest exporter.

    - At the 2007 European PV Industry Exhibition, Chinese companies were the third largest exhibitors, and at the May 2008 Lighting Africa Conference in Accra Ghana, 30 Chinese companies exhibited off-grid lighting products.

    - Many REDP-supported companies won competitive bids issued by the World Bank for PV systems in the Lao People's Democratic Republic, Mongolia, and Papua New Guinea.

23 The procurement agreed between Long Yuan and the World Bank introduced for the first time in China the single responsibility for the performance of the procured turbines.
24 A national program promoting deployment of a solar PV system with 50 percent of the installation cost covered by subsidy.
25 *Deutsche Gesellschaft für Technische Zusammenarbeit* (GTZ) at the time.

- It is recognized that exposure of REDP-supported companies to international industry experts and the incentives provided to focus on quality contributed to, and accelerated, their success. Many of the positive impacts of the REDP are documented in a paper prepared jointly by the World Bank and the Ministry of Finance (MoF) entitled 'Photovoltaics, An Innovation Success Story'. The REDP was also rewarded the Ashden Awards for Sustainable Energy, the world's leading green energy prize.[26]

46. During project implementation, China's interest in scaling up renewable energy grew stronger. The REDP was followed by CRESP, which focused on legal and policy issues and long-term sustainability of grid-connected renewable energy in China. At the early stage of CRESP preparation, GEF funds were used to support several studies carried out by recognized consultant companies focusing on the importance of first-level legal instruments and policies to sustain RE development. The studies focused on comparison of different mechanisms used to support RE development (bidding, feed-in tariff, and obligation) and case studies to learn from best international practice.

47. The studies were followed by workshops and seminars that increased awareness of Chinese experts and decision-makers and led to the development of the Renewable Energy Law in a relatively short time. It was the first law to be circulated for comments by domestic and international experts in a seminar mainly financed by the World Bank. The Renewable Energy Law took effect in 2006 and was followed by several regulations promoting RE development with a major focus on wind, including onshore wind farms of 1 GW or more and plans for offshore development. Several lessons drawn from the REDP informed these institutional changes.

The China Renewable Energy Scale-up Program

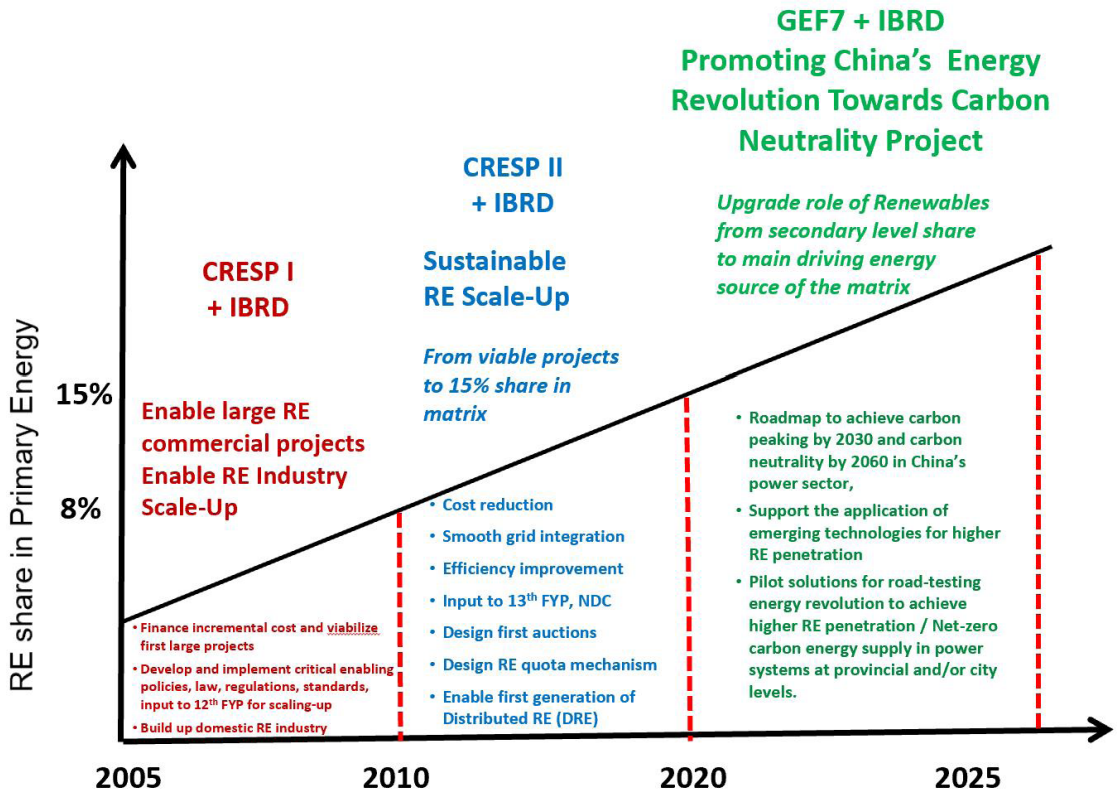
48. In the early 2000s, the Chinese government, the World Bank, and GEF began exploring programmatic approaches to support RE development and cooperated to prepare CRESP, a strategic long-term partnership among them. The program initially included three GEF-supported phases over 15 years. It set out to enable commercial renewable electricity suppliers to provide energy to the electricity market efficiently, cost-effectively, and at a large scale. During the preparation of CRESP, the World Bank assisted Chinese counterparts to undertake numerous policy and technical studies funded mainly by GEF grants followed by seminars and policy dialogue involving high-level decision-makers.

49. The policy dialogue between the GoC and the World Bank during this period was centered around (a) the most appropriate way to overcome obstacles hindering RE development, (b) introduction of international best practices, (c) capacity building and knowledge transfer, and (d) building of a legal and regulatory environment conducive to sustainable RE development. This three-year Asia technical assistance activity[27] included the preparation of several study notes on legal and regulatory frameworks in RE advanced countries, incentive policies to address market failure in internalizing externalities, study tours and training sessions for Chinese experts, and development of methodologies and models to determine RE shares in total primary energy consumption. The policy dialogue was essential to jointly develop a 15-year programmatic approach to sustain RE development as illustrated in Figure 7 and informed future legal and regulatory decisions. As an example, before the approval of the Renewable Energy Law by the Standing Committee of the National People's Congress on February 28, 2005, the Chinese Energy Research Institute requested the World Bank assistance to hold a workshop to present the draft law with international experts and representatives of multi- and bilateral institutions and gather comments.

26 https://www.worldbank.org/en/news/feature/2008/06/19/chinas-renewable-energy-project-wins-global-green-energy-prize.
27 The activity was mainly funded by GEF grants (PDFs for project preparation, ESMAP, and the Asia Sustainable and Alternative Energy (ASTAE).

The workshop, a first in Chinese legal history, was funded for the most by ASTAE with contributions from different institutions and its discussions contributed to the drafting of the final document.

Figure 7: Two Phases of CRESP and Follow-Up GEF support[28]



50. In the 'Letter of Sector Development Policy on Renewable Energy Development in China', the Vice Minister of the NDRC stated, before the project approval by the Board, that "The China Renewable Energy Scale-up Program (CRESP) is, for the time being, the largest international technical assistance program in China. We attach high importance to this program and hope to make joint efforts with GEF and the World Bank so as to push and promote the preparatory work and make the implementation of the program as soon as possible."[29]

28 It must be noted that the first and second phases of CRESP were implemented as originally designed. The third phase initially planned is now being replaced by a new program to be supported by GEF-7 to implement the new Chinese 'Energy Revolution' policy and build the pathway toward the long-term objective set by China's recent commitment to achieve carbon neutrality by 2060.

29 Letter of Sector Development Policy on Renewable Energy Development in China Zhang Guobao, Vice Minister of the NDRC.

Stage 3 (2005–2017): From Lagger to Leader

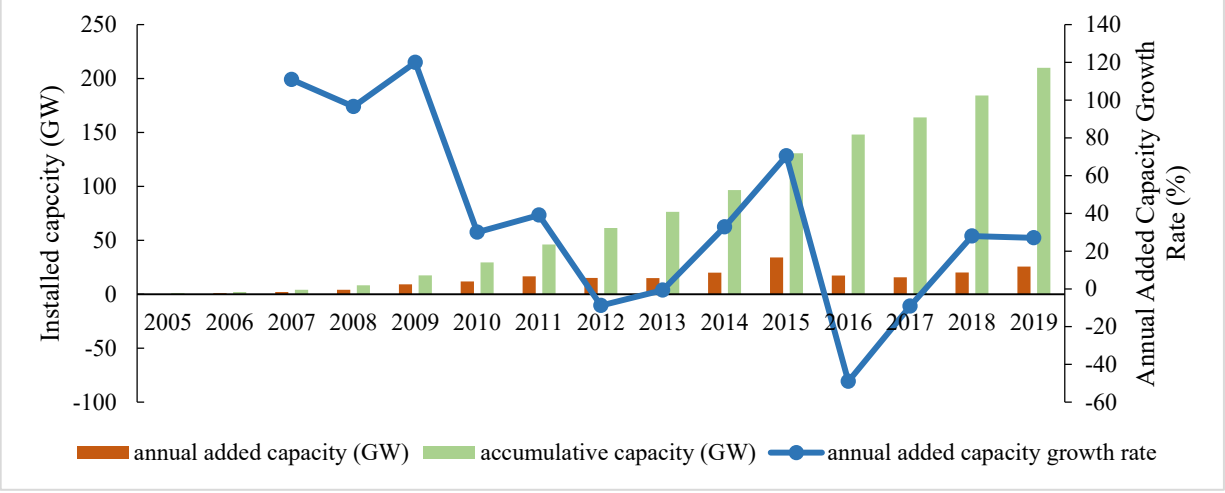
51. Following the enactment of the Renewable Energy Law, the partnership focused on its implementation and enforcement by supporting implementation of policies and regulations that provided a wide range of incentives to increase investment and build a sizable market, especially feed-in tariffs for wind in 2009 and PV in 2014, manufacturing industries to improve quality and reduce prices, and pilot projects to promote emerging technologies and innovation.

52. During this stage, the proportion of RE in the energy mix increased constantly, making a significant dent in coal's long-reigning supremacy and contributing to the expansion of China's industrial basis and economic development. The share of RE in the power mix continued to grow at an accelerated rate, still led by hydro but with a growing role of first wind (mainly onshore) then solar PV and, to a lesser extent, biomass, geothermal, and waste to energy. By the end of 2017, China was the world leader in RE development.

53. The installed capacity of major RE power generation amounted to 650 GW, accounting for almost 37 percent of the total installed power generation capacity:

    - The total RE power generation was about 6,418 TWh, accounting for almost 27 percent of the total power generation: (a) the cumulative installed wind capacity reached 188 GW, including about 3 GW in offshore wind power, and the industry achieved a record annual capacity increase of more than 34 GW in 2015 (see Figure 7), and the single unit capacity of wind turbine reached more than 6 MW; (b) cumulative installed PV capacity reached slightly more than 130 GW, including 30 GW of distributed PV power; (c) cumulative installed hydro capacity reached more 340 GW, including 29 GW of pump storage; (d) cumulative installed biomass capacity reached 15 GW, including 7 GW of straw-fired power, 7 GW in municipal solid waste incineration power, and about 450 MW of biogas power; and (e) the cumulative installed solar thermal power capacity reached 24 MW, geothermal power reached 27 MW, geothermal heated area amounted to 650 m^2, and bioethanol and biodiesel consumptions reached 2.6 million tons and 600,000 tons, respectively.

Figure 8: China On-Grid Wind Power Installed Capacity

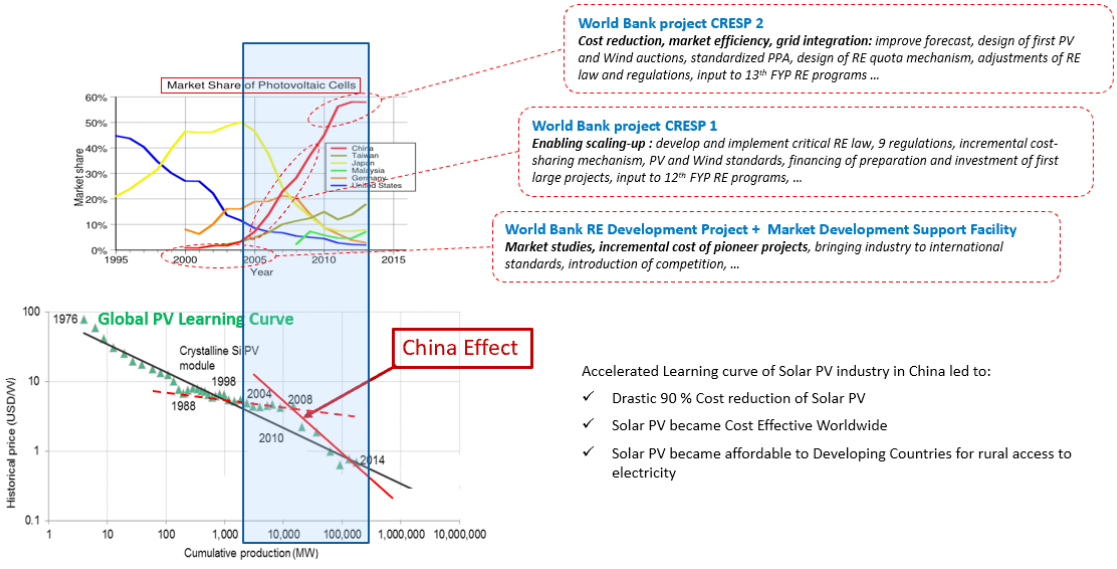


Source: The study team based on the Renewable Energy Data Book published by the China National Renewable Energy Center (CNERC) 2019.

- The operational efficiency of wind farms improved considerably with the development of high-precision wind pattern prediction models.
- Commercial RE utilization amounted to 540 million tce (more than three times higher than the utilization in 2005) and accounted for 12 percent of the national primary energy consumption (about 60 percent higher than the share in 2005).

54. This formidable development of the RE industry in China had a direct impact on the global RE industry. By bringing scale and innovation, the global learning curve was considerably accelerated, lowering unitary costs worldwide and turning RE more affordable to other developing countries. Figure 8 presents in parallel the rapid evolution of the China market share of solar PV cells, from a lagger to a leader, the total cumulated production, and the fast decline of the unitary cost of PV cells. A similar decline of the unitary cost of wind turbines was also observed once China wind industry and projects ramped up in the late 2000s. As the installed capacity of wind power in China ramped up from around 1.2 GW in 2005 to around 130 GW in 2015, that is, twice the installed capacity in the United States, the decrease of the unitary cost started to accelerate in 2009.[30] The upper graph in Figure 8 displays the evolution in time of the global market shares of China (in red) and other main producers, from 1995 to 2014. The lower graph displays the 'learning curve' of the PV cells technology, that is, the evolution of the unitary cost of PV cells in US dollars per watt according to the cumulated volume of PV cells generation capacity produced. As cumulative production increases in time, this graph can also be read as the evolution of that unitary cost in time, allowing for a parallel analysis with the upper graph. The unitary cost was plateauing (in log scale) from 1998 until 2004, indicating a slow pace in cost reduction, until the cumulated capacity (also in log scale) considerably accelerates, driven by the ramp-up in Chinese production, which is evidenced in the upper graph by the ramp-up in the market share of China, leading to an accelerated fall of the unitary cost (around 90 percent decrease between 2008 and 2014). This graph also positions in time the main projects of the China-World Bank partnership under stages 2 and 3, which were precisely aimed at defining, testing, and expanding the conditions for such development, as detailed in the following paragraphs.

Figure 9: China-World Bank Partnership and Accelerated Learning Curve of Solar PV Industry



Source: Bloomberg New Energy Finance, Maycock, Battery University, MIIT.
Note: Prices are in real (2014) US dollars.

30 World Bank, 2019, http://documents1.worldbank.org/curated/zh/853541560564145944/pdf/China-Renewable-Energy-and-Battery-Storage-Promotion-Project.pdf; Michael Liebreich, BNEF, 2017, https://assets.bbhub.io/professional/sites/24/2017/09/BNEF-Summit-London-2017-Michael-Liebreich-State-of-the-Industry.pdf

55. The third stage of RE development coincided with the approval of CRESP I on June 17, 2005, its successful implementation and closure in 2011, and the preparation and approval of CRESP II on October 29, 2013.

Successful Implementation and Closure of CRESP I

56. CRESP I made significant contributions to the legal, regulatory, and policy framework for scaling up renewable energy in China and catalyzed government investment in and support to RE development at a large scale during the 11th FYP (2006–2010). The outputs, outcomes, and achievements of CRESP are categorized in the following three key pillars. CRESP played an essential role in the rapid growth and quality improvement of the domestic wind and, to a less extent, biomass manufacturing industry, through cost-shared subgrants and establishment of standards, testing, and certification facilities. CRESP also supported the development of eight wind turbine standards based on best international practice. It has contributed to large-scale RE investments by supporting two 100 MW wind farms in Fujian and Inner Mongolia, a 25 MW biomass power plant in Jiangsu, and 6 new and 10 existing SHP plants, which increased the total installed capacity by 24 MW in Zhejiang. The investments focused on quality, efficiency, and sustainability of the built infrastructure when many RE projects were below par in China and performed at lower capacity factors and/or exhibited technical problems that hampered their connection to the grid. Equipment improvements, adequate designs, and technical standards developed under CRESP and financed by GEF grants were disseminated and benefitted numerous similar projects in China (see Figure 8).

57. The Chinese participants in the closing seminar and survey of CRESP I representing the government, industry, and research institutes stressed that the commitment to a long-term partnership between the government, World Bank, and GEF was a critical success factor of CRESP I. All interventions highlighted CRESP I's contributions to RE development, including, but not limited to, the following:

- CRESP has strongly influenced RE policy development, Renewable Energy Law, and regulations in China. The recommendations made in many policy studies supported by CRESP have been adopted by policy makers and incorporated in laws and regulations. In particular, the project played an instrumental role by funding the analytical studies that supported the formulation of feed-in tariffs for wind, PV, and biomass.

- CRESP has played an essential role in rapid growth and quality improvement of the domestic wind and, to a less extent, biomass manufacturing industry through support of domestic manufacturers with cost-shared subgrants. Before CRESP, Chinese wind manufacturers were facing difficulties producing megawatt-scale wind turbines and securing international quality certification. At the end of CRESP I, four domestic wind manufacturers supported by CRESP had won Level A certification for their megawatt-scale wind turbine design. In particular, Sewind has won type certification for 2 MW wind turbine design from an internationally recognized wind turbine certification center. The program also supported the development of eight wind turbine standards based on international standards and the establishment of two wind testing and certification centers in China (one in China Electric Power Research Institute and one in the CGCC).

- CRESP has contributed to large-scale RE investments by supporting 2 × 100 MW wind farms in Fujian and Inner Mongolia, a 25 MW biomass power plant in Jiangsu, and 6 new and 10 existing SHP plants, which increased the total installed capacity by 24 MW in Zhejiang. These windfarm investments were among the largest at the time. These projects substantially improved the capacity of RE developers. In particular, the 100 MW wind farm in Fujian set high standards for large-scale wind farms in China and is still considered as best practice in the country. The project introduced

and facilitated transfer of international best available technologies, improved quality, and reduced costs of such plants by setting cost benchmarks through international competitive bidding. The SHP projects in Zhejiang Province enhanced technical and management capacity of local small and medium enterprises; increased their access to financing; improved SHP technical design, environmental, and social safeguards; and installed capacity at project sites. CRESP I also assisted RE developers in identifying and preparing more than 1,000 MW of new RE investments through support to investors and 24 demonstration projects.

58. Following the closing of the first phase, the Independent Evaluation Group (IEG) of the World Bank visited China for the post evaluation of the project and concluded that: "The extensive efforts undertaken by the World Bank, through workshops, study tours, and studies during the prolonged preparation and early implementation, to achieve consensus and cohesiveness between relevant agencies about key policy directions and reforms, are credited as an essential factor for the success of the project."[31]

59. The IEG report referred to earlier noted that: "Key stakeholders consulted by IEG have credited CRESP with a major contribution to this transformation. In their view, a major role can be attributed to the tariff-related studies, which provided the analytical and knowledge underpinnings for China's replacement of a project-by- project tariff-setting and concession system to the development of a national tariff structure that offered attractive and predictable returns to investors, while gradually phasing out the implicit premium. Other studies were credited with essential contributions to modernizing and stabilizing the enabling framework for renewable energy covered the clarification of the power grid's dispatching rules and established a methodology for the determining the economically optimal targets for renewable energy expansion in various parts of China (based on the avoided cost of environmental damages from coal-fired power)."[32]

CRESP II: Policy and Efficiency Focus

60. CRESP II did not include an IBRD investment component as developers, state-owned enterprises (SOEs), or companies listed in Chinese and international markets were already able to fiercely compete to invest in fast-growing RE power markets, especially wind and solar. CRESP II focused on efficiency improvement and reduction of incremental costs to sustain the RE scale-up, including feasibility studies, and assistance to investment in pilot and demonstration projects.

61. CRESP II focused the GEF grant support on (a) developing and implementing RE legislation and policies to achieve cost reduction, efficiency improvement, and smooth grid integration; (b) reducing power curtailments through better grid integration/access of variable RE technologies; (c) furthering technology improvement including, but not limited to, increasing efficiency of existing wind farms, improving quality and reliability and reducing costs of offshore wind turbine technologies, increasing efficiency of existing large-scale grid-connected solar PV farms, and possibly improving concentrated solar power (CSP) domestic manufacturing capacity; (d) piloting and demonstrating innovative projects; and (e) improving capacity and investment support and project management.

62. CRESP II launched several studies to sustain RE development, including, but not limited to, (a) support to the preparation of the 13th and 14th FYPs; (b) RE pricing and subsidies and the 'quota system'[33]; (c) improved layout of wind bases and refurbishment of existing farms to improve efficiency and capacity

31 IEG Project Performance Assessment Report - China Renewable Energy Scale-up Program: Phase I. June 30, 2017.
32 See footnote 23.
33 Similar to the Renewable Portfolio Standards (RPS) principle.

factors; (d) smooth RE grid integration and dissemination of domestic and international best practices of large-scale integration of wind; (e) piloting and support of heat storage to reduce wind curtailment; (f) development of technical standards for onshore and offshore wind and micro-grids; (g) support to wind and solar concessions; and (h) technology improvement, especially for CSP.

Stage 4 (2018 to Present): The Way Forward

63. By the end of 2018, the share of China's commercial renewable energy amounted to about 12.5 percent of the national primary energy consumption, compared to 4 percent in 1980 and about 6.5 percent in 2005. The non-hydro RE installed capacity increased to 377 GW and the power generation increased to 650 TWh, both almost 90 times higher than the 2005 capacity and generation. Hydropower, wind power, and solar PV have become the main power sources in some regions. Solar thermal utilization, geothermal energy, and biomass have become important substitutes and supplements for urban and rural clean heating and clean fuel.[34]

64. The momentous growth was mainly driven by a top-down approach and national and provincial policies mandating RE use and supported by subsidies mainly from the RE Fund and special national and provincial programs. However, several issues also emerged, including mainly (a) low efficiency evidenced by the very low capacity factors of existing wind and PV assets, (b) ballooning subsidies as feed-in tariffs remained high despite a significant decrease of wind power equipment and a sudden and substantial decrease in PV system costs, and (c) lack of trade leading to development of sites with poor resources to meet RE provincial targets.

65. The measures taken by decision-makers at the highest level during the first three years of stage 4 indicate that future RE development would rely more on market-oriented and decentralized approaches to improve cost-effectiveness and ensure a sustainable and increased share of all RE forms to put the country on a greener and sustainable path. Support of the ambitious goals of China's Energy Revolution and at a later stage the commitment to achieve carbon neutrality by 2060, the dramatic cost reductions of RE technologies, especially PV, and the emergence of promising technologies, such as storage, required the realignment of the RE partnership priorities.

66. The realignment of the partnership priorities stem from the midterm review (MTR) of CRESP II, the preparation of the GEF China Distributed Renewable Energy Scale-Up Project (CDRESP), and the preparation of the follow-up to CRESP:

    - During the CRESP II MTR, the World Bank and NEA agreed to focus on technical, policy, and institutional measures to better integrate RE in the power system; market-oriented RE policies such as RE auction; improvement in the use of existing RE assets through increased efficiency; and continued support to distributed generation.

    - The objective of CDRESP is to promote the scale-up of distributed renewable energy and greenhouse gas (GHG) emission reduction through policy interventions and demonstration pilot projects in different provinces and cities in China..

    - During the preparation of the new GEF-7 grant following CRESP II, the World Bank and Chinese counterparts agreed on adapting its objectives to address the unforeseen issues currently facing

34 Use of ethanol gasoline is currently mandatory in more than 15 provinces in China.

RE development and renaming the grant Promoting China's Energy Revolution Towards Carbon Neutrality Project to align and renew the guiding principles of the partnership (see paragraph 69).

CRESP II Assessment and Achievements

67. By the MTR (May 2017), CRESP II was involved in studies and activities to further RE policies in China such as the development of the 13th Five-Year Plan (FYP), improve RE grid integration through technical studies on heat storage and support to Inner Mongolia, home to some of the largest wind bases in Northern China, increase efficiency of wind farms and large wind bases, and develop technical standards for offshore wind power and micro-grids to widen the potential of RE. CRESP II support to RE deployment includes, but are not limited to, the following:

- The preparation of the RE-specific 13th FYP (2016–2020) was adopted by the government and awarded the first prize across the overall 13th FYP preparation. The RE 13th FYP not only set ambitious RE targets to achieve China's (Nationally Determined Contribution [NDC]) target of nonfossil fuel accounting for 15 percent of primary energy mix by 2020 but also was the first time to integrate the RE generation plan with the transmission plan to reduce RE curtailments. As a result, China's solar PV installed capacity increased almost fivefold and the wind power capacity almost doubled from 2016 to 2020. Also, CRESP II supported the development of the RE 14th FYP (2021–2025), currently under discussion and revision to align it with China's commitment to achieving carbon neutrality by 2060.
- Issuance of the RE quota policy that mandates RE share in electricity consumption in each province by the joint NDRC and NEA Decree No. 807 on May 15, 2019.
- 12 GW solar PV and wind power pilot auctions that significantly drove down the solar PV and wind power prices in China. Based on the encouraging solar PV and wind power auction results, the government decided to cancel subsidies to RE during the 14th FYP and rely on more market-oriented measures to sustain the RE development.
- Heat storage to make the coal cogeneration plants more flexible to reduce wind power curtailment.
- Studies to design a path to achieving Shanxi Province's commitment to be a leader in energy transition.
- Distributed RE in the pilot 'New Energy Cities' and clean heating from RE.
- Technology improvement—three offshore wind turbine standards were issued by the Standardization Administration of China (SAC), and the project plans to support the establishment of the first offshore wind turbine testing center in China.
- Efficiency improvement for large-scale onshore wind farms and technology improvement for concentrated solar power development.
- Assertion of the priority of RE development and definition of more ambitious RE development targets in a new strategy backed by first-order legal instruments to meet the commitments of the '"Energy Revolution' and 'carbon neutrality' by 2060. This would contribute to mobilizing the whole society to actively promote RE development and weaken efforts deployed by vested interests to constrain it.
- Revision and completion of current policies governing the energy sector to promote more market-oriented and decentralized RE development.

- Rethinking of existing energy supply and consumption models to realize more efficient allocation of resources.

Renewal of the China-World Bank Partnership

68. During the last decade, several innovations drove down the price of RE-based electricity generation and storage, behind the meter and utility scale. These innovations, accompanied by energy efficiency and new business models such as distributed PV, threaten coal supremacy in China and have a transformative potential to significantly accelerate the decline of coal and contribute to meeting the objectives of the 'Energy Revolution' and the recent commitment of China to achieve carbon neutrality by 2060. As a consequence, the World Bank, GEF, and Chinese counterparts decided to renew the partnership to adapt it to meet the new challenges facing RE development in China and worldwide. They agreed on

    - Extending and broadening the GEF support to bring about investments in disruptive technologies, replacing the third phase of CRESP by a new broader program named Promoting China's Energy Revolution Towards Carbon Neutrality Project, now aimed at supporting the Energy Revolution and paving the way toward carbon neutrality by 2060;

    - Supporting the phasing-out of coal to free up space for RE in the energy matrix, including facilitating the economic and energy transition of provinces specialized in coal production and use toward a less coal-dependent economy, such as the Shanxi Province; and

    - Supporting the scale-up of new technologies needed to facilitate the increase of the share of RE such as distributed renewable energy, utility-scale and behind-the-meter battery storage, and electrification of conventional use of fossil fuel, such as transport and space heating, using renewable energy.

69. The strategic direction of this new partnership aims to replicate the successes achieved during the last two decades, especially regarding the wind and PV energy, to help develop and disseminate the new supply and demand technologies that are needed for RE to progressively become the dominant source in the energy mix. This is needed to help China achieve the objectives of the Energy Revolution and its long-term goal of carbon neutrality by 2060. This will also be essential to improving the affordability of these technologies worldwide and thus deliver both local and global good benefits.


WORLD BANK GROUP