
Summary April 2017

Accelerating the Energy Transition

The Co-benefits of Wind and Solar PV Power in China

This report projects the impact of China's wind and solar PV industry between 2015 and 2030, based on the current state of the renewable energy industry, available technologies, government policy and the decreasing cost of energy generation sources. The analysis also takes into account the current structure of China's energy system, as well as the government's commitment to reducing fossil fuel emissions and to limiting the operating costs of China's power-generating systems. Greenpeace East Asia used quantitative and qualitative analysis to assess the co-benefits of wind and solar photovoltaic (PV) energy, including the industry's impact on energy substitution, the environment, the economy and society at large.

1. Research Background

China has long been dependent on coal as its primary energy source. In 2015, coal accounted for 64% of China's total energy consumption¹. The use of fossil fuels has led to catastrophic consequences in China, including widespread air pollution, severe public health effects and the destruction of natural ecosystems. Moreover, global fossil fuel dependence is the root cause of climate change. In response to the dangers posed by fossil fuel emissions, the international community has reached a consensus to jointly accelerate the global energy transition by catalyzing renewable energy development.

Given the dual impetus of preventing air pollution and meeting emission reduction commitments, the incentives are aligned for China to reduce its coal consumption and carbon emission levels within the 13th five-year plan period. In fact, China has pledged to increase the proportion of non-fossil fuels within its primary energy consumption to 15% by 2020 and 20% by 2030.

The acceleration of wind and solar PV development is considered crucial to realizing these benchmarks. By the end of 2015, wind and solar PV installations in China reached 129 GW² and 43.18 GW³, respectively, following a period of rapid renewable energy development. China now ranks first globally in terms of new wind and solar PV installations, as well as cumulative wind and solar PV installation.

However, China's wind and solar PV industry faces several major obstacles, including increasingly high curtailment levels. Moreover, utilization hours have yet to be fully protected. One root cause behind these issues is a lack of understanding of the benefits of wind and solar PV. Greenpeace aims to provide a comprehensive analysis of the wind and solar PV industry's impact in China, in order to create a positive environment for renewable energy development and to accelerate China's transition toward "clean and low carbon".

¹ Energy Research Institute National Development And Reform Commission, Analysis Book on Energy Data 2016, P29

² http://www.nea.gov.cn/2016-02/02/c_135066586.htm

³ http://www.nea.gov.cn/2016-02/05/c_135076636.htm

2. Research Methods

The report, "The co-benefits of Wind and Solar PV power in China," is the result of a year-long collaboration between Greenpeace East Asia and five industry associations and research groups: the Chinese Wind Energy Association, the Energy Research Institute National Development and Reform Commission, the Institute of Energy, Environment and Economy of Tsinghua University, the Department of Earth System Science of Tsinghua University and Draworld Environment Research Center (Beijing). The project analyzes the impact of the solar PV and wind industries on energy substitution, the environment, the economy and society at large.

Research was based primarily on a review of academic literature and government sources, as well as scenario analysis. This report projects changes in the scope and impact of China's wind and solar PV industry between 2015 and 2030, based on the current state of the renewable energy industry, available technologies, government policy and the decreasing cost of energy generation sources. The analysis also takes into account the current structure of China's energy system, as well as the government's commitment to reducing fossil fuel emissions and to limiting the operating costs of China's power-generating systems. Greenpeace East Asia used quantitative and qualitative analysis to assess the co-benefits of wind and solar PV power, including the industry's impact on energy substitution, the environment, the economy and society at large.

Research methods varied across the four dimensions:

- **Energy benefits:** Analysis of energy benefits was primarily based on methods adapted from the Clean Development Mechanism (CDM). By taking into account regional grid CO₂ emission rates, renewable energy generation rates and emissions from various fossil fuel sources, we calculated the volume of standard coal that could be replaced by renewable energy. In addition, this report analyzed the energy payback period of wind and solar PV by calculating the ratio of life cycle energy consumption to annual power generation.
- **Environmental benefits:** External environmental benefits were calculated based on the difference between the environmental cost of coal and that of wind and solar PV energy. Researchers primarily utilized Importance-Performance Analysis (IPA) and Life Cycle Assessment (LCA) methods to evaluate environmental costs. IPA primarily consisted of analyzing pollutant emissions, dispersion, impact and cost quantification. The LCA of coal power took into account the production, transport and consumption of coal. The LCA of wind and solar PV generation primarily took into account the production, installation and operation of systems.
- **Economic benefits:** We primarily adopted an "input-output table" to evaluate the effects of wind and solar PV energy on direct and indirect investment, GDP and employment. The report cataloged industries as "directly related" or "indirectly related." We then used modeling tools to evaluate the impact of the wind and solar PV industry on other economic factors.
- **Benefits to society at large:** Research on societal benefits was primarily based on literature review. This report outlines the profound changes brought on by the increase in wind and

solar PV, such as increased electricity access in rural areas, reduced water consumption and diversified energy industry stakeholders.

3. Research Findings

Based on the Development Scenario Projection for China's Power System from 2015 to 2030, we employed both quantitative and qualitative analysis to evaluate the co-benefits of wind and solar PV. The main findings are as follows:

1) In order to meet the commitment to increase the proportion of non-fossil fuel sources in primary energy consumption to at least 15% by 2020 and at least 20% by 2030, wind and solar PV power must be increased from 4% of total power generation in 2015 to 8% in 2020 and 17% in 2030.

2) Wind and solar PV replaced nearly **60 million** tons of standard coal in 2015. By 2030, wind and solar PV in China will reduce the consumption of fossil fuels by nearly **300 million** tons of standard coal, an amount roughly equal to France's total primary energy consumption in 2015⁴.

3) When compared to coal-fired power, the external environmental benefits of China's wind and solar PV amounted to approximately **0.16 RMB/kWh** in 2015. This figure **exceeds the wind power subsidy in Zhangjiakou, Hebei Province in 2016, which was 0.14 RMB/kWh**. By 2030, the external environmental benefits of China's wind and solar PV are expected to reach **0.3 RMB/kWh**. According to our analysis, total external environmental benefits from wind and solar PV power in China will amount to RMB **456 billion** by 2030.

4) In 2015, wind and solar PV power attracted RMB **400 billion** in investment, **accounting for approximately 0.7% of China's total fixed asset investment**⁵. By 2030, this figure is expected to reach RMB **495.4 billion**. Between 2016 and 2030, wind and solar PV power are projected to attract RMB **5.4 trillion** in total investment. In 2015, wind and solar PV power generation contributed RMB **0.31 trillion** to China's GDP. By 2030, this figure is projected to reach RMB **1.57 trillion**, accounting for roughly 1.1% of China's GDP. Between 2015 and 2030, wind and solar PV power will contribute RMB **14.3 trillion** to China's GDP, **seven times Beijing's 2015 GDP**⁶.

5) In 2015, the wind and solar PV industries created direct job opportunities⁷ for approximately **450,000** people in China. This figure will increase by more than fourfold by 2030, to **2.4 million**. Likewise, the number of indirect job opportunities⁸ will increase from 1 million in 2015 to 5.3 million in 2030. By 2030, China's wind and solar PV industries are projected to provide employment to **7.7 million**⁹ people -- **the total number of students in**

⁴ BP Statistical Review of World Energy 2016

⁵ National Bureau of Statistics of the People's Republic of China: Statistical Communique of the People's Republic of China on the 2015 National Economic and Social Development
http://www.stats.gov.cn/tjsj/zxfb/201602/t20160229_1323991.html

⁶ The number of GDP and investment will be converted to fixed price in 2010.

⁷ Direct job means the jobs in wind and solar PV plants.

⁸ Indirect job means the jobs in related industries driven by wind and solar PV development.

⁹ The "Input-Output Table (I-O Table)" will be updated every 5 years. We referred to the latest I-O Table (I-O

China who graduated in 2015¹⁰.

6) Solar energy has become instrumental in providing electricity to those who lack access to the grid. Between 2013 and 2015, China spent a total of RMB 24.78 billion on electricity access. Of the energy poverty that was addressed between 2013 and 2015, **43.4% of new energy access was achieved via solar PV, despite only 16.5% of total investment in energy poverty being allocated to solar.** Off-grid solar PV energy has become the most economical way of supplying electricity to remote areas, providing a model for other nations to address electricity access issues.

7) In 2015, the development of wind and solar PV reduced water consumption by approximately **0.57 billion m³**. By 2030, this figure is expected to increase to **3.6 billion m³**, **equivalent to the annual basic water consumption of 200 million people.** Solar PV and wind allowed for the preservation of approximately 1 billion m³ of water in northwest China, where water resources are extremely scarce. Because coal plants are concentrated in water scarce areas, the ecological benefits of wind and solar PV are magnified.

8) Energy consumption is an unavoidable part of the energy production process. However, **the amount of energy consumed during the wind and solar PV production process is almost negligible.** During the 20-year life cycle of a wind facility, 0.06 kWh electricity is consumed to generate 1 kWh electricity. During the 25-year life cycle of a solar facility, 0.1-0.15 kWh of electricity is consumed. The energy payback period¹¹ for wind power is 0.7 years, while it is 1.6 years for solar PV.

Based on the findings of four working groups, Greenpeace East Asia and the Chinese Wind Energy Association invited a committee of external experts to review the research methods, content and main findings of this report over several rounds. We hope that this report can help to provide the public with a more thorough understanding of the co-benefits of wind and solar PV. We aim to raise public awareness of the environmental costs of fossil fuels, and thus to create a more favorable environment for renewable energy development.

【The full report can be downloaded [via this link](#)】

Table 2012) when forecasting employment number. But the wind and solar PV industry expanded rapidly after 2012, the forecast in this report is conservative compared to the actual number.

¹⁰ Minister of Education: College graduates will amount to 7.49million in 2015
(<http://news.sohu.com/20141205/n406690530.shtml>)

¹¹ Energy Payback Period: the ratio of the energy consumption and the annual energy production.