Thoughts on Green Energy Industry Growth in Developing Countries

Yuan Jian

For a considerably long period of time, renewable energy power was considered a luxury that only rich countries could afford. This view was not entirely unfounded. The development of solar energy and wind energy in Germany and other Western European countries lead the world, thanks to policy instruments such as generous subsidies for costs and price. Developing countries generally lacked such policy resources.

Just a few years ago, few people would have expected the renewable energy industry to rise so rapidly throughout the developing world, not only outpacing developed countries in terms of growth, but also making breakthroughs in terms of volume. In 2015, the investment in wind energy and solar power projects in developing countries exceeded the scale of that in developed countries for the first time. A couple of years ago, few would have predicted that "to see how bright the future of solar energy is, look to the developing world."[1]

The unexpected development of renewable energy in developing countries prompted people to rethink this question: what is the main condition for the development of the renewable energy industry? Based on a summary of relevant practices and experiences in developed countries, existing projections and assessments emphasize the role of financial, technical and policy incentives. The achievements of developing countries show that the power market demands, resource richness, as well as the extent of policy resistance, also affect the development of the renewable energy industry to a

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1 "The New Sunbathers," *The Economist,* April 16, 2016.

large extent. In other words, in the development of renewable energy sources, developing countries have their own conditions, or relative advantages.

Growth Momentum

Beginning in 2011, the growth in global solar power capacity began to significantly speed up. In the decade before, the incremental global capacity totaled 39 GW (39,000 MW), up from 1 GW in 2000 to 40 GW in 2010. But in 2011 alone, the newly added capacity reached 30 GW. Since then, the average annual capacity growth has reached or exceeded 30GW.[2] It is generally recognized that this substantial increase has direct links with the rapid development of solar power in developing countries, especially China and India.[3] In Latin America, Chile, Mexico and Brazil are among the countries that have witnessed the fastest growth worldwide in investment of renewable energy generation since 2013.

By 2014, developing countries accounted for nearly half of the total investment in global renewable energy. "The days when renewables were largely a sop to rich-world consumers' consciences are clearly over."[4] In 2015, the growth rate of the world's renewable energy reached a new high, with solar power capacity growing by 26 percent and wind power by 17 percent.[5] The investment in new solar power generation projects exceeds the total investment in coal and natural gas power projects for the first time. Behind this record-breaking growth is the renewable energy industry "taking a big step forward in the developing world."

In 2015, developing countries attracted more investment in solar and wind power projects than developed countries for the first time.[6] China's

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2 European Phtovoltaic Industry Association, "Global Market Outlook for Photovoltaics 2013-2017," May 2013, http://www.epia.org/fileadmin/user_upload/Publications/GMO_2013_-_final_PDF.pdf.

3 "China's 12GW Solar Market Outstripped All Expectation in 2013," *Bloomberg New Energy Finance,* January 23, 2014, http://about.bnet.com/files/2014/01/BNEF_PR_2014-01-23_China_Investment-final.pdf.

4 "Not a Toy," *The Economist,* April 11, 2015, p.56.

5 "Follow the Sun," *The Economist,* April 16, 2016, data quoted from an annual report of International Renewable Energy Agency, April 2016.

6 "The New Sunbathers," *The Economist,* April 16, 2016.

installed solar power capacity overtook that in Germany, to rank first in the world. The Indian government of Narendra Modi has proposed an ambitious solar power development plan to increase its solar power generation capacity to 100 GW by 2022, 20 times the existing installed capacity.[7]

Africa's renewable energy industry started relatively late, but in recent years the momentum has been the strongest, one of the reasons being the wave of solar power project construction that has "swept across the African continent."[8] According to statistics, since 1992, independent power companies have increased their investments in the continent's power industry, with an average annual growth rate of up to 14 percent. Although most of the capital investment has gone to coal and natural gas to generate power, the proportion of renewable energy power generation investment is growing continuously. South Africa is one of the fastest growing African countries in renewable energy capacity. Over the past four years, related power capacity has increased by more than 4 GW, or 10 percent of the country's total electricity supply.[9]

Concentrating solar power technology (CSP) is very popular in Africa. CSP uses mirrors to concentrate sunlight onto receivers that collect the solar energy and convert it to heat. With the completion of the one under construction in Morocco, which will be the largest of all, six of the world's ten largest photo-thermal power stations will be in Africa. According to McKinsey & Company estimates, by 2040 the proportion of solar power in Africa's total electricity supply will have increased to about 10 percent. If there are good management policies and enough investment funds are guaranteed, Africa will become one of the world's leading photovoltaic power generation bases.[10]

Solar power's growing momentum reflects the recent sharp decline in the cost of solar power generation. Since 2010, the price of photovoltaic

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7 "Greenery by Stealth," *The Economist,* October 10, 2015, pp.14-15.
8 "Follow the Sun."
9 "The Leapfrog Continent," *The Economist,* June 18, 2015, pp.37-38.
10 *Ibid*.

panels has fallen by nearly 80 percent, largely thanks to rapid expansion of China's manufacturing capacity.[11] The decline in PV power costs is also a result of the improvement in solar panel efficiency: the conversion of light energy into electrical energy has increased by about 20 percent, thanks to the use of new materials. Because of the decline in PV power costs, the levelized cost[12] point is approaching, and in some cases will be even lower than the cost of natural gas electricity and coal electricity. In some markets, PV power is already competitive in retail prices.[13]

Obviously, seizing the opportunities brought about by cost reductions is an important reason for the success of many developing countries. However, the cost factor does not fully explain the rapid rise of the PV power industry in developing countries, because in recent years, the price of coal and other fossil fuels has also significantly decreased. Moreover, despite the cost reductions, in some of the first European countries to develop solar power, the investment is facing stagnation. This means, in addition to the costs, there are other factors at play.

Development Needs

Developed countries usually support the renewable energy industry under the "climate policy" framework. Admittedly, the real driving force is often multiple: in addition to the pursuit of emission reduction targets, it also reflects the considerations of energy security, scientific and technological innovation and nurturing new economic growth points. The priority of the objectives varies from country to country.

In the developing world, these goals are highly valued. Overall, however, the policy drivers are mainly derived from basic development needs:

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11 Michael Liebreich, "Global Trends in Clean Energy Investment," *Bloomberg New Energy Finance,* April 17, 2013, http://about.bnet.com/presentations/global-trends-in-clean-energy-investment; "Follow the Sun," *The Economist,* April 16, 2016.

12 Levelized cost is the investment cost divided by total power capacity in the expected validity period of the power station.

13 "Follow the Sun."

addressing the growth bottleneck caused by power shortages; providing power to rural populations to improve their basic living conditions and economic opportunities.

Huge power supply shortage

At present, there are 1.1 billion people in the world who do not have access to electricity, and another nearly 1 billion people who do not have a stable power supply. About two-thirds of them live in Sub-Saharan Africa, with the majority of the remainder in India and other South Asian countries. Over the past 10 years, with the economic growth in these countries significantly speeding up, the power supply gap is becoming more prominent and it is one of the main bottlenecks hindering the economic growth of these countries. Since the beginning of the 1990s, new power generation capacity in Africa and South Asia has increased significantly, but it can barely keep pace with population growth, let alone economic development.[14]

Africa is the continent with the greatest power shortage in the world. It has been estimated that the power shortage drags down the annual growth rate of the African economy by about 4 percentage points. Almost all sectors are affected, not only energy-intensive industries, but also emerging industries related to network technology services, and even the agro-processing industry. In Tanzania, half of the enterprises list regular power outages as the primary cause of operating difficulties.[15] Power supply system is relatively developed in South Africa, but the power gap is also very obvious. For example, the country's economic growth in the first quarter of 2015 was struck in stagnation, and lack of electricity supply was listed as the primary reason.[16]

According to statistics, of the 600 million people in Africa who have no access to power, many rely on kerosene and disposable batteries for cooking

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14 Morgan D. Bazilian, "Power to the Poor: Provide Energies to Fight Poverty," *Foreign Affairs,* March/April, 2015, pp. 133-138; "Power to the Powerless," *The Economist,* February 27, 2016.

15 "Power to the Powerless."

16 "The Leapfrog Continent."

and lighting, with energy consumption costs accounting for 16 percent of their income. If the cost is converted into unit price, it is up to US$10/kWh, dozens of times higher than in developed countries. African companies, for the lack of power grid coverage or due to constant power outages, usually purchase diesel engine power generation facilities. The electricity costs are at least $0.5/kWh while in Europe the average retail price is $0.26/kWh and $0.12/kWh in the United States.[17]

The growth of green energy industry in developing countries is to address the bottleneck of power shortages and provide power to rural populations to improve their basic living conditions and economic opportunities.

Although India's power generation capacity is growing rapidly, its cities are still generally short of electricity, and there are frequent power cuts; 60 percent of the enterprises need to rely on self-purchased diesel generators. In addition, there are 100,000 villages without electricity.[18]

New method to solve power shortages

In recent years, developing countries have generally put the issue of addressing electricity shortfalls to the forefront of their development agenda. For example, the primary objective of India's development plan is to increase its electricity generating capacity, the most direct reason for which is that every year 10-12 million Indian youths enter the job market, and the lack of electricity corresponds to a lack of job opportunities created by companies.[19] In addition, in many countries in South Asia and Africa, electricity is seen as the key to improving the quality of life and income prospects for the rural population. Having access to the use of electricity is related to many issues from farmland irrigation to whether they have access to the most basic

17 Dickon Pinner and Matt Rogers, "Solar Power Comes of Age," *Foreign Affairs,* March/April, 2015, pp. 111-118.
18 "Catching up with China," *The Economist,* October 10, 2015, pp.25-27.
19 *Ibid.*

modern medical services and assistance.

In poor developing countries, the use of renewable energy sources, particularly solar power, as a new way to deal with electricity shortages and lack of electricity is, in many cases, more practical and effective than traditional solutions.

First of all, the construction of new coal-fired power plants involves high fixed asset investment and a long construction time so private capital is mostly reluctant to get involved, while government investment capacity is often constrained. According to the estimates of Africa Progress Panel, to solve the power shortage in Africa, investment of $55 billion is needed each year. The existing scale of investment is only $8 billion. Many African coal-fired power projects have not been completed and put into production after decades of planning.[20]

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Second, in developing countries with power shortages, the existing power grid and other power infrastructure are old and inefficient, restricting the growth in power supply. For example, in addition to having limited coverage, the power capacity of India's existing power grid system is also constrained by transmission and distribution facilities. In 2012, a large-scale grid paralysis affected more than 600 million people. The transformation and upgrading of the existing power grid system will also be time consuming.[21]

In contrast, the fixed asset investment required for large-scale solar power stations may not be higher than the coal-fired projects, especially in places that enjoy lots of sunlight, and the construction will be much faster. At present, the price of solar electricity may be less competitive than coal and natural gas power, but taking into account the fact that in many parts of Africa and India, businesses and families have no access to electricity,

20 "The Leapfrog Continent," *The Economist,* June 18, 2015, pp.37-38.
21 "Catching up with China."

or have to buy diesel engines to generate power, photovoltaic power has a noticeable cost advantage. Moreover, if priority is given to developing small-scale distributed power supply systems, a lot of expenses can be avoided in the construction of transmission facilities.

An effective rural power supply

In Africa and South Asia, 85 percent of those who do not have access to electricity live in rural areas which are far from the existing power supply infrastructure. At least in the short term, it is difficult to expand the coverage of the main power grid to solve their power supply problems. In addition to the difficulty of raising power production capacity, the cost of constructing transmission lines and the other infrastructure involved would be very high. It is estimated that the per capita cost of connecting vast rural areas of Africa without electricity to power grids could be as high as several thousands of US dollars on average.[22]

In contrast, the construction of distributed power generation systems, such as the installation of rooftop photovoltaic panels for rural households, or the erection of a wind turbine for a village, is more efficient, flexible and costs less. The threshold of investment in installations of PV power generation facilities is particularly flexible: simple micro-generators can be first installed, and then connected to small grids to upgrade the power supply capacity to power larger communities. Ultimately, the regional power generation system may also be connected to the main grid. Unlike the fragility and inefficiency of the existing grid system, a distributed power supply system would be stable and reliable.

At present, this power supply method has become popular in many developing countries. For example, India has a large number of small companies helping rural residents install rooftop photovoltaic power generation devices. The low-power dissipation power generation facilities can be installed in just one or two days, with relatively low initial installation

22 "The Leapfrog Continent."

and maintenance costs. Although the facilities are simple, they can meet the basic needs of the villagers, powering lighting, TVs and charging cellphones. In India, millions of rural people in areas not covered by power grids are using electricity for the first time by installing small-scale solar or wind power generation facilities.[23] In Bangladesh, the market for micro-PV power generation devices is also large: annual sales reached more than 3 million units in 2014, and this figure is expected to double between 2015 and 2017.[24]

Most of the power companies in Africa are also involved in the business of small-scale photovoltaic power supply. For example, in countries, such as Kenya, Uganda, Tanzania and Rwanda, foreign-funded enterprises such as Kopa and Off-Grid Electric provide rooftop photovoltaic power generation facilities and small grid power supply systems. Some companies have a rather low starting point, selling the most basic power generation and electricity tools: a photovoltaic panel, a battery, a few LED bulbs, a cell phone charger and an electric radio with prices ranging from $150 to $500 that can be paid in installments. Such "packages," accommodating the spending power of local residents, are very popular.[25]

Technically, to further develop the distributed power system, the power reserve capacity needs to be strengthened to maintain a stable supply of electricity. Historically, the cost of power storage technology has been high and has been a major obstacle to the expansion of the independent grid system.[26] This situation has begun to change in recent years. During the period 2010-15, the cost of battery storage has decreased by 50 percent. It is estimated that in 5 to 10 years, the cost of electricity storage will continue to decline. By 2020, counted in unit storage capacity, the battery storage cost is expected to fall by 40-60 percent from 2015's level.[27] This decline will undoubtedly increase the attractiveness of distributed power

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23 "Catching up with China."
24 "Not a Toy."
25 "Power to the Poor: Provide Energies to Fight Poverty."
26 "Banishing the Clouds," *The Economist,* June 13, 2015, pp.59-60.
27 Craig R. Home, "Energy Storage 4.0: The Plug-and-Play Grid Is Not That Far Off," *Greentech Media,* May 17, 2016, http://www.greentechmdia.com/articles/read/The-Plug-and-Play-Grid-Is-Not-That-Far-Off.

generation systems. New cost-effective technology can not only improve the storage capacity of micro-grids and community power grids, but also provide conditions for the integration and management of distributed power generation system networks. By integrating small power generation capacity and transmitting surplus electricity, the adequacy and stability of power supply can be secured.[28]

In recent years, in Germany and other Western European countries, the growth momentum of the renewable energy industry has slowed, partly as a result of weak domestic demand for electricity. In many developing countries, to achieve comprehensive electrification, there is still a long way to go. They need to seize the opportunities brought by new energy technologies and power generation cost reductions to meet their basic development needs. Compared with other considerations, development need-driven policies are perhaps stronger and more stable.

Resource Factors

In developed countries, government funding is still an important precondition for the rise of the renewable energy industry. Large-scale renewable energy projects generally enjoy tax incentives, and even direct subsidies. The purchase and installation of rooftop PV power facilities are also subject to certain tax breaks and loan facilitation. In addition, developed capital markets can provide financing for new electricity projects.

In most developing countries, the capacity of governments to provide funding and subsidies is limited, and the size of domestic capital markets and their ability to provide financing cannot be compared with those of the developed countries. The attractiveness of solar power projects in developing countries for investments lies largely in these countries' abundant sunlight.

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28 Center for American Progress, "Girding the U.S. Electric Grid with Community Energy Storage," July 13, 2016, https://cdn.americanprogress.org/wp-content/uploads/2016/07/13090123/1CommunityStorageForResilience-brief.pdf.

Attractiveness of sunlight resources for international investors

Countries that lack electricity in Africa and South Asia are mostly rich in sunlight resources—the average number of sunny days, daily sunlight duration and solar radiation intensity significantly exceed the global average. For investors, in addition to technology costs and market demand, sunlight resources to a large extent determine the prospects for the profitability of a solar power project, including the potential of economies of scale.

By virtue of their advantages in sunlight resources, many developing countries are able to attract a considerable amount of international investment without resorting to government subsidies. For example, India's photovoltaic power projects have attracted the highest amount of international investment, which has a lot to do with it having plenty of areas that are rich in sunlight and its large amount of cheap flat land, suitable for the construction of large-scale photovoltaic power stations. At present, investment in photovoltaic power projects in developing countries is not only from new energy companies in developed countries, but also from developing countries. For example, Morocco has built the world's largest photo-thermal power project; the investor of the first phase of the project was the Saudi Arabian company Acwa Power.[29]

Converting Resources Superiority into Price Competitiveness

To a large extent the competitiveness of new energy, especially when compared with energy from coal and other fossil fuels, depends on its cost, or rather price competitiveness. At present, in some developing countries with rich sunlight resources, the decline in photovoltaic power prices has been among the fastest globally. According to some research institutions, even in the context of the decline in oil and gas prices, the power generation costs of solar power facilities with good sunlight conditions has been lower than that of burning oil and gas in terms of heat units.[30]

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29 "Follow the Sun."

30 "We Make Our Own," *The Economist,* January 17, 2015.

In South Africa, the unit price of electricity from renewable sources has fallen by nearly 70 percent in four years. In a recent auction of electricity, the wholesale price of solar electricity and wind power was almost the same as that for other energy sources.[31] For instance, the bidding price for solar power from some states in central and southern India approached or was even lower than the price of coal-generated power. For example, the cost of electricity from an imported coal-fired power plant is around 6 rupees/kWh. In the southern Indian state of Karnataka, the new solar power station offers an electricity price of 5.5 rupees/kWh. Thanks to its abundant sunlight resources, India is considered one of the most likely countries to reduce the price of solar electricity. It is expected that the price of electricity generated from India's solar power projects will be lower than that of coal in 2020.[32]

In the long run, the possibility of attracting investment by resource advantages and securing cheap power will make more developing countries think about how to utilize their rich natural resources to solve their power shortage problems.

In developing countries, bidding for contracts of solar power projects tends to be a "reverse auction" approach. That is to say, the winner will always be the company which promises to offer the lowest wholesale price of electricity after the project is completed. In recent years, the prices offered by investors have kept hitting new record lows. In November 2014, the bidding price of a solar power station project in the United Arab Emirates hit a low price of $60/MWh for the first time. In February 2016, a Peruvian project reported an even lower price of $48/MWh. One month later, the price of a Mexican project was $40/MWh, a record low bidding price for a project that would enjoy no government subsidies.[33]

In the long run, the possibility of attracting investment by resource advantages and securing cheap power will make more developing countries

31 "Power to the Powerless."
32 "Catching up with China"; "Follow the Sun."
33 "Follow the Sun."

think about how to turn their rich natural resources into an effective way to solve their power shortage problems.

Policy Environment

In developed countries, the growth rate of the new energy industry is often impacted by the unstable supportive policies, which are often caused by conflicts of interests which are hard to be reconciled and the huge influence from the opposition on policymaking. A knowledge of dilemmas the developed countries are faced with will give us a better understanding of the reason why a simpler policy environment, where there is little opposition and conflicts of interest, should be considered a favorable condition for developing countries seeking to develop renewable energy sources.

Conflicts of Interests behind Controversial Policies

Most of the electricity market in Western countries is basically saturated, or there is a relatively limited additional demand. That means power suppliers who are already in the market are sensitive to any possible competition. Moreover, the traditional power plants, which rely heavily on economies of scale, have a high cost in terms of fixed assets and consequently a much lower marginal cost of power generation after a plant has been constructed. Therefore, a long-term stable market share is one of the most important conditions for investors to make a profitable return on their investment. Public utility companies, which are the biggest buyers of wholesale electricity in countries such as the United States, basically run their business with monopoly in a strictly divided territory and have justified reasons to hope the status quo will not be impacted.[34] In addition, after years of development, the power industry in the developed countries has a basically mixed commercial operation mode. New entrants and new power supply

34 Varun Sivaram and Teryn Norris, "The Clean Energy Revolution: Fighting Climate Change with Innovation," *Foreign Affairs*, May/June 2016, pp. 147-156.

modes will not only impact the original market structure, but also force the existing system to change its rules. That is why insiders in the power industry believe that the effect distributed generation will have on the whole industry "is what the internet did to newspapers."[35] Since large coal power corporations usually have great political influence, it is very likely that those conflicts of interests will become resistance to policy.

Some examples of controversial policies are as the following:

Feed-in tariff policy of Germany. The German government supports the development of renewable energy mainly by a "feed-in tariff" policy. The government gives priority to wind and solar power, which enjoy a high electricity price set by the government for a time span of 20 years. The tariff subsidy here mainly comes from an additional charge imposed on consumers via their electricity bills. The stimulus of the policy is clear: Renewable energy accounted for 30 percent (the largest globally) of the total power generation in Germany in 2015, much higher than the 3.6 percent in 1990.[36]

That growth has obviously impacted on the traditional power companies. To start with, the massive entrance of new energy power into the market squeezes the profit margins of traditional power plants. In addition, due to government subsidies on investment and capacity expansion, the renewable energy power generation projects enjoy an extremely low marginal cost, and so can afford a zero electricity price at times in the wholesale market. If that becomes the norm, the decline of settlement prices in the market could threaten the very survival of traditional power plants.[37]

Policymakers therefore are greatly pressured to make some adjustments. The German government started to reduce subsidies for photovoltaic power projects in 2011. In July 2016, the German parliament decided that from 2017 the government would provide price protection only to investors who offer the lowest price in biddings, and stop providing universal "feed-in

35 "Let the Sun Shine," *The Economist*, March 8, 2014.
36 "It's not Easy Being Green," *The Economist*, August 13, 2016; "When the Wind Blows," *The Economist*, November 28, 2015, pp. 7-8.
37 "When the Wind Blows."

tariff" for all investors of wind and solar power projects.[38]

Net energy metering policy in some US states. 43 states in the United States have introduced a "net energy metering" (NEM) policy. The basic content of this policy is to allow the owners of distributed power generation facilities to integrate their surplus electricity into the power grid and ask the utility companies, the operators of the power grid, to provide some compensation based on their retail prices. In most cases, the compensation is made through providing credit lines to these owners or reducing their electricity charge.[39]

While the policy has played a key role in stimulating the rapid development of the rooftop PV system in the United States, it has also aroused strong dissatisfaction from the existing power suppliers. For example, utility companies who operate power grids argue that the entry of PV power increases market supply and threatens their original pricing power and return on investment; in addition, the new power inputs, which have increased the burden on the grid, are compensated at retail prices, which means new users do not have to pay for the management and maintenance of the grid.[40]

Due to pressures from the interest groups in the coal power industry, a few states in the United States began to charge a certain amount of fees to PV power entrants in 2013. In 2015, more states started to review their NEM-related regulations, and made some adjustments to meet the demands of critics to varying degrees. These adjustments have included reducing the reimbursement price for PV power entrants; lowering subsidies for the installation of rooftop PV facilities, or raising the standard for subsidies; and limiting the size of the rooftop power facilities, or limiting the amount of PV power that can be integrated into the grid.[41] Nevada is considered one

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38 *Ibid.*

39 Luke H. Bassett, "Net Energy Metering: Growth and Accountability in the Distributed Solar Market," July 14, 2016, https://cdn.americanprogress.org/wp-content/uploads/2016/07/14133555/NetEnergyMetering1.pdf.

40 Solar Energy Industries Association, "U.S. Solar Market Insight," June 9, 2016, http://www.seia.org/research-resources/us-solar-market-insight.

41 Nichola Groom, "Future of U.S. Solar Threatened in Nationwide Fight over Incentives," *Reuters*, March 4, 2016.

of the states to have made the largest policy adjustment, one which has had an obvious impact: a lot of solar energy companies have chosen to cut their business in the state. [42]

Clean Power Plan of the United States. The US Environmental Protection Agency (EPA) released the final version of the Clean Power Plan (CPP) on August 3, 2015. It is the US regulation to limit carbon emissions of the power industry, and is one of the pillars of the Obama administration's climate policy and the main greenhouse gas emissions reduction commitments the United States has made under the framework of the Paris Agreement. The CPP provides significant incentives for the development of renewable energy: one of the most effective ways for US states to meet the EPA's new emissions standards is to increase the share of carbon-free electricity in total electricity generation. The US Energy Information Administration (EIA) has predicted if the CPP is implemented, the share of wind and solar power in the whole power capacity of the United States will grow to 18.7 percent in 2030.[43]

From the beginning of the introduction of the draft, the CPP has been criticized by the coal power industry, which says the overly strict restrictions on the emissions of existing power plants and the short time limit will result in the growth of costs being so fast that the companies cannot afford it. The EPA has also been accused of acting beyond its authority. In October 2015, some large companies in the coal and power industry and some industry associations, with the help of the attorney generals of 24 states including West Virginia, went to the Court of Appeals for the DC Circuit to accuse the EPA of acting beyond its authority in making the CPP. Statistics from the Center for American Progress show 43 of the largest 100 power companies in

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42 Daniel Rothberg, "Regulators Vote against Grandfather Clause for Existing Solar Customers," *Las Vegas Sun*, February 12, 2016, http://lasvegassun.com/news/2016/feb/12/regulators-vote-against-grandfather-clause-for-exi.

43 U.S. Energy Information Administration, "Annual Energy Outlook 2016," http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2016).pdf.

the country have taken part in the lawsuit directly or indirectly.[44]

On February 9, 2016, the US Supreme Court ruled 5: 4 that all states suspend the implementation of CPP before a formal ruling by the Circuit Court, which has brought uncertainties to the prospects of CPP's implementation.[45]

Nature of Policy Challenges

The above examples show that the efforts of the developed countries to support the renewable energy industry are challenged by a very complex policy environment. On the one hand, new energy power needs strong policy support to enter a market already occupied by fossil fuel electricity and compete with it on an equal footing. On the other hand, coal-fired power plants and other traditional power supply companies will continue to be the main power suppliers for a considerable period of time. Therefore, their need to early recover the investment on fixed assets and maintain a certain level of profitability should be taken into consideration.

The development of new forms of electricity requires major changes in the existing electricity supply system. It takes time and money for a developed country to change the business model of its electricity sector.

On the one hand, to develop a relatively independent and distributed power grid system that is mainly composed of renewable energy generation facilities is conducive to improving the safety and reliability of a country's power supply system. On the other hand, the main power grid is still playing an irreplaceable role. Utilities companies who operate the power grid should make some profit so that they have the capability and incentive to invest in the maintenance and upgrading of the grid system.

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44 Erin Auel, "Suing and Spewing: The Massive Pollution behind the Fight to Overturn the Clean Power Plan," Center for American Progress, June 24, 2016, http://cdn.americanprogress.org/wp-content/uploads/2016/06/22/22125138/SuingSpewing-brief.pdf.

45 "Supreme Emissions," *The Economist*, February 13, 2016.

To a certain extent, the difficulty in balancing different needs can be considered a cost problem. The development of new forms of electricity requires major changes in the existing electricity supply system. Or, to put it another way, it will take time and money for a developed country to change the business model of its electricity sector.

In most developing countries, the entry of new energy power into the market is unlikely to trigger very intense conflicts of interests. Thanks to a large supply gap in the electricity market, capacity growth will not result in a large-scale redistribution of market share for different players. The development of distributed power generation systems will also have a limited impact on the existing grid supply systems which have a limited coverage themselves. Therefore, the opposition to policies as a consequence of conflicts of interests has been relatively small. The relatively favorable policy environment has provided conditions for the renewable energy industry to develop steadily.

Climate Concerns

Green energy policies in the developing countries at present are mainly driven by economic development. However, climate concerns and environmental protection objectives keep driving policymaking. Many developing countries, while pursuing their growth targets, have significantly prioritized emissions reductions and other environmental goals on their policy agenda, and invested more in needed policy. For example, both China and India attach great importance to the fight against smog. In China, the relevant control objectives have become one of the major drivers for industrial restructuring and transformation of the energy structure.

It is foreseeable that climate and environmental concerns will become increasingly important policy drivers in the future. Because relevant scientific studies and research are helping us have a better understanding of the relationship between economic growth and environmental protection. Here are a few examples:

Smog more than a health threat

Smog is mainly harming the developing countries, especially countries with rapid economic growth. For a long time, we have known smog is a major health threat. For example, smog-related air pollution is the main reason for the high incidence of respiratory diseases in developing countries.

But according to the latest study from some international research institutions, smog has another consequence: It changes light intensity and rainfall in the area it covers. Because the airborne particulates, which are the composers of smog, can block the sunlight from reaching the ground, smog slows the evaporation of water and changes the pattern of water circulation, including the location, time and amount of rainfall. As a result, the area will see abnormal (reduced on a whole) rainfall.[46]

It is foreseeable that climate and environmental concerns will become increasingly important policy drivers in the future. Relevant scientific studies and research are helping us better understand the relationship between economic growth and environmental protection.

In addition, studies show that aerosol particles which cause smog can interact with sunlight. Some of them scatter sunlight and others absorb sunlight. These will affect the warming rate of the atmospheric column and change the speed difference between the warming of the land and ocean, which is the original force for a monsoon. As a result, the rainfall associated with the monsoon and the flood season will be changed. Due to the fact that some aerosol particles can be blown into the atmosphere over thousands of kilometers away from the Indian Ocean, the influence range of monsoonal anomalies might be possibly enlarged. In South Asia and some parts of Southeast Asia, monsoon rainfall is generally declining, although rainstorms sometimes do occur. In some parts of southern Africa, drought has

46 Report of the National Center for Atmospheric Research, and Princeton University's Geophysical Fluid Dynamics Laboratory, quoted from Veerabhadran Ramanathan, Jessica Seddon and David G. Victor, "The Next Front on Climate Change," *Foreign Affairs*, March/April, 2016, pp. 135-142.

Renewable energy, outpacing coal, becomes the largest source of newly-produced electricity for the first time in 2015, according to report of International Energy Agency (IEA).

lasted for years because of changes in the monsoon paths and rainfall.[47]

It is not difficult to imagine how much economic losses the rainfall changes will cause for the developing countries that have a large agricultural population and are heavily dependent on the agricultural economy. In South Asia and Africa, agricultural harvests in some areas rely almost entirely on the monsoon rainfall. In India, farmlands that rely on irrigation by monsoon rainwater account for nearly two-thirds of the total cultivated land, which involves more than 600 million farmers. In Africa, farmers suffer from a serious lack of means to deal with any reduction in the monsoon rainfall.[48]

Price of carbon emissions may be higher than expected

Since climate change has raised public concerns, there is a growing awareness

47 *Ibid*; "Monsooner or Later," *The Economist*, June 25, 2016.
48 "Monsooner or Later."

of how dearly we will pay for a warming climate in terms of economic damages and social costs. Since the 1990s, the study on the problem has attracted a large number of scientific personnel and other research resources. DICE & Co in the United States is one of the most well-known research institutions. Its deductive model DICE, which is called "dynamic integrated climate-economic model," was put into use in 1992. It estimated that the loss caused by carbon dioxide emissions stood at $2 per ton in terms of 2014 US dollar. Since then, the DICE model has been continually improved and refined, and the calculated emission cost also keeps increasing. The figure hit $20 per ton in 2014.[49] The figures calculated by other research institutions are generally much higher. Based on statistics from DICE and other well-known models (FUND and PAGE), the US government puts the cost at $40 per ton.[50] For some scholars, this figure is still far from reflecting the total social costs of carbon emissions, which they say stand at more than $100.[51]

While the figures are still controversial, the increasingly larger figure shows that a consensus that the real costs of carbon emissions may be higher than our understanding at present and that the credibility of the new estimates is significantly higher than that of original data. Because the calculations involved are extremely complex, it takes time to make the result more accurate. Researchers need to measure carbon emissions first, the concentration of carbon dioxide in the atmosphere, changes in atmospheric temperature, and then the economic and social losses associated with it. A number of factors that are difficult to determine are involved in every part. In addition, they need to compare these figures with those made when no emissions reduction actions are taken and temperatures naturally increase to a certain level, and to consider the impact emissions reduction measures will have on GDP growth. In order to make the cost assessments more comprehensive and accurate, they need

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49 William D. Nordhaus, "Estimates of the Social Cost of Carbon: Concepts and results from the DICE-2013R Model and Alternative Approaches," *Journal of the Association of Environmental and Resource Economists*, Vol.1, No.1 (2014), pp. 237-312.

50 Nicholas Stern, "The Structure of Economic Modeling of the Potential Impact of Climate Change," *Journal of Economic Literature*, Vol.51, No.3 (2013), pp.838-59.

51 Van den Bergh and W.J.W Botzen, "A Lower Bound to the Social Costs of CO_2 Emissions," *Nature Climate Change*, Vol.4, No.4 (2014), pp.243-258.

to collect more data over a wider range, improve data processing and follow the latest scientific findings.

Economic growth cannot offset environmental damage

For the assessment of economic losses caused by climate change, researchers have widely used the following hypothesis: GDP growth can to some extent offset the economic damage caused by climate change. Many believe that if a country's annual GDP growth remains at 3 percent, people's living standards are likely to improve despite climate change.[52]

Climate change costs cannot be simply calculated by only deducting some percentages from the GDP growth rate.

But this hypothesis is being questioned more frequently. One of the primary reasons is that some environmental damage cannot be offset by GDP growth. To cite a simple example, the production or consumption growth of electronic products such as Apple's smartphones, though a factor to improve GDP, will not offset the serious consequences it has caused to the global food chain and ecological balance. More importantly, climate change affects not only the total amount of GDP, but also the rate and growth potential of GDP. For example, a higher temperature will affect labor productivity, one of the important factors for economic growth, and therefore harm the potential for sustained GDP growth. In addition, the economic costs of higher temperatures grow incrementally, rather than in a manner of simple addition. That is to say, every one degree rise in temperature will bring disproportionate harm.[53] This means that climate change costs cannot be simply calculated by only deducting some percentages from the GDP growth rate. It should also be noted that the conventional

52 Gernot Wagner and Martin L. Weitzman, *Climate Shock: The Economic Consequences of a Hotter Planet*, Princeton University Press, 2015, p.63.

53 Robert S. Pindyck, "Climate Change Policy: What Do the Models Tell Us?" *Journal of Economic Literature*, Vol.51, No.3 (2013), pp.860-871; Martin L. Weitzman, "What is the 'Damages Function' for Global Warning and What Difference Might it Make?" *Climate Change Economics*, Vol.1, No.1 (2010), pp.57-69.

wisdom is unfounded that environmental protection needs should be decided by a country's development level. Climate change may have a larger impact on the developing countries that badly need to improve economic growth.

As research on climate change deepens and improves, there will be more and more similar findings to challenge the popular idea that economic growth and emissions reduction is a typical trade-off relationship, in which economic growth results in increased greenhouse gas emissions and therefore an effective climate policy will make us pay economically.[54] For developing countries, a better and more accurate understanding of the relationship between the two will provide new ground for them to take the incentive for them to implement emissions reduction and environmental protection measures, including developing green energy.

Conclusion

The rise of the green energy industry in the developing countries is not only driven by their economic development needs, it is also an important part of the global efforts to reduce greenhouse gas emissions. It is generally predicted that for a long time in the future, the vast majority of the net increase in the global energy demand will come from the developing countries. That means changes in the energy structure, especially an increase in the share of carbon-free energy sources, in the developing countries will be significant to meet the global emissions reduction targets.

In the long run, the rise of green energy industry will bring not only economic growth but also a new development path for developing countries. For the developing countries that are still in the early stages of industrialization, green energy offers a way that can save them from a carbon-intensive development. For countries with faster growth, carbon-free electricity provides an opportunity for them to abandon the pattern of "treatment after pollution" at an early date. These are prospects that will be significant for us to protect the living environment on the earth.

54 *Climate Shock: The Economic Consequences of a Hotter Planet*, pp.x-xi.