Renewable Energy in China: Market Barriers and Policy Options

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With an obvious characteristic of innovation, the development of renewable energy (RE) industry is a process of industry innovation itself. There are serious market failures and barriers in the RE technology innovation process. The reasons for RE innovation's market failure include "dual information externalities", "coordination failure" and "lock-in effect". As an emerging strategic industry, the RE industry has gained sound support from policies in recent years. Nevertheless, industrial development is being impeded by difficulties such as a lack of core technology, disorderly competition and a rupture in market demands, which also brought to the light the deviation of the current industry policies. Combined with industrial innovation theories of Neoclassical Economics, New Institutional Economics, and Evolutionary Economics, and based on the perspective of new industry policies, this paper reexamines the RE industrial policies in China and tries to explore new industry policies that accord with the innovative essence in the RE industry.

1. Introduction

In recent years, the renewable energy (RE)[1] industry being an emerging strategic industry in China, has seen both a rapid growth and a number of problems that cannot be ignored, for instance, insufficient capability in innovation of core technology, the rupture in market demands and the disorderly competition, etc. In regard to these obstacles, traditional industrial policies distinguished by "picking winners" seem to be getting less effective with its intervention failure being exposed, which is resulting in a series of new problems. For example, various projects of RE were started to vie for the benefits of preferential policy, leading to an over-expansion in the industry and the phenomenon of "structural similarity"; The industrial strategic target is not properly located and the policies are always in alterations, as a consequence, some projects were terminated right after being started, resulting in a huge waste of resources. Combining the industrial innovation theory and the notion of new-type industrial policies, this paper attempts to seek for new-type industrial policies which can overcome market barriers to RE innovation, and would promote the RE industry development more effectively and efficiently.

[1] Renewable energy usually refers to those energies that don't pollute environment and could be recycled in nature. International experts have now categorized RE to be traditional and new RE. The former mainly includes giant hydropower and biomass burnt directly; the latter mainly refers to small hydropower, solar energy, wind energy, biomass energy, geothermal energy and ocean energy, etc. The RE mentioned in this article all refer to the latter.

The paper proceeds as follows. Section 2 offers a brief literature review of the industrial innovation and industrial policies in economics. Section 3 describes the market failures in the innovation of RE industry and the necessity of policies. In Section 4, by rethinking on current RE industrial policies in China, we point out severe challenges facing the RE industry and the deficiency of the policies. Section 5 proposes the new type industrial policies that would complement existing policies, and promote the RE industry sustainable development

2. Literature Review

Numerous researches have been seen on industrial innovation and on industrial policies in the field of economics, yet studies on energy and environmental technology innovation policies are results of the expansion from the original field in recent years. (a) Under the assumption of "rational economic man", innovation is regarded as an investment activity in pursuit of maximizing the profits of enterprises from the perspective of Neoclassical Economics. From the opinions of Newell et al., as an induced innovation process, the innovation of energy-saving technology are likely to respond to changes in relative prices, therefore, innovation policy instruments should correspond to endogenous technological progress, and market-based policy exceed mandatory policy.[2] （b）Under New Institutional Economics' hypothesis of bounded rationality, the stimulation posed on innovation by institutional arrangement is emphasized after the analysis of the incentive mechanism in which behavioral subjects bring about innovation. Williamson has studied the main factors influencing innovation from various aspects including transaction costs, bargaining costs and decision-making costs etc.[3]（c）Evolutionary Economics considers innovation as an open procedure with dynamic evolvement on the assumption of bounded rationality of microeconomic entities. Kallis has stressed that the market and social factors are the two major powers that determine the evolvement of technology. At the same time, when it comes to innovation policies, he has focused on the balance between diversity of technology and the short-term costs, making a point of the importance of providing diverse options of technology under uncertain circumstances in case of being locked up by a specific structure or technology.[4]The theories mentioned above present meritorious ideas for the intervention of the government's industrial policies, but still with some limitations of their own respectively as guidance to China's renewable industrial policies. Under Neoclassical Economics' assumption of "rational economic man", the space for intervention by industrial policies is very limited, and it is far from enough to conduct emerging industries merely by "redressing the price". Although research into innovation by New Institutional Economics and Evolutionary Economics is more realistic on the assumption of "bounded rationality", which broadens the

[2] Newell R G, et al. "The induced Innovation Hypothesis and Energy-saving Technological Change, Quarterly Journal of Economics, 114,1999:941-957

[3] Williamson O E et al. "The Nature of the Firm-Origins, Evolution, and the Development, Oxford: Oxford University Press, 1991

[4] Giorgos Kallis. "Socio-environmental Co-evolution: Some Ideas for an Analytical Approach", International Journal of Sustainable Development and World Ecology, Feb. 2007:14

vision of industrial innovation policies from the angle of both institutional incentives and the evolution of society and economy. However, a comprehensive and sound solution has not yet been brought up for addressing market failure that the renewable industrial innovation process currently confronts.

As understanding towards market failure is deepening since the late twentieth century, theories of new-type industrial policy starts to present new ideas for industrial innovation. Rodrik et al have expounded the basis for industrial policies in two respects---namely "information externality" and "coordination externality".[5] Within their vision, entrepreneurs introduce new technology, experiment on production line and found new industries that suit local circumstances, all these innovation behaviors characterized by "self-discovery" could result in information externality because the risks and costs loaded on private sectors are out of proportion to their earnings due to imitation. Meanwhile, linkage between downstream and upstream investment is necessary in establishing new industries, moreover, maintenance for supporting facilities generate high fixed costs. Therefore a single enterprise can hardly afford to accomplish innovation on its own, yet the market is not powerful enough to coordinate different investors. That's why "coordination failure" occurs. Owing to "information externality" and "coordination externality", the government needs to offer necessary support for the establishment of new industries and of related innovation acts by industrial policies so as to sustain the momentum for industrial progress. However, this new type of industrial policies differs considerably from the traditional policies that pick winners and facilitate industrial development by means of tax, finance and even administrative regulation. It is named "functional policy" by Lall or "pragmatic policy" by Sable.[6] The aim of new-type industrial policies is to compensate for the deficiencies of the market and to improve market function so that the establishment of innovation ability could be accelerated. In comparison with traditional industrial policies, new-type industrial policies have the following attributes: (a) the industrial policies are intended as a complement and expansion for the market function, viz. a course during which the government collaborates closely with private sectors to overcome information externality and coordination externality. (b) In order to boost enterprises' innovation ability known as "self-discovery", instead of targeting at a specific industry, industrial policies concentrate on the enhancement of innovation ability by harmonizing factors including technology, information, financial capital, infrastructure, human capital, etc., and by sharing risks and costs that originate from innovation. (c) Industrial policy as a process of "matching best performers" instead of "picking winners". In other words, the

[5] Dani Rodrik, "Industrial Policy for the Twenty-first Century", One Economics, Many Recipes: Globalization, Institutions, and Economic Growth, Princeton University Press, 2007, 99-103; Ricard. Hausmann, Rani Rodrik, Doomed to Choose: Industrial Policy as Predicament, http://www.cid.harvard.edu/bluesky/paper/hausmann.doomed_0609.pdf.

[6] Sanjaya Lall, Reinventing Industrial Strategy: "The Role of Government Policy in Building Industrial Competitiveness", The IMF and The World Bank at Sixty, London: Anthem Press, 2005, 197-233

Charles Sable, "New industrial policy: Solving Economic Development Problems Without Picking Winners", http://infro:worldbank.org/etools/docs/library/143895/New_Industrial_Policy_June%2013.pdf,

new-type policy focuses on setting search networks that allow enterprise to rapidly identify people or institutions that are solving a problem closely related to what the enterprise is trying to solve. The above notion of new-type industrial policies is a significant reference to developing countries on how to enrich the domestic industries' ability to innovate under worldwide competition.

3. Market Failures in the RE Technology Innovation Process and the Necessity of Policy

As an emerging industry, the development of RE industry is a process of industry innovation itself. From the perspective of Evolutionary Economics, this course is more than merely a practice of enterprises, but a comprehensive process involving with complex elements including the enterprises, the citizens, the government and the non-government organizations (NGOs). Besides, it is not a linear process, but rather an interactive process of information exchange and negotiation within enterprises, citizens, the government and NGOs. Furthermore, as the result of the fact that RE is supplementing and replacing traditional energy, a profound reform will be activated towards the mode of production and utilization of energy. However, from the traits stated above of the innovation of RE industry and from China's actual conditions, there exist in the innovation of China's RE industry several market failures as following:

Firstly, the innovation of RE industry is in the face of a lack of core technology caused by "dual information externalities". Currently, R&D in wind power and solar thermal technology has been refined to an advanced extent while China is holding fairly limited core technology, expanding manufacturing ability by purchasing production licenses or by designing in alliance with foreign counterparts. This is because of the "dual information externalities" in innovation of RE technology. The first externality---the enterprise which innovates and develops the RE technology is not the monopolist of the achievements of R&D with part of the "technology spillovers" ----exists in every innovation act. The second externality is a "privilege" of RE technology innovation in that innovation of RE technology could not only reduce carbon emission and lessen externality costs, but contribute to environmental protection, energy security and energy independence as well, which leads to greater externality gains. Yet it cannot be reflected entirely on the price of RE the decrease in externality costs and the increase in externality gains. Dual externalities connote that the innovator of RE technology cannot monopolize all the social benefits originating from innovation and that its ratio of earnings to costs is far lower than that of general technology innovation. Given inadequate incentives of policies, the issue of "exclusion" discussed above will lead to a lack of motivation to innovate for entreprises. This can explain why developed countries such as the U.S., Germany and Japan give every assistance to technology innovation of RE.

Secondly, the innovation of RE industry is in the face of "coordination failure". Involving various phases, RE industry encompass a wide range of industrial chains including R&D, manufacturing of equipment and material, power generation, power transmission and grid connection, thus coordination of every industrial chains is essential to the progress of RE

industry. In particular, wind and solar power are very sensitive to seasonal and climate change and may cause grid instability and increase the complexity of grid management. Therefore they call for more organized and comprehensive coordination in the overall power system. Meanwhile, arrangement concerning power network planning and designing should show foresight so that RE industrial could develop in harmony with traditional energy industries. For instance, the majority of renewable resources needed for power generation are located in the west of China, which requires: (a) the construction of long-distance high-voltage transmission lines; (b) an adequate amount of backup generation capacity to maintain sufficient capacity in the grid to handle peak loads, (c) the restraint of the regular conventional power supply in the east in order to accept renewable power. Evidently, the market mechanism is not competent for such complicated tasks of coordination.

The third barrier to the innovation of RE industry is "lock-in effect". One of the outstanding problems in technological innovation of RE is the "chicken-egg problem": Market demand in RE depends on its cost and price; in the meantime, the cost and the price are determined by the scale of market demand due to network effects and economies of scale. Traditional fossil energy is still dominating the current energy structure in China. Particularly, 46% of installed capacities of thermal power, with international advanced levels, have operated less than 5 years and 65% less than 10 years. Therefore, the operating space for RE to replace traditional energy directly is very limited.[7] In addition, the cost of RE is relatively high, attenuating its market share exceedingly. At present, the proportion of wind power and solar energy in generating electricity per year is less than 2%. It is significant to create new market demand for RE through incentives of policies so as to break with the "lock-in effect".

The above mentioned market failures offer the demand for industrial policies in two areas: on the supply side, energy policies should enhance the capability of innovation. Investment in innovation of RE should be encouraged, uncertainties be reduced, stable expectations be guaranteed and benefits of new energy innovation be increased so that the "dual externalities" could be counteracted. On the demand side, the policies should create new market demand，clearing away the obstacles for the development of RE industry from the aspect of demand management.

4. Reflection on Current RE Industrial Policies

RE is gaining significant support and assistance from policies in recent years. Since the Renewable Energy Law (REL) of the People's Republic of China has been passed in 2005, the government has successively issued a series of regulations including the Renewable Energy Industry Development Guidance Catalog (2005), Interim Measures on Pricing and Cost Sharing for Renewable Energy Power Generation (2006), Relevant Regulations on the Administration of Power Generation from Renewable Energy (2006), Interim Measures for Renewable Energy

[7] Wu Jiang, The Basic Motivation and the Main Direction of RE, China's Energy, 6,2010

Development Special Funds(2006), Notice Regarding the Price Policy of Grid-connected Wind Power (2009), etc. Further, the principle that RE should be a priority and be purchased in full amount was indicated by Amendments to Renewable Energy law launched in 2011. Heretofore, a meaningful institution has been established for facilitating RE industry to progress---namely RE Target Policy (RETP), Feed-in-Law (FIL), Feed-in Tariff (FIT), System on Cost Sharing and Special Fund for RE.

Thanks to assistance from industrial policies and spur from market demands, RE industry is speeding up, ranking among the top ones worldwide in various fields. In 2010, China's installed wind power capacity has outstripped the U.S., ranking first in the world at 44.7GW (table 1); China became the world's largest solar photovoltaic (PV) cell manufacturer in 2010, the output of solar PV cell reached 1 MW, taking up 45% of global production.[8] However, RE industry is also confronting severe challenges, which is profoundly manifested in the following ways:

Table 1. Added and Existing Wind Power, Top 10 Countries, 2010

Country	Cumulative at end of 2009 (GW)	Added in 2010 (GW)	Cumulative at end of 2010 (GW)
China	17/25.8	14/18.9	31/44.7
United States	35.1	5.1	40.2
Germany	25.7	1.5	27.2
Spain	18.9	1.8	20.7
India	10.9	2.3	13.2
Italy	4.8	0.9	5.8
France	4.6	1.1	5.7
United Kingdom	4.4	0.9	5.3
Canada	3.3	0.7	4.0
Denmark	3.5	0.3	3.8

For China, the lower figure is the amount classified as operational by the end of 2010; the higher is the total installed capacity.
Source: Renewables 2011 Global Status report

(a) Self-dependent innovation capability of core technology is far from sufficient. Although China has turned the world's largest producer of solar PV cell and ranked top in terms of installed capacity of wind power, the major part China is playing is concentrated on the low end of the manufacturing process in the industry. In regard to wind power, at the moment it is the international mainstream trend that the power of onshore wind turbine exceeds 3 MW and that of offshore wind turbine is over 5 MW, still there are merely few of Chinese firms possessing the

[8] Renewables 2011 Global Status report, http://www.ren21.net/REN21Activities/Publications/GlobalStatusReport/tabid/5434/Default.aspx

manufacturing ability of more than 3 MW wind turbines. Also, most manufacturers of wind power equipment are simply an assembly plant while the acquire control system and the pivotal bearings need to be imported. Despite the fact that there has emerged over 500 photovoltaic firms, the majority of them still specialize in the manufacturing and assembling of solar panels. Both high-purity silicon materials and high-class equipment used for crystalline silicon photovoltaic cells are heavily dependent on import. Also, China still has a long distance to go in comparison with advanced world levels in terms of thin film solar cells and equipment manufacture.

(b) Industrial standards are not consistent and market competition is out of order. In respect to RE industry where market access threshold is low, there could still see deficiencies in the system of technical standards, product testing and authentication, bringing about an influx of smaller firms into the industry, which consequently results in backward over-production. Some products are launched into the market in huge quantity without being tested, putting a great deal of equipment at the risk of breakdown. Several cases of wind fan off the grid in succession this year is a worrying alarm.

(c) Another difficulty is the violent uncertainty as well as the lagging demand management. The extensive exploitation of wind power is far from commensurate to the construction of power grid, leading to such a huge excess of generating capacity. By the middle of 2011, nearly one-third of the domestic wind turbines are idle. It is even a worse case for the PV market. It should be noted that photovoltaic power generation costs a much larger amount than thermal power and wind power while both feed-in tariff and market support mechanisms are unsatisfactory, which contributes to the consequence that the growth of domestic market is lagging behind. With 95% of the production being exported, PV manufacturers in China are in a dilemma of “production without utilization” and the industry profit often fluctuates radically with the international market’s undulation.

The issues discussed above are closely related to the deviation of current RE industrial policies.

Firstly, the goals of RE industrial policies tend to overemphasize quantity but ignore quality at the same time. Industrial policies set specific goals in magnitude of production for the development of RE and adopt various measures including tax and subsidy to expand the industry, but seldom strict norms are posed upon technology standards, environment standards and competition rules. The development-oriented industrial policies are too obsessed with expansion in quantity, the possible aftermath of which is the inferior low-level expansion, overlapping projects as well as vicious competition.

Secondly, as a result of lack of in-depth understanding in the innovation’s essence in RE industry, the thinking patterns of industrial policies are still bounded in “picking winners” rather than fostering innovation ability, along with neglect of the need for forward-looking and

systematic strategic arrangement of industrial innovation. For example, R&D funded by the government is relativly low; with inadequate support entreprises would rather take a shortcut by introducing foreign technology than innovate rashly under high market risk and unpredictable return on investment (ROI).

Thirdly, the dislocation of the government and the market could be seen in implementing RE industrial policies. On one hand, policies are most often top-down approaches without communication with entreprises, tending to overlook both the entreprises' independent innovation ability and inspirations for their innovative spirit. As a consequence, RE entreprises are over-dependent on policies with an absence in long-term market strategy. On the other hand, industrial policies have placed deficient concern on public affairs, such as energy resource assessment, technical standards and certification, etc. Meanwhile, the policies are placing excessive intervention on problems that ought to be tackled chiefly by the market, for instance, industrial layout and the scale of production.

5. New Perspective on China's RE Industrial Policies

With regard to the abovementioned problems in China's RE industry, it is hereby advised that changes should be attached to the following aspects in China's RE industrial policies.

(a) Supply Management Policies Directed by Enhancement of Independent Innovation

Mastering independent core technology is a prerequisite for the RE industry's sustainable development in China. Preliminary research shows that China's low carbon technologies including RE technology, remained nearly a decade behind the world advanced standards, implying that there is still the possibility for China to overtake them.[9] RE technology is regarded as an influential component of the future national competitiveness, hence would not be transferred to developing countries out of political consideration. Besides, difficulties in aspects such as market, capital and information are obstacles in the way of technological cooperation. Therefore, with regard to RE technology, its development should rely mainly on independent intellectual property rights (IPRs), supplemented by introduction of foreign technology. In the meantime, it is necessary to adopt corresponding guide policies discriminately according to specific phases in the innovation cycle, seeking for greater efficiency of innovation. The government should financially place emphasis on R&D of strategic core technology in RE and facilitate the breakthrough of RE technology by founding national laboratories, establishing open public research platforms and organizing forces to break through the technical problems. In respect to technologies which have been put into certain trials, such as new-type thin film solar power and offshore wind power, groundbreaking R&D with entreprises being the mainstay should be encouraged and supported. On the basis of a wide-range collection of ideas from experts and entreprises, the government could bolster entreprises to address key technological

[9] Sustainable Development Research Group in Chinese Academy of Science, the Report on the Sustainable Development Strategy in China(2010), Beijing, Science Press, 2010,88

difficulties by means of subsidies, tax preference and technological innovation platforms (for example, innovation alliance of RE firms). In terms of mature technology with a commercial prospect, the government could share costs and risks with entreprises through guide policies such as appropriate fiscal subsidies, government procurement and direction for private investment. By these policies, the government should also urge entreprises to employ new technology, clearing away the path for the pervasion of new technology.

(b) Demand Management Policies aimed at exploitation of RE market

The key to the exploitation of RE market lies in reform of electricity system. Firstly, a sound pricing mechanism is needed for renewable power. The new policy should gradually explore suitable pricing for different regions and define the principle for renewable power price adjustments. Secondly, the price support mechanisms need to be structured in such a way as to reward the most efficient RE suppliers and to give them an incentive to reduce costs as rapidly as possible. Thirdly, grid companies need to be motivated to fulfill their primary obligations on purchase electricity generated by RE in full amount. Indeed, this kind of sustaining policy relying mostly on government subsidies is merely an "accelerator" for RE industry in the early stage of development rather than a permanent solution. In the long run, important tasks include: to speed up the reform of the pricing mechanism of electricity, to build up a power pricing system that could reflect scarcity and environmental factors, and to rationalize the power price relations of various types of energy. Meanwhile, developed countries could be taken as a good example for us in carrying out the policy of Renewable Portfolio System (RPS) and the Tradable Green Certificate (TGC), which could finally realize the specific goal of RE's market share at the minimum cost.

(c) Functional Industrial Policies on the Basis of Positive Interaction between the Government and Entreprises

RE industrial policy should be based on proper government-entreprise relations: instead of a passive recipient, entreprises are acting as the leading role in the growth of RE while the government is the strategic guide. (i) Within the decision making in RE industrial policy, the government should collect opinions from the business circles on a wide-range basis, taking every actual condition and obstacles into consideration. Also, the policy should be devised with definite goals and clearly-defined time range with the purpose of a diminution uncertainty and of the stable expectation for entreprises, which enables the entreprises to adapt their development plans and major fields to the goals set by the government.（ii）The enforcement of RE industrial policies is a course of information exchange, rendering the entreprises more adaptable and flexible during dynamic adjustment. Based upon the development of the market, the government should modify industrial policies in time, repeal certain preferential policies and encourage private investment into RE industry under appropriate circumstances.（iii）Respect and cultivation for entrepreneurship is important. RE industrial policies should make every effort to inspire entrepreneurship in that it is the source of innovation. Convenience provided in terms of capital

market, venture capital investment, intellectual property rights protection could allow entrepreneurs to seize every opportunity of development in RE industry.

6. Conclusion:

Renewable energy is playing a potentially important role in increasing electrification levels thereby protecting the environment, and providing for economic and social needs. China will aim to have 15% of primary energy consumption come from RE sources by 2020, and the government is pushing ahead with its vows to clean up its energy supply and is working on overcoming some barriers that have stood in the way of achieving this goal. However, three facts prevent us from being optimistic about China's RE industry future. First, China is concentrated on the low end of the manufacturing process in the industry. This is due to lack of self-dependent innovation capability of core RE technology. Second, market competition is out of order because industrial standards are not consistent. Finally, a significant amount of renewable generation capacity is wasted because the growth of domestic market is lagging behind. These three problems are likely to persist unless there are substantive policy changes. Based on the analysis of China's existing RE policies, we suggest that these challenges should be dealt with by introducing a new type industrial policy that directed by enhancement of independent innovation, aimed at exploitation of RE market and based on the positive interaction between the government and enterprises. It is clear that reforms in RE are still underway, with further rapid, effective and sustainable developments of RE in coming years.