



Green Energy for Belt and Road Initiative: Economic Aspects Today and in the Future

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ABSTRACT

The belt and road initiative (BRI) is a comprehensive megaproject, which includes numerous projects in the sphere of green energy. The effectiveness of these projects is often doubted. The article reveals the main mechanisms of green energy projects' influence on the economy and through the research of 8 BRI countries demonstrates the method of green energy projects efficiency estimation. China is considered to be the main driver for green energy proliferation in Asia, receiving economic benefits through its policy. The authors prove this to be right, but the effects for PRC differ in short and long-run periods. The main findings of the paper are that the BRI green energy dissemination is just the first step to building a tightly interconnected Asian energy infrastructure, and that the BRI least developed countries have less positive long-run effects from green energy investment, while in short-term they get a boost for their economies.

Keywords: Belt and Road Initiative, Green Energy, Energy, Asian Region, China

JEL Classifications: F21, K32, O44

1. INTRODUCTION

The Chinese initiative "One Belt, One Road" also known as belt and road initiative (BRI) is one of the most ambitious and complex projects of the 21st century. It covers a wide range of subjects of integration, including infrastructure, finance and economics, energetics and ecology. The synthesis of the last 3 mentioned is the main subject of this article. It's obvious, that BRI is aimed at developing international cooperation in these spheres, and at strengthening the influence of Chinese companies in the countries along the BRI. Still, it's an issue for active discussion whether the energy projects under BRI stimulate the development of countries, receiving foreign direct investments (FDI). The impact of the energy projects on the national economy differs, depending

on the country, but it no doubt provides additional impetus for the economies of participating countries. The description of this impetus and estimating the potential economic benefits is vital for understanding the effectiveness of BRI initiative in general.

The main aim of this article is to estimate the economical effects of BRI green energy projects realization for the development of the initiative itself and for the overall narrowing of the gap between the least developed countries (LDC) in Asia and the most dynamically developing economies of the region. The problem of forecasting the long-term effects of the described projects is vital for Asian economies due to the fact that their intense development requires both energy resources, stable and burgeoning economies and a better ecological situation in industrial districts, than it is today.

It's also important to reveal the extent, to which the green energy projects help the development of the energy BRI.

The scientific novelty of the article comprises the new approach to the estimation of the effectiveness of green energy projects in developing economies and the revelation of the effects of these projects on the Chinese economy. The latter is the intrinsic reason for the realization of the green energy component under the BRI, hence contributes to understanding the future of the Initiative.

2. LITERATURE REVIEW

The study of green energy projects in the world and in BRI is a highly discussed topic. The main themes of discussion involve the estimation of the effectiveness of green energy development under BRI (Andrews-Speed and Yao, 2019). It's notable that the BRI is considered as a loosely-linked countries platform that includes countries of different development levels. In this paper, we pay attention to the LDC of Asia and to the most dynamically developing countries of the region. Still, we think, that action in this sphere is vitally important and tend to stick to the opinion expressed in the (Zhou et al., 2018), that the actions should be taken, but with respect to the economic development of the countries.

The security aspect is important in the context of BRI development too (Umbach, 2019), moreover, the importance of energy security for the most dynamically developing countries is even more important in our vision, than for the LDCs. We can't avoid mentioning the articles about the impact of green energy on the BRI and China and other BRI countries (Fan et al., 2018; Gopal et al., 2018; Morris, 2018; Mathews and Tan, 2017; Sun et al., 2016; Yueqin and Yisi, 2012), as this aspect of cooperation under BRI should be considered for every economy individually, and only after that expanded to BRI in general.

The key issue of all these articles is estimating benefits from green energy to BRI countries, but most of them involve empirical or complex and too sophisticated statistics analysis methodic. China has contributed greatly to forming a view of BRI as an instrument of promotion of green energy (Rauf et al., 2018), so today energy policy under the BRI are viewed as green (Li et al., 2018). We mostly rely on the statistics of the U.S. Energy Information Administration (EIA), because of the most comprehensive base on alternative energy statistics. In addition to that, we used Deloitte analysis in our study (Deloitte, 2018).

3. METHODOLOGY

First of all, let's determine what we understand under green energy or alternative energy resources in this article. In our opinion, green energy includes any sector, that lessens the CO₂ emissions. According to that, nuclear energy seems to be green, but with respect to the history of nuclear energy and the consequences of technological catastrophes on nuclear energy plants, we assume that at the current level of development it's not green. Summarizing, green energy includes: Solar, wind, hydro energetics as the dominant sectors, geothermal and tidal energy and the construction of infrastructure for these industries.

The methodology of this research is based on the rating methods, tailored by authors to the economic development in the BRI countries. We put forward two main factors: Share of green energy in total energy consumption in the country and FDI in green energy in 2013-2018. We analyze the statistics and calculate the values of the factors. In accordance with the same methodology, we research the Chinese economy. We introduce correction coefficients for the 1st factor, these are: Gross domestic product (GDP) growth 2013-2016/average GDP growth 1980-2016 ratio, energy market growth 2013-2016/average energy market growth 1980-2016, green energy growth 2013-2016/average consumption growth 1980-2016, quantity of green energy projects 2013-2018. Afterwards we calculate the investment price of an additional green energy unit of measurement in these economies and in this way, we can give conclusions on the financial effectiveness of green energy for BRI countries.

The described method allows to estimate the economical effectiveness of BRI green energy mechanisms in general and to give a forecast of their future development.

We put forward a hypothesis that the development of green energy in BRI countries contributes to the development of the industry in PRC. It will be proved, if the cost of an energy unit in China will be higher, than in other researched countries in case, BRI developed in a free trade zone, the contrary is true too. This should be regarded as a consequence of competitive advantages of the Chinese industry of energy generating machines that are exported by the Chinese companies.

The recommendations for the future development of green energy under OBOR are made with respect to the hypothesis testing results and other findings of the article.

4. MAIN GREEN ENERGY PROJECTS IN THE BRI COUNTRIES

The most attractive countries for the green energy projects, realized under BRI are Myanmar, Pakistan, Iraq, Ethiopia, Thailand, Vietnam and Malaysia. Still, the majority of green energy projects are hosted by China itself (Rising Powers, 2019). The reason for this will be demonstrated hereinafter.

First of all, let's give a short overview of projects in Myanmar. We can't avoid mentioning the Myitsone Dam dilemma. It's one of the biggest hydropower plants in Asia, required financing of over \$3.6 bln. The project was suspended, because of the public protests of local citizens, indignant on the fact of destruction of their cultural heritage (Fawthrop, 2019). The dam should have provided 6000MW power that would have allowed Myanmar to extend its electric energy surplus (IEA, 2019). Today China is pressing Myanmar authorities to allow the construction, because the social benefits will be more significant than losses.

Pakistan is another significant milestone in the Energy BRI. Pakistan has already been a part of Chinese energy diplomacy and taken part in coal development projects. Still, there are 2 main green energy projects there. The first one is Quaid e-Azam

Solar Park, a partnership between a Chinese state-owned company TBEA Xinjiang SunOasis and the Pakistani Quaid-e-Azam Solar Power. The project, when fully operational will provide 1000 MW power (Durrani, 2015). The average cost will be equal to US14.15 cents/kWh. The second project is Jhimpir Wind Farm, capable of providing 106 MW. It will be a part of a larger project — Gharo-Keti Bandar Wind Corridor (Naeem, 2012). The whole project is pricey; \$1.35 bln is the lowest estimation of finance required.

There are two main projects on the territory of Bangladesh: Tangail solar farm and Mongla solar farm. The economic effects of these projects have already been assessed (World Bank, 2015), just as the climate availability to implement solar energy technologies (Rahman et al., 2013). The two solar power plants will produce a total of 150 MW, the costs of kWh equalling to \$14 cents (Rising Powers, 2019).

Ethiopia receives significant investments wfrom China for the construction of the energy infrastructure. First of all, the Aisha wind farm project, that comprises three 100 MW turbines (Bekele, 2012), is a logical part of the Energy BRI project. But, the most important for the national energy infrastructure is Wolayita Sodo power transmission project that establishes a new standard for energy infrastructure in Africa (AFDB, 2009).

The overall costs of energy development in Ethiopia under BRI are estimated as no less that \$280 million. The transmitting line connects Ethiopia and Kenya, so partly the costs are undertaken by the Kenyan side.

Thailand, Vietnam and Malaysia are developing solar energy projects. Yingli Solar Plant in Thailand is supposed to produce 300 MW energy and will cost Yingli Green Energy Holding Company Ltd. \$19 million. Trina Solar Sciences and Technology in Vietnam and JA Solar Malaysia Solar Facility will produce solar panels, the yearly capacity of which is equal to 700 MW and 400 MW.

As we have demonstrated, alternative energy production and the creation of infrastructure for its production play a significant role in financial politics of the Chinese companies and banks. It's clear, that China is pushing forward the idea of greener Asia, being especially pushy in the LDC. Still, it seems, that at some point PRC has realized the extreme persistence of its actions and tends to act more flexible.

We won't describe or mention all the green energy projects under BRI, because there are no less than 57 of them since 2015, the FDI involved in their fulfillment balancing on the verge of \$19 bln (\$18,870 mln) (Scissors, 2009). That's why we have mentioned only the most notable and salient of them, that illustrate the main tendencies of green energy development and impacts.

5. THE ASSESSMENT OF THE IMPACT OF GREEN ENERGY PROJECTS ON THE DEVELOPING ECONOMIES AND FINANCE

First of all, green energy projects are financially dependent on FDI in most of the developing countries. The amount of financial capital requested to operate these projects is significantly higher, than

the one of traditional energy resources. In addition to that, higher quality of human capital and energy infrastructure is necessary to develop alternative energy.

The main economic effects energy sector development provides to the economy are similar to the effects of the development of any other economic sector — these are: More vacancies, consequently, lower unemployment rate, higher GDP and gross national product, lower energy costs for corporate (industrial) and private sectors and in addition to that stimulates the economy in general (GDP growth as a result of higher consumption). Lower costs for private and corporate sectors allow to allocating more financial resources for investments, in this way forming an economic multiplier.

Green energy adds some new factors to the development of the national economy. First of all, green energy is one of the pilot industries for innovations. It's clear, that the efficiency of current technologies in this sphere is lower, compared to the traditional energy sources (The Economist, 2014). On the example of North America, higher costs of green energy are demonstrated in (Aghahosseini et al., 2017). In this aspect, new technological solutions can provide a significant boost for the economy, that offers innovations. Moreover, the innovation and creative solutions horizons in green energy are wider than in traditional energy industries. Through this effect, the growth of GDP is more likely for the recipient countries. Secondly, the FDI in the green energy is significantly more regionally concentrated: This is tightly connected with technical and climate conditions of the region (many sunny days for solar energy, stable winds, low dependent on season for wind energy, rich hydro resources and territories, available for flooding for hydro energy, and even more specific conditions for tidal electro-generators and thermal electro-stations. The regional specifics of the industry lead to higher requirement for energy transportation, accordingly, energy infrastructure, providing in this way more jobs, higher contribution to GDP and a base for human capital development. All these factors stimulate the integration of the least developed economies, following the path of green energy development, in global economy and finance through tighter cooperation with developed economies, moving in the same energy policy track, and via the cooperation under the international conventions, such as Vienna Convention for the Protection of the Ozone Layer (UN Treaty Collection, 2019), Stockholm Conference (UN Documents, 2019) and other fundamental international agreements.

6. THE ASSESSMENT OF THE ROLE OF BRI IN THE DEVELOPMENT OF GREEN ENERGY IN PARTICIPATING COUNTRIES

One Belt, One Road is a comprehensive initiative, that allows to attracting FDI in a wide range of projects, including green energy initiatives. The main problematic aspect is whether the green energy projects significantly contribute to the development of the economies of chosen countries.

Figure 1 demonstrates the production of alternative energy and nuclear energy in the named countries. It looks like in the past

40 years the changes in the situation on the market began only 6 years ago (the period of fast growth began in 2012-2013). Still, it's important to notice the dynamics of consumption of energy in the researched countries (Figure 2).

Figure 2 demonstrates a stable tendency of linear growth of consumption of energy resources in the researched states. When comparing Figures 1 and 2, it becomes clear that the new sources of energy don't have a significant role in the development of energy markets in Asian countries. The highest share of alternative energy in the consumption of these countries barely reaches the level of 10% with the major growth achieved in the last 3 years.

The contribution of green energy in the GDP of the developing countries is hard to assess statistically, but we offer a rating methodic, described in the methods.

The analysis of the Tables 1 and 2 allows to concluding that Malaysia, Vietnam and Thailand demonstrate the most effective green energy industries development among the BRI countries. At the same time, the average cost of a green energy project is the lowest in Malaysia, when in Vietnam it exceeds the cost of Thai green energy projects nearly two times. The leader of the industry development effectiveness is Malaysia, Thailand follows and Vietnam is on the third position. At the same time, we have to mention that green energy in Myanmar, Ethiopia and Bangladesh seems to be a worse path of energy industry development than traditional energy. Bangladesh alternative energy may be under-financed, as a result, its effectiveness may be low, but the FDI in Ethiopian projects seem to be close to median values. The sector in Myanmar may seem over-financed, especially, taking

into account poor results, but the project mentioned in the table, is temporary put on hold, hence, despite little or no investments, Myanmar is desperate to develop its green energy industry and has reached success. Further study is required to give an answer of the economic effectiveness of green energy in these countries. Moreover, it's worth mentioning, that Myanmar is building its energy industry (green energy included) on domestic financial resources.

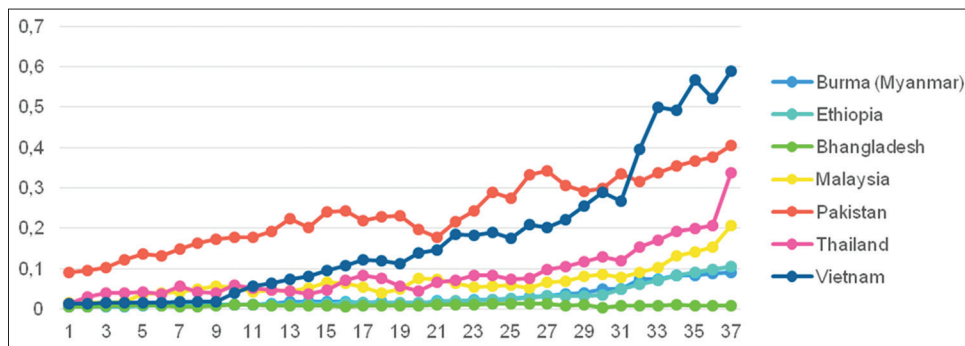
Let's calculate the price of an additional energy unit in these countries (we divide the delta between green energy production in 2013 and 2016 on the FDI for this period).

The analysis allows to concluding that Bangladesh needs massive reforms in order to succeed on the path of green energy development. Myanmar successes are low, but positive, still it's a matter of discussion whether the return on investment in Myanmar is acceptable. The preliminary estimation results from Table 1 proved to be right.

The next step of the research is the estimation of the effect of green investment on China.

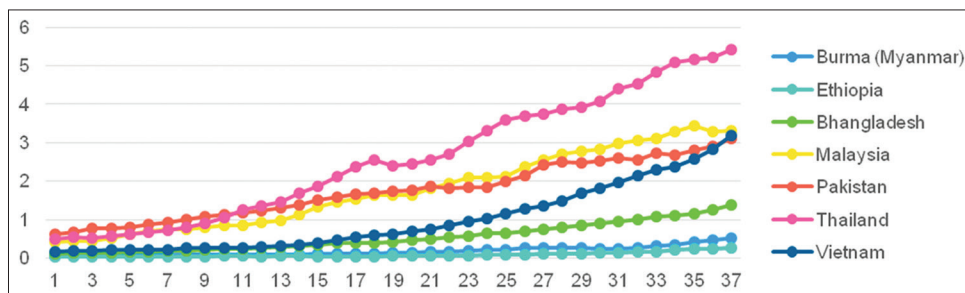
Table 3 demonstrates lower effectiveness of the Chinese investments in green energy, than in most of the alternative energy sector countries it invests in. Taking into account the fact, that PRC is the biggest investor in this sector in the world and the fact that BRI stimulates trade, but still isn't a free trade zone, the hypothesis of the Chinese dominance in the sector may be considered temporary proved. Still, the future of the Chinese green energy sector seems not that bright. FDI in green energy

Figure 1: Production of green energy by countries



Source: Compiled by the authors based on the EIA statistics (EIA, 2019)

Figure 2: Production of green energy in the chosen countries



Source: Compiled by the authors based on the EIA statistics (EIA, 2019)

Table 1: Indexes for the chosen countries (except for China)

Country	GDP growth 2013-2016/average GDP growth 1980-2016 ratio	Energy market growth 2013-2016/average energy market growth 1980-2016	Green energy growth 2013-2016/average consumption growth 1980-2016	Quantity of green energy projects 2013-2018	FDI in green energy 2013-2018, million \$	Overall green energy index	Average cost of a green energy project
Myanmar	0.96	1.04	0.97	1	3600	0.97	3600
Pakistan	0.99	0.99	1.00	6	2210	1.02	368.33
Bangladesh	1.06	1.00	0.84	2	78	0.79	39
Ethiopia	1.07	0.97	1.01	1	260	0.97	260
Thailand	0.92	0.97	1.16	4	620	1.29	155
Vietnam	0.96	0.87	0.99	4	970	1.18	242.5
Malaysia	0.91	0.92	1.11	3	440	1.32	146.67

Source: Calculated by the authors based on the EIA statistics (EIA, 2019) and the Heritage Foundation data (2012). GDP: Gross domestic product, FDI: Foreign direct investments

Table 2: Calculation of the effectiveness of investments

Country	Millions BTU per \$ million
Myanmar	1771
Pakistan	82,072
Bangladesh	-38,212
Ethiopia	9544
Thailand	40,755
Vietnam	224,038
Malaysia	290,138

Source: Calculated by the authors based on Table 1

demonstrate higher efficiency, than domestic direct investments, what puts under question the financial efficiency of the Chinese green energy program (US-China Energy Center, 2019).

The most effective investments in the sphere of green energy are concentrated in the sector of solar panels and parts for green energy equipment production. Both Vietnam and Malaysia received investments in developing this sphere. At the same time, China is investing in researches on the issue of higher efficiency of alternative energy sources. It is a promising direction of development, especially taking into account the fact, that PRC is searching for greener ways of economy development. Furthermore, the cheaper production technologies it explores, the more effective will the whole Energy BRI be. To sum up, despite low returns of BTU per investments, China is tending to build an effective industry of green energy exports via the mechanism of BRI.

7. DISCUSSION

In general, BRI is one of the most efficient mechanisms of attracting FDI to participating countries, still the main issue is whether the declared goals of development correspond with the real situation. As it was demonstrated earlier, green energy is one of the key directions of cooperation in BRI countries. China makes generous investments in the energy sphere of other countries, moreover, it develops national green energy sector. PRC and its multinational companies aren't altruistic, so they expect high returns on their investments (both in political benefits and in economic merits). Still, it's just the first layer of their policy. They test the efficiency of their technologies and collect a wide portfolio of projects in order to take active participation in the global reformation of the Chinese energy sector. The exports of green energy infrastructure components allow to attracting long term inflows of revenues, that are needed to invest in scientific researches. The long run revenues are gained via the servicing of the constructed green energy infrastructure and the returns on investments. All in all, this model allow to accumulating financial resources in the sphere without massive state financing and national direct investments. Still, the green vector in the BRI is a matter of discussion.

It's clear that the investment risks in the LDC are higher, so the general risk for the donor economy grows with the growth of investments in their economies. At the same time, many Chinese partners under the BRI pursue their own short run economic goals and green energy investments can help to achieve them. The situation with green energy in the LDC is the following: As

Table 3: Indexes and the effectiveness of green energy in China

Country	GDP growth 2013-2016/average GDP growth 1980-2016 ratio	Energy market growth 2013-2016/average energy market growth 1980-2016	Green energy growth 2013-2016/average consumption growth 1980-2016	FDI in green energy 2013-2018, million \$	Overall green energy index	Millions BTU per \$ million
China	0.94	0.94	1.05	445,900	1.19	10,177.99

Source: Calculated by authors based on references (Mathews and Tan, 2017; Rivera, 2018)

the costs of green energy development are higher, compared to traditional energy, the Chinese investments are one of the ways to support economy and fight the unemployment. The effects are considerable, especially, if the climate and natural conditions allow to develop green energy actively. Still, the long run prospects for green energy development are doubtful.

The consequences of green energy projects development in the BRI countries' economies differ, but the main course is the same. Green energy investments have a multiplication effect for their economies. They boost the production of technologically simple details, provide working places and thereby stimulate national consumption. In addition to that, they stimulate international trade, contributing to integration of the LDCs in global economy, but this consequence can be both positive and negative, because, the more integrated national economy is in the global, the more it suffers from crises. Still, it's notable, that BRI is a framework for the activities of multiple trade agreements, investment partnerships and development banks (Ohashi, 2018). This fact allow to making a conclusion about the prevailing positive effects for LDCs. In short term, the economies of the recipient countries get a mighty boost, but with the fading effects of this boost come the doubts on whether the decision of accepting green energy investments was wise.

In long term green energy is more expensive and has some specific moment to take into account:

1. The price of servicing the infrastructure for green energy is bigger, than for traditional
2. Once the infrastructure for green energy is built, it's nearly impossible to cheaply reconstruct it for the use of traditional energy
3. The green energy technologies are less effective than the traditional technologies and require higher professional skills to manage the energy system
4. Green energy is most efficient for small consumers (for example, villages, lone habitats etc., but it doesn't cover industrial needs and needs of large cities).

All these factors contribute to the fact that green energy is considered as a supplementary source of power, and sometimes even as an occasional opportunity to receive investments. It contributes to the opportunist behavior in this sphere and if BRI is regarded as a single massive of energy consumers and producers, BRI doesn't get significantly greener. Last, but not the least important is the fact, that the Chinese producers of green energy components are not that eco-friendly as they should have been (Hilton et al., 2011; Zhang and Wang, 2016), so the main problem is that the harm for the environment from the manufacturers of these components is significant.

In long term, green energy in Asia brings many benefits to the people (cleaner air, less hydrocarbons extractions, lower budget spending on import of energy, compensated by higher expenditures on national production), but not that many positive effects for industries. First of all, greener energy means higher environmental standards, which in turn make the developing countries less attractive for dirty industries. The Asian developing countries lose OLI benefits (Sharmiladevi, 2017), and their economies are forced to change in order to survive. Secondly, when the standards are imposed, it's nearly impossible to reverse them. Today fast economic growth involves either exploitation of resources (both natural and human) or innovative growth, the second isn't characteristic for the LDC, so green energy in long term potentially prevents their growth.

The framework of BRI is based on the fast economic growth and is buttressed by benefits, that come today, not tomorrow. Green energy is only the first step for future cooperation in energy sphere, but not a very long-lasting and stable trend. The development of alternative energetics is necessary for China, India, Indonesia, Vietnam and other industrially developed countries, when the development of this sphere in the LDC is less effective. The most powerful countries of Asia, being at the same time the most industrially polluted countries tend to make the other states follow the trend of greener BRI, trying to shift a part of costs of the development of their national industry on them. But the economies of less developed countries need more conventional and cheaper energy resources. These controversial dynamics are a potentially conflict point in promoting Energy BRI and building its energy strategy.

8. CONCLUSION

BRI is a mighty instrument of promoting the interests of the dynamically developing countries of Asia. One of the key spheres of partnership under BRI is energy policy, green energy playing an important role in the Energy BRI. The impact of green energy on the economies of participating countries differ, the hypothesis, that the more developed countries (on the example of China) get more benefits, than the LDC from green energy is proved for the current situation, but with one correction — the FDI in green energy are far more effective, than national direct investments. In long run the hypothesis wasn't tested, but empirical findings show the countries involved get more benefits, when they produce components for green energy, than when exporting energy resources, or introducing green technology in national economies.

BRI countries need to develop green energy, the short-run effects on their economies are positive, but in long term the negative

consequences create a negative synergetic effect and their economies face higher risks. In order to estimate the short-run effect we offer a simple method of estimating the cost of one energy unit in dollars of FDI. We expand the simple calculation, described in the text and offer a median estimation method, when the countries are divided to quartiles (by the indicator of BTU/\$ of FDI) and in accordance to that the recommendations of whether green energy is efficient or not are given. At the same time, we understand the ecological situation on our planet and support the trend of disseminating of greener energy in BRI countries, despite the fact, that in some cases their intentions are more of a financial, not ecological character.

The main tracks to be developed in order to promote greener BRI are:

- Achieving higher efficiency of green energy technologies
- Cutting the costs of their servicing and constructing
- Developing a conception of individuals as suppliers of green energy in Asia
- Financial support to the companies, introducing green energy in their manufacturing process.

The green energy is a vital point for the future development of Asian industrial giants, and a very important issue for the LDC, but the approaches to developing this sphere should be different.

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