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Problems in the Accomplishment of Solar and Wind Energy in India

Problemy z pozyskiwaniem energii słonecznej i wiatrowej w Indiach

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Abstract
This article focuses on the current energy status and the obstacles related to the development of solar and wind capacity in India. The fast growing demand of electricity exerts huge pressure on the conventional energy sources. Due to the intermittent nature of irradiation and wind velocity, hybrid grid structure is more preferable in the present scenario. The use of alternative energy sources like solar and wind is the measure, which helps to attain eco-friendly, green environment. It decreases the dependency on fossil fuel energy for the highly populated country like India. Elimination of the hurdles discussed in the article works serves as a catalyst for the sustainable development of the country. The proposed paper deals with the problems which need to be solved in order to accomplish the solar wind energy project planned by the government of India.

Key words: solar energy, wind energy, barriers, renewable energy

Streszczenie
Artykuł przedstawia obecną sytuację i problemy odnoszące się do rozwoju energetyki słonecznej i wiatrowej w Indiach. Rosnące zapotrzebowanie na energię elektryczną oznacza wzrost wykorzystywania konwencjonalnych źródeł energii. Z uwagi na nieregularny poziom nasłonecznienia i zmienną siłę wiatru preferowana jest obecnie hybrydowa struktura sieci energetycznej. Wykorzystywanie odnawialnych źródeł energii prowadzi w kierunku powstania proekologicznego zielonego środowiska. Zmniejszeniu ulega poziom uzależnienia od paliw kopalnych, co jest istotne w krajach o wysokim poziomie zaludnienia, takich jak Indie. Eliminacja nadal występujących przeszkód to znaczący krok w kierunku rozwoju zrównoważonego tego kraju. Artykuł omawia problemy, które stoją na drodze do planowanego przez rząd Indii zwiększenia wykorzystywania odnawialnych źródeł energii.

Słowa kluczowe: energia słoneczna, energia wiatrowa, bariery, odnawialne źródła energii

1. Introduction

Solar energy is the energy which comes directly from the sun in the form of light and heat that is converted in the useful form with the help of variety of technologies, such as solar heating, photovoltaic, molten salt power plants, solar thermal energy, etc. (Tiwari et al., 2016). The radiation of the sun amounts to3.9×1026 W and the average power at the highest point of the Earth's atmosphere is 1353 Wm^{-2}, coming at perpendicular angle (Sorensen, 2000). Wind is the form of the solar energy. Power generators are used to convert the kinetic energy of the air passing through wind turbine into electric energy (Sumathi et al., 2015). However, 95% of the world energy production still comes from non-renewable energy or nuclear power, which plays an essential role in fulfilling the energy requirement of the world (Owen, 2006).

The fundamental device used for this application is called solar cells. Semiconductors in the form of P-N junction are used as the fundamental materials for

solar cell devices, which produce electricity using photon from solar rays hitting on its surface. The operation of the solar cell follows three basic characteristics. Firstly, it absorbs the light and frees the electrons from the semiconductor. Secondly, it separates the charge carriers of opposite types. Thirdly, it separates extraction of those carriers to an external circuit.

In wind turbines, there is a wide range of vertical and horizontal axis turbines. The smaller turbines are used in battery charging, bus stands, boats etc. Medium size wind turbines are used in domestic power supply and big wind turbines are used in wind farms operation onshore and offshore in different parts of the world. The biggest wind park in India is in Kanyakumari, Tamil Nadu. It produces 1500 MW, which constitutes 59.3% of the total kinetic energy of the air flowing there through the turbine (according to the Betz's law).

India is facing huge problem of energy crisis and also, the energy demand is increasingly growing day by day. In order to deal with this issue, India needs to generate 3-4 times more energy than that of the energy consumed by India today. Achieving the required amount of energy is possible by exploitation of renewable resources (Kumara et al., 2010).

The present study shows solar photo voltaic (SPV) rooftop capacity of India (figure 1) on the basis of technical, economic and market capacity (Sundaray et al., 2014).

In India, estimated gross wind power capacity is approximately 48,561 MW (Sharma et al., 2012); with the addition of 32.17 GW of wind firm installation by March 2017, India is now fifth largest wind power producing country of the world.

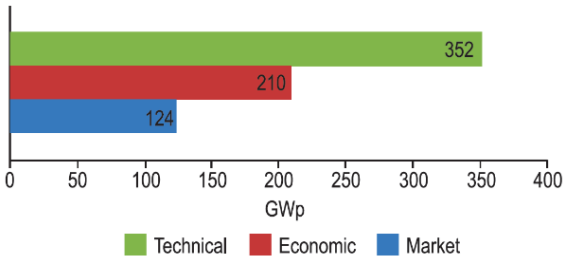

Figure 1. India's potential for rooftop solar PV (Sundaray et al., 2014).

The PV technology finds its applications not only in stand-alone and building connected systems, but also in street lighting, street signaling, garden and transportation stops, water pumping installations, radio and television relay stations etc. Moreover, energy storage devices are used in remote refugee camps, boats, and solar driven vehicles etc. (Chakraborty et al., 2016, Sharma et al., 2015, Sharma et al., 2017).

In 2012, Indian government proposed 38,000 crore rupees project for the infrastructure development to enhance green energy corridor in India. It is likely to be accomplished by 2019 (Why India might not achieve its 2020 renewable energy targets, 2017). In this regard, a solar project of 100 MW is installed in Gujarat, popularly known as a Gujarat solar park (Statewise Solar Parks, 2017). Moreover, major scopes for the accomplishment of the power needs of India's rural poor citizens exists in the process of rural electrification, power sector reforms and advance utilization of sustainable power resources (Chaurey et al., 2004). The safety in the system is also very significant. For the workers working on solar and wind farms, safety management system can be an effective method to save their lives (Transportation Research Board, 2013).

2. Current Market Scenario and targets of Solar-Wind Energy Technologies

2.1 Solar and wind Energy Technologies

There are two types of solar energy technologies: passive and active. The passive technology uses the solar energy directly from the sun without converting it to another form, like current or heat and active converts it and stores for use in different applications (Chakraborty, 2016).

In the active solar technology, concentrating solar power (CSP) concentrates sunlight at one point to produce heat and temperature and use it to obtain steam from water. With turbines and generators, the steam then is converted into electricity. It is very common in the solar-rich areas of the world, especially South Asia and America (Wolff et al., 2008).

Photovoltaic power system is also an active technology which is connected with utility grid. This system contains solar panels, inverters, charge controller and bidirectional meter. It is installed on the roofs of residential and commercial places. Moreover, large utility-scale solar power stations are also grid connected. In some places standalone power systems are used, connected with rechargeable batteries. During the day time, surplus power generated from roof top solar PV power system, after the consumption, is sold to the utility grid via bidirectional meter.

2.2 Current Market Scenario and targets

Solar energy is accepted worldwide as the largest source of renewable energy supply (EPIA, 2011, PVRES, 2010, Mills et al., 2008). Figure 2 shows the dramatic growth of solar energy use throughout the recent years in India and figure 3 shows that the price of the solar cell is decreasing dramatically from 1977 to 2015. The solar energy is a technology, not a fuel. It is limitless and the cost decreases when the demand increases.

As shown in Table 1, Indian government has set the target of 100 GW from solar power, 60 GW from wind, 10 GW from biomass and 5 GW from small hydro power (Riding the Renewable Wave, 2017, Grid connected solar rooftop systems, Indian Rooftop Solar Photovoltaic Landscape – Business Models & Opportunities, German cooperation).

Table 1. Total Installed Capacity and 2022 Target of India

Source	Total Installed Capacity (MW)	2022 Target (MW)
Waste-to-Power	130.08	10,000.00
Small hydropower	4379.85	5,000.00
Biomass power	8181.70	10,000.00
Solar power	12288.83	100,000.00
Wind power	32279.77	60,000.00
Total	57260.23	175,000.00

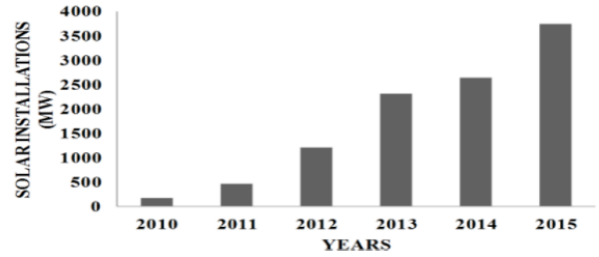

Figure 2. Expansion of Solar installation capacity of India (Chakraborty et al., 2016)

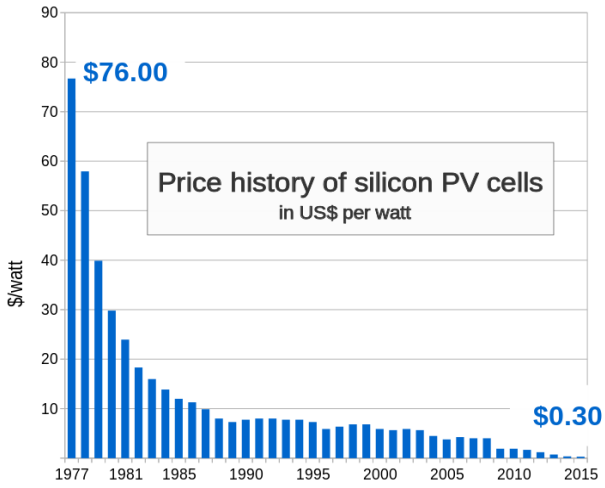

Figure 3. Price history of silicon PV cells since 1977.

Currently, small energy grids and solar home systems together produce about 1 gigawatt (GW) of electricity – a miniscule part of India's total renewable energy targets, 175 GW by 2022 (JNNSM, 2015, Future Perspective for Renewable Energy in India, 2017, Renewable Energy, 2017). According to a 2016 report by the Renewable Energy Policy, India's 2022 target is equal to 22% of the world's cumulative renewable energy capacity in 2015 which is 785 GW and solar capacity targets are equal to 44% of the world's 2015 total solar capacity which is 227 GW. India's current total installed capacity is 57.26 GW. In order to attain the targets, India has to include about 117.74 GW of renewable energy in the next coming six years which is an average of 19.62 GW per year.

3. Obstacles towards solar wind renewable energy development in India

The propagation of solar and wind energy technology faces different types of barriers (IDFC, 2010). This paper presents an in-depth description of different types of obstacles to solar and wind energy production technologies.

In India, the most common energy generation fuel is coal, which will last till 2050. The use of coal is the main factor for the global warming and health hazards (Ghosh et al., 2011). Renewable energy is the best solution to overcome these hurdles. If renewable energy plans are implemented in the rural areas, it will not only meet the growing energy needs but also stop them from migrating to urban areas (Kothari, 2000).

The obstacles are classified as: Economic, Technical, Institutional, Environmental and Social.

3.1 Economic Obstacles

Solar:

1) The proper financing mechanism is absent in India. Banks provide debt at a rate much higher than what is available in the developed nations. Due to the lack of the funding, many projects are struggling to finish.
2) The access to advanced technology is very restricted for a general population, which causes either availability of the technology at very high cost or its unavailability.
3) Tax issue is also a dominant hurdle for low cost power tariff based on renewable power generation. Furthermore, trade complication occurs for the import of such power due to its high tax rate.
4) For the developing countries like India, it is not economically tolerable to install wind mills and solar modules at high rate. Hence, initial financial funds are required in terms of subsidies at the initial phase of roof top projects.
5) High initial and installation costs lead to loss of consumer interest, which causes a decrease in the market size.
6) Overseas companies from Europe and China link up with new solar and wind entrepreneurs' which shrinks the indigenous local market. Therefore, the Indian solar and wind projects are more dependent upon import.
7) High initial investments for robot technology for the cleaning process of solar panels is required for the project like Kamuthi Solar Power Project commissioned by Adani Power with a generating capacity of 648 MW at a single location at Kamuthi, India.

Wind:

1) High initial investment is required to establish a wind energy generation farm.

2) Good wind sites are usually located at remote areas, but load centers are located at urban places, hence, extra investments are required to compensate for the transmission & distribution losses.
3) High cost and low efficiency is a major drawback of Savonius VAWT.

3.2 Technical Obstacles

Solar:

1) Intermittent nature of solar irradiation is a problem to meet the consumer's power demand.
2) Absence of sun position tracking mechanism decreases the overall efficiency of the system.
3) Dust over the surfaces of the panel for a long duration causes adverse effect over the generation of electricity.
4) PV panels are designed for standard test conditions but, due to diversified weather condition in India during the year, factors like temperature, isolation, humidity, air mass etc. changes, which causes less rated output.
5) Natural degradation of solar PV cell can be given as

$$\%P_{\max}\ \deg Rate = \frac{(P_{\max,nameplate-}P_{\max,present})*100}{P_{\max,nameplate}*Panel\ Age}$$

whereas some parts of Gujarat and Rajasthan in the India's are characterized by a very hot and dry climate, which means the highest degradation rate in power generation.
6) Component Failure, like cracking of PV panel, is causing the unusual penetration of light into the panel surface, which further reduces the effieciency and maximum energy output of the panel. Hence, a complete replacement of the panel is required to maintain the desired output level of power.
7) Visual discoloration occured in the solar panel due to humidity, very high surrounding temperature and also when panels are installed near oceanic regions. This causes detoriation in the absorbtion of desired wavelength of light. Subsequently, causes the loss of power and decreases the energy output of the panel.

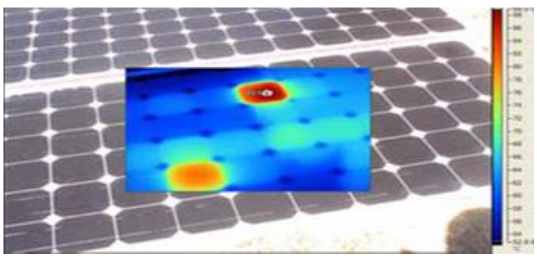

Figure 4. Showing hotspot in a solar panel (Shapiro)

8) Problem of hotspots, as shown in figure 4, in PV panel is a noteworthy issue while operation at very high temperature, since panels are configured with the interconnection of PV cells. Even one small hot spot in a panel can heavily diminish the energy output and the efficiency of the panels.
9) Snow that spreads over the surface of panel in some geographical locations does not slide off the panel naturally. This can damage the panel, and also adversely affects the power output of the panel.
10) If the panel has been installed in the coal mine areas or the places where environment is dusty in nature, a formation of carbon layer starts over the surface of the panel due to tilt angle less than 5 degree. In order to maximize the gain of solar irradiance, the tilt angle is kept 5 or less than 5 degree which increases the chance of dust formation over the surface of panel, and subsequently decreases the panel efficiency.
11) Considering wind with variable speed, large scale frequency of vibration is observed in the corners of the solar panel, because it is the most sensitive part for dynamic wind speed. Therefore, the lifespan of the panel decreases with installation over high wind speed prone region.
12) Lack of technical knowledge becomes a hurdle in the selection of PV panels. Considering efficiency and cost, a mono crystalline panel is best suited, whereas thin film panels are a poor choice.
13) There are several issues regarding the power inverters used in the system. In continuous overloading, heat sink may overheat. Moreover, inverters may have over or under grid AC voltage mismatch with the grid frequency.
14) India is lacking sufficient laboratories and organizations, like National Institute of Solar Energy, to provide certifications, standards etc. for the quality confirmation and its suitability of solar panels and wind turbines for renewable energy technology utilization. This adversely affects the perception of technology.
15) Only a skilled and technically sound person can replace a skillful professional. However, developing countries have very much deficiency of such people, which is a big constraint for the entrepreneurship to establish the startups for a solar or wind company.
16) Poor quality and reliability of the solar and wind product used for the power generation reduces the market size.
17) Irregular cleaning and inspections of the solar panels reduces their lifespan and efficiency.
18) The power grid should not be far away from the site. The grid connected to the plants is responsible for very high aggregate technical and commercial losses which are directly proportional to the proximity of the site.
19) Power electronics devices used in PV power generation systems inject harmonics to the system which decrease the overall RMS value of the output power. However, harmonics in PE

devices becomes lower if the Photovoltaic generators are located near the transformer.
20) Off-grid solar-wind hybrid generation system requires energy storage devices to store the surplus power when the generated power is greater than the demand by the consumer. It constitutes an extra initial investment for the entrepreneur.
21) Short life cycle, high maintenance cost, low energy density and smaller power capacity are some major disadvantages of the battery banks used in the system.

Wind:
1) Challenges of L3 i.e., low cost, long term operation and low maintenance are required.
2) Sometimes, the sound produced by blades in the wind turbine system causes noise pollution. Although, it is less perceptible in comparison with conventional power plant, but it is nevertheless noticeable.
3) Due to the intermittent nature of wind energy, its reliability is very low. Therefore, wind energy system requires operation in a hybrid structure with other distributed generation units to maintain its reliability.
4) Icing is also a prime concern over the wind farm for cold places. Ice builds up when turbine blades do not move. It causes a change in the turbine blade shape and hence, reduces its overall efficiency.
5) When bearings in the turbine are overheated, it causes spark and leads to fire damage to the system. Moreover, lightning is also a natural factor for the fire damage issue in the wind mill.
6) Horizontal axis wind turbines (HAWT) used in the system, are not suitable for stormy wind.
7) Reliability of HAWT is very low because it is very much sensitive to the force applied by the wind to the blade, which varies in the rotation process. Consequently, it leads to the bending or cracking of blades /and finally the damage of the turbine happens.
8) Vertical axis wind turbines (VAWT) are manufactured with low power rating index in order to restrict the installation height for smooth operation. Thus, it is not suited for large turbines for high power ratings above 1MW.
9) Vertical axis wind turbines (VAWT) is a self-start unit but Savonius VAWT is a manually starting turbine.

3.4 Institutional Obstacles
1) Absence of synchronization and collaboration between government, educational institutes and agencies delays the development and growth of the solar and wind energy projects.
2) Lack of research and development environment and infrastructure is the biggest hurdle to attain India technological leadership in solar and wind energy projects.
3) Shortage of the better financing infrastructure, models and arrangements decelerate the solar and wind energy industry.
4) Lack of institutions to publicize needful information leads to lack of information for the customer as well as the entrepreneurs.
5) In India, the stability of macro-economy is not fixed. Therefore, the afore-mentioned scenario raises a high risk and unpredictability for novel investors. Therefore, there are products with high payback period.
6) Research and development cultures are lacking in basic research institutions. This causes issues in the transformation of solar and wind energy technologies.
7) Although privatization in electricity is growing rapidly in India, the participants of new private companies are not strong enough to establish wind and solar power plants and rooftops. This encourages the monopoly nature of the firm.
8) Unavailability of proper skilled training and development of human resources to drive the solar and wind industry.
9) There are insufficient numbers of workshops and conferences organized to share technical information to install and run the solar and wind power projects.
10) Due to the large number of government agencies like NISE, NIWE, SECI, IRDEA, MNRE, electricity regulatory commission etc., it is complicated for an investor or entrepreneur to obtain authentication for the installation of solar and wind projects.
11) Generation Based Incentive scheme takes a long and time consuming process in PPA signing and land allotment.
12) There is a lack of closer industry-government cooperation for the technology to achieve big scale projects.

3.5. Environmental Obstacles
1) It is a challenge to have an availability of suitable land which must be non-agricultural and unused, with good solar irradiance. It must be free of undulations and trees. Moreover, acquisition becomes the next problem to set up the solar power plant.
2) Although traditional silicon panels constitute no chemical hazard after the end of their life, cadmium Tellurium (CdTe) panels become toxic when unused. If these panels are disposed in a landfill, it becomes harmful as cadmium is taken in the process of ingestion.
3) Lubricating material in wind turbines ends up in the environment via total loss applications, volatility, spills or accidents. It is a threat to the environment and becomes a hazard for human health.

4) Sometimes, a catastrophic event occurs on wind farms, such as fire and explosion, due to high wind speed.
5) During the installation and operation, environmental hazards occur to the personnel, including worker's injuries from cranes and heavy lifts, musculoskeletal injuries from lifting, slips and trips.
6) Visual impact and landscape perception is a crucial obstacle in the application of wind farm for the power generation. Both are associated with nature and geographical location of the place. Therefore, it varies with the position of the farm.

3.5 Social Obstacles

Solar:
1) With the increase of the population, the total requirement of electricity in India will be of 5,000 TWh in 2040 which is a four-fold increase from 2014. Instead of indulging financial and technical efforts in the growth of solar and wind energy programs, India's priority is to start antipoverty programs to overcome poverty by providing industries and health care facilities.
2) Raw Industrialist faces the problem of high cost capital requirement to establish renewable energy based generation units. At the same time, subsidized government policies on generation units give negative impact over the competitiveness in the market.
3) Negative perception about the products reduces the acceptance rate of the technology. This is a major issue of the reduced market size of renewable energy technology.
4) Lack of consumer understanding of finance and usage of photovoltaic rooftop system leads to non-recommendation for new houses and buildings by planners.
5) Land acquisition is a difficult task in India, if religious places come in between solar power plants. According to the Land Act, 2013, it will take up to five years for acquiring land if all steps followed smoothly.

Wind:
1) Local wildlife damage is observed with the operation of wind turbine. Flying birds get killed on the spinning blades of the turbine.
2) At night time, red light in the wind system disturbs the biological clock of night migrating birds, which causes adverse effects on their lifecycle. It leads to the decrease of their local population.
3) Considering the aircraft safety, wind turbines cannot be installed near airport runways and helipads.
4) Potential displacement requiring immigration, when land is expropriated for installation of wind farms.
5) The shadow flickering effect is observed when turbine blades cut the sun rays causing a reappearance of the shadows. This causes serious health related problems like headache, stress etc.
6) For onshore wind farms, the problem of land acquisition is a major obstacle. It occurs in the process of material, prices, penalties and distinction between the voluntary and land owner.
7) Loss of income, as well as assets, occurs in the process of potential displacement and resettlement to install a wind farm.

The primary technological obstructions involve low conversion efficiency of the PV modules, performance limitations of energy storage devices and inverters, inadequate supply of raw materials like silicon (Si). The main problem of standalone PV system is the storage of the surplus energy produced. Battery used in the system for this purpose are characterized by a very short life time comparable to that of the PV module (Zhang et al., 2012, Margolis et al., 2006).

On the other hand, applications of wind and solar has major technical barriers, such as increase in the level of onshore wind which can produce a dramatic dip in between 9 am to 4 pm in which low load requires less power from conventional power plants and wind-solar generation at the peak need to ramp up quickly as the sun sets (Luckow et al., 2015)

In some aspects, barriers are linked with the financial measures. Finance resources itself become a leading hurdle (Becker et al., 2000). Wind and solar energy projects as estimated by financial organizations are characterized by a lesser durability, but the payback period is very long and revenue structure is small (Jacobsson et al., 2000, Anthony, 2006, Goldman, 2005).

In order to evade further problems after planting or implementation of the solar-wind projects it is crucial to consider the beliefs, traditions and superstitions of the local society. It is very important for solar and wind plants developers to include local societies and people to know their opinion regarding planned projects (IDFC, 2010).

There are also some hitches in a project under green energy, such as market competition risk, technology up gradation, credit returns and less income risks (Goldman et al., 2005).

4. Conclusion

India has a huge capacity of solar and wind energy resources to overcome the rapidly growing demand for energy in the next decade. India's first ever auction of wind power in 2017 shows the decrease of wind tariff and previously, a significant reduction in solar power tariff was also observed. This indicates that the use of solar energy along with wind in hybrid plants is the best alternative to get rid of conventional energy resources in near future. For the incip-

ient of solar and wind technology, it requires more research and development to reduce the renewable energy system's cost. It is essential to concentrate on improved policies, government efforts and private sectors involvements for the further development.

For the maximum exploitation of solar and wind energy resources, India needs to overcome the key challenges like lowering the initial investment, enhancing research and development culture, positive consumer perception, boost in funding agency's interest. Assessment of all the proposed issues for the development of this sector reveals that a single window certification system for solar-wind energy projects is required in India. Promotional measures need to be enhanced by the ministry of new and renewable energy, so that the use of conventional resources can be minimized. Without participation of the private firms, proper growth of this industry is not possible. Moreover, the problem of limited access to technology, high initial investment, lack of skilled personnel, poor quality of product, transmission issue of power from generation site to load site, grass route level implementation of government policies, absence of micro grid technology etc. are the major obstacles to the conversion of India into a green country. Additionally, India possesses a huge scope of offshore installation of windmills because the country is surrounded by three seas. By the end of March 2017, 32.17 GW was the total installed wind power capacity of India which lower the tariffs to Rs. 3.46/kWh. Moreover, in rural areas, due to continued growth in international crude oil prices and developments in the hybrid solar-wind energy technologies, standalone power systems are becoming very popular. Development of these industries may not only help to meet the energy demand, but also works as an asset for new job creation.

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