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ACHIEVING PRICE AND PERFORMANCE EQUALITY ON AND OFF THE GRID BY EXAMINING GLOBAL RENEWABLE ENERGY TRENDS

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ABSTRACT

Renewable energy sources are an increasing trend in the world as an alternative solution to rapidly depleting fossil fuels. Due to the depletion of fossil fuel resources and the reduction of climate change, societies are forced to internalize these effects and to pave the way for sustainable energy technologies. Other reasons for preference are that these resources are cost-effective and environmentally friendly. Looking at rapidly falling cost curves such as solar and wind energy and the comparability of traditional production technologies in the global market help in establishing the price and performance balance. Today, with the storage options becoming more affordable, the popularity of renewable energy sources has increased. While storage methods provided an advantage for traditional energy sources in the past, today it has provided great convenience in terms of both distribution and transmission of electrical energy produced from renewable sources. The electrical energy obtained from renewable sources and the maturation of the technologies used to obtain this energy, the increase in distributed energy sources, the decrease in the costs of storage technologies, strong consumer behaviors affect the price-performance balance, as well as the way we produce, use and trade electricity. In this study, global renewable energy trends will be examined and information will be given on price and performance equality on and off the grid.

Keywords: Renewable energy, Energy sources, Price and performance equality, Energy trends

1. INTRODUCTION

With the developments supporting renewable energy and developments on the demand side, renewable energy can get ahead of traditional energy sources and set a trend in developed and developing countries. In order for renewable energy to become more preferable on a global scale, some obstacles need to be removed. It is observed that support from three factors is being started to remove these obstacles.

- The fact that renewable energy resources have reached levels equivalent to other technologies in terms of price and performance at the grid and end-use level,
- Wind and sun can be used cost-effectively in grid balancing, and
- Renewable resources surpass traditional resources as new technologies improve the competitive side of wind and sun.

When we examine the demands of the consumers, it is observed that they converge into three goals:

- The use of reliable,
- Cheap and
- Environmentally friendly energy sources.
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Renewable energy sources show a more successful way to meet the demands of consumers than traditional energy sources.

The leading consumers that create this demand are smart cities that include renewable resources in their development plans, community energy projects created by the gathering of certain groups that can offer

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the benefits of renewables to people in places included and not included in the grid, emerging markets leading the spread of renewables, and renewable energy using solar and wind resources.[1]

2. BALANCING ECONOMIC OPTIONS

2.1. Renewables and Conservation

In general, one should not only make comparisons between different renewable energy sources or between conventional and renewable sources. Recently, these energy sources have started to be compared for new investments to be made in energy sources developed within the scope of energy efficiency. These comparisons are very important. The following items are of great importance for protection and efficiency measures.

- They are usually more cost-effective than many renewable supply actions,
- Narrow the gap between demand and the supply of renewable energy.[2]

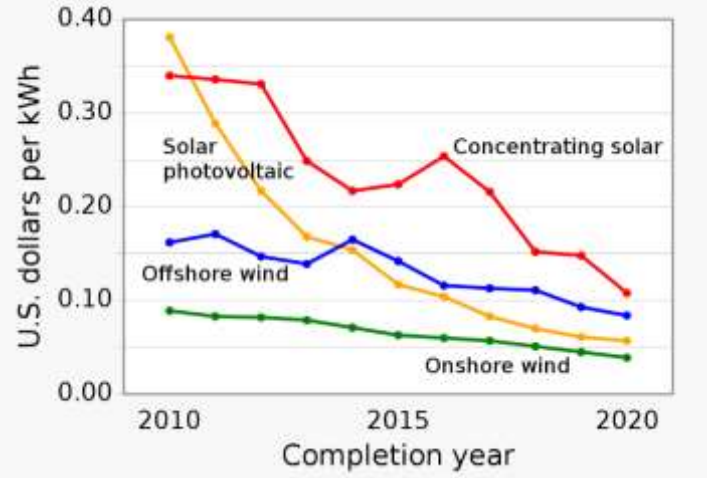

Figure 1. Cost of renewable energy

Figure 1 shows a line graph of renewable energy costs based on data from the International Renewable Energy Agency (IRENA)[3]. This graph shows us that the costs of renewable energy sources have decreased. As a result, when 2020 is examined, it is seen that 62% of the electrical energy produced from renewable energy sources is less costly than the cheapest fossil sources used to produce electrical energy. It is possible to conclude that renewable energy sources are preferable.

Considering energy generation prices, there may be options among investments in biomass, onshore wind, more efficient cooling, or lighting. This diversity is important to consider when considering the challenges of deciding between fossil fuel, nuclear and renewable energy sources on environmental grounds.

2.2. Balancing Economic and Environmental Considerations

Considering the economic and environmental impacts, it can be difficult to balance energy production methods. There are several benefits of using renewable energy sources instead of conventional sources:

- They cut carbon dioxide emissions,

- It reduces a country's dependence on imported fuel and contributes to the diversity of energy supply,
- They cut emissions of acid rain pollutants, Sulfur dioxide and nitrogen oxides.

It should be noted that all renewable energy sources have some environmental consequences; their benefits should be considered in relation to alternatives.

3. GRID COST PARITY

Grid parity occurs when an alternative energy source is capable of producing power at a leveled cost of electricity (LCOE) equal to or lower than the price of power from the electrical grid and plays an important role in the future of power generation systems. The term is most used when discussing renewable energy sources, particularly solar and wind energy, but diversity needs to be increased. Grid parity depends on whether you're calculating it from a utility or retail consumer perspective.
Achieving grid parity is the point at which an energy source becomes a contender for widespread development without government support. It is widely believed that once they reach grid parity, there will be a transition to these forms of energy through electrical power producers. Germany was one of the first countries to reach parity for solar PV for utility-scale solar and rooftop solar PV in 2011 and 2012, respectively. [4]

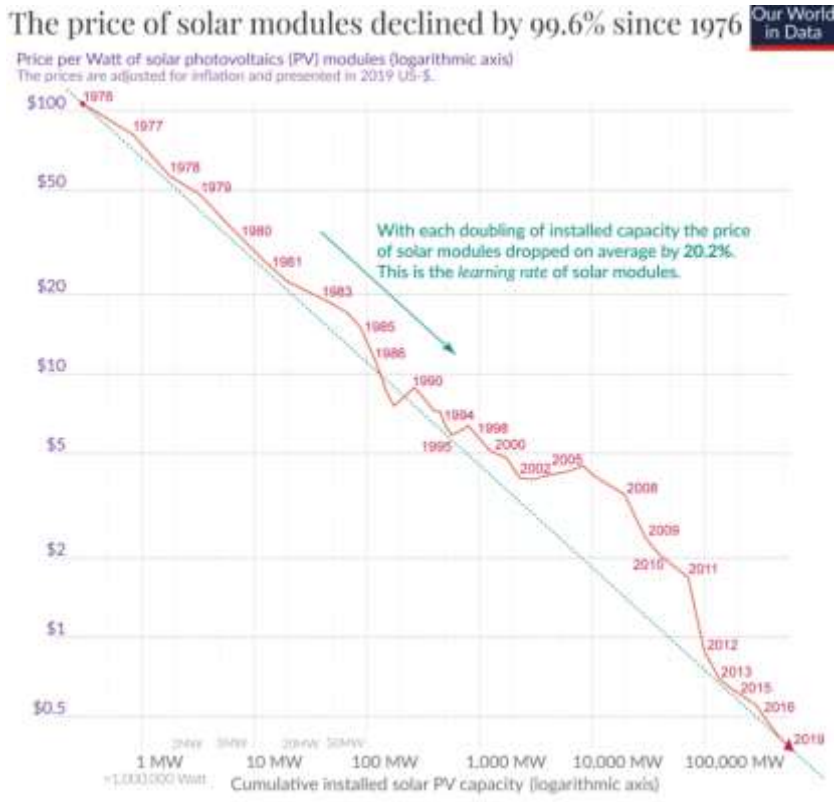

Figure 2. Swanson's Law

In Figure 2, the graph obtained using Swanson's law shows that for every doubling of the cumulative output of solar panels, there is a 20 percent reduction in the cost of the panels [5].

Studies are needed to create a radically different energy ecosystem. When we think globally, self-production, which is the most important part of the energy ecosystem, turns out to be an affordable

option. In addition, it is an indisputable fact that in a world where electric vehicles have started to become the main mobility option and consumers have become "productive consumers" by producing their own energy, it will have positive results for the future.

Considering these options, some dynamics will be affected in electrical energy production. E.g.:

- When the integration of distributed energy sources and the management of complexity with increasing population are analyzed, energy companies will face more performance problems and increasing costs for sustainable energy network.
- With the rapid decline in the cost of self-generating technologies, electric power will accelerate the withdrawal of consumers from the fields, allowing manufacturers using non-traditional power generation methods to steal market share from their competitors and put pressure on existing business models.
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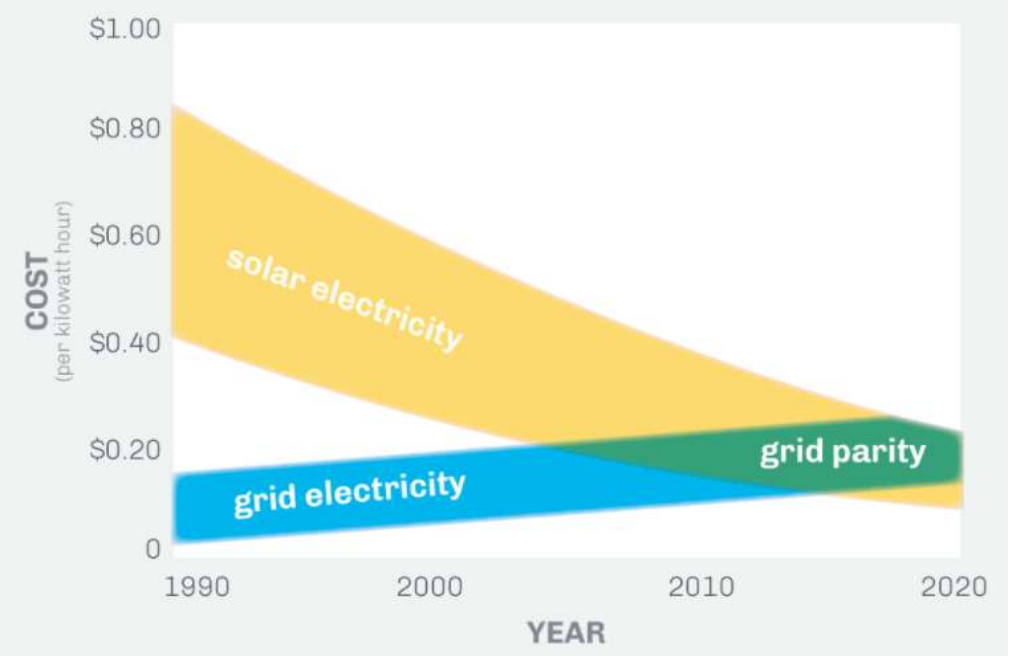

Figure 3. Example of solar-PV/grid parity

- The expected large purchases of electric vehicles for the future will place additional burdens on the electrical system. For this reason, the charging system must be well managed. Variable renewable energy outputs will need to be used by changing energy use patterns.
- To operate a reliable and efficient network, distribution systems need to be digitally transformed and their remote traceability and controllability extended. Energy distribution systems will need to become more localized and dynamic, requiring more intervention.
- Energy companies need to give more value to their customers, who are influenced by experiences in other sectors and whose expectations are rising.

Such radical changes highlight the need for competitive energy companies to decide.

In Figure 3, grid parity is fast being achieved in regions within and outside the United States as the cost of renewable energy technologies drops. Since 2008, the costs of both wind and solar installations have plummeted, and that has led to faster adoption of renewables. Investment in wind and solar has brought

improved technology, better supply chains and an increase in production — all of which help lower prices. [6]

4. LEVELIZED COST OF ENERGY (LCOE)

The leveled cost of energy (LCOE), or leveled cost of electricity, is a measure of the average cost of electricity generation over its lifetime for a power generation facility. It is used to construct investment plans and to consistently compare different electricity generation methods. To summarize the definition of leveled energy cost, it "represents the average revenue per unit of electricity produced that would be required to recover the costs of constructing and operating a power generation facility during an assumed financial life and duty cycle" and is calculated as the ratio between all discounted costs. The lifetime of a power generation facility is divided by considering the discounted version of the actual delivered energy quantities.

The information that LCOE provides to us is as follows:

- Shows the lifetime costs allocated to energy production
- Calculates the present value of the total cost of constructing and operating a power plant over an assumed lifetime
- Allows comparison of projects with unequal lifetimes, alternative technologies with different cost of capital, risk, returns and capacities.

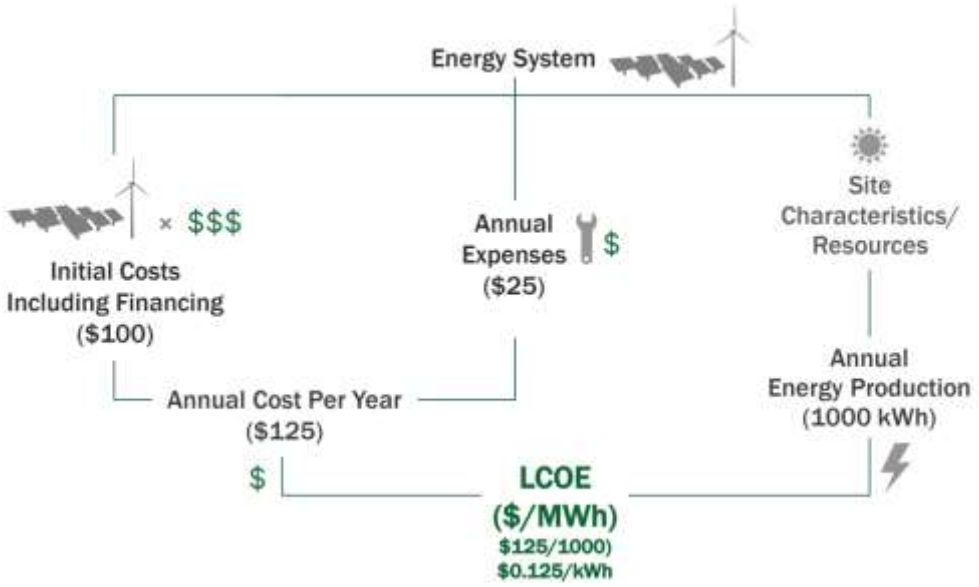

Figure 4. Simple LCOE Concept

In Figure 4 simply illustrates the concept of an LCOE analysis [7]. The potential limits of the leveled electricity cost analyze we use to compare energy producing sources are of great importance. One of the major potential limitations of the LCOE is its inability to control the time effects associated with the creation of the environment necessary for electricity generation to meet the quantities demanded.
This can happen in two ways:

- Transmissibility, the ability of a production system to quickly go online-offline or increase-decrease in parallel with demand fluctuations.
- The extent to which the availability matches or conflicts with the market demand character.

If the storage systems used with the existing grid energy of variable renewable energy sources such as solar and wind, which cannot be transmitted otherwise, are not included, unnecessary electricity generation can be made when electricity is not needed in the grid without storage. The value of this electricity may be lower than it was produced at any other time. At the same time, demand that peaks at midday in summer in hot countries where air conditioning is most used, and the use of storage systems during peak electricity prices can affect competitiveness if appropriate. Intermittent power sources such as wind and solar can incur additional costs associated with the need to have storage or backup generation.

Simplified LCOE calculation in equation 1:

$$\frac{\Sigma_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\Sigma_{t=1}^{n} \frac{E_t}{(1+r)^t}} \tag{1}$$

I_t = Investment expenditures in year *t* (including financing)
M_t = Operations and maintenance expenditures in year *t*
F_t = Fuel expenditures in year *t*
E_t = Electricity generation in year *t*
r = Discount rate
n = Life of the system
The advantages of calculating and comparing LCOE are as follows:

- Measures value over the long term by showing projected lifecycle costs.
- Emphasizes opportunities for facility, community, or companies to develop projects of different scales.
- Interprets the sustainability of projects on an economic basis compared to their benefit rates.

4.1. Key Driving Forces of Grid-parity Analysis

- Experience curve approach

Technological change analyzes identify patterns in the way technologies are invented, developed, and diffused into society. The experience curve model contains an exception. The experience curve approach brings together all industries, not just labor, but all production costs and single production facilities.

- Growth rate of the industry
- System performance
- Electricity prices
- Access to electricity

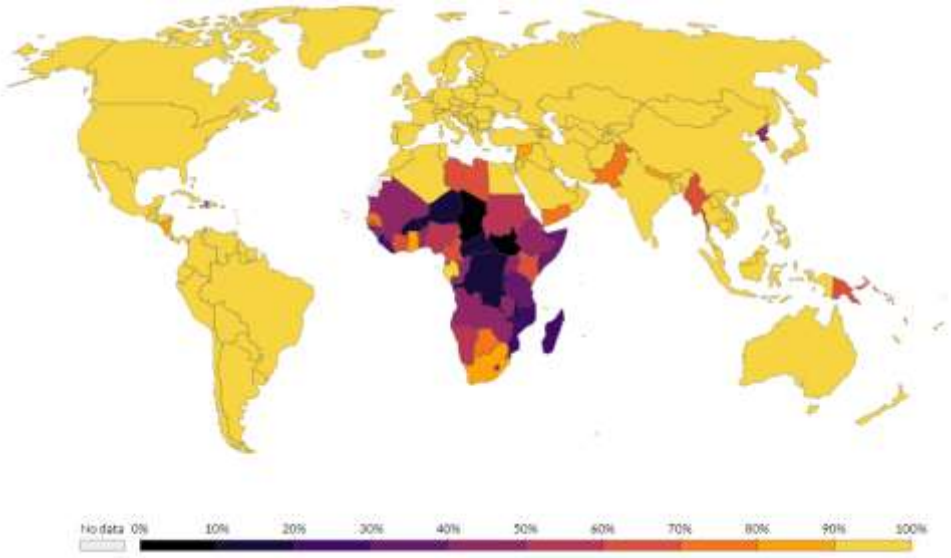

Figure 5. Access to electricity 2019, Global Electrification Database - World Bank

In Figure 5, access to electricity is shown and the percentage of the population with access to electricity is indicated. High-income countries – or countries defined by the UN to be 'developed' are assumed to have an electrification rate of 100% from the first year the country entered that category. Therefore, the increasing global share has primarily been driven by increased access in low and middle-income economies. In many countries, this trend has been striking; access in India, for example, increased from 43 percent to almost 85 percent. Indonesia is close to total electrification (sitting at almost 98 percent) – up from 62 percent in 1990. For countries with strong population growth, such improvements in the share of the population with access is even more impressive. [8]

5. REACHING PRICE AND PERFORMANCE PARITY ON AND OFF THE GRID

The falling costs of solar and wind power generation systems, which are among the top renewable resources, affect even the optimistic producers in the sector. Wind and solar energy technologies continue to compete with traditional energy generation systems globally.

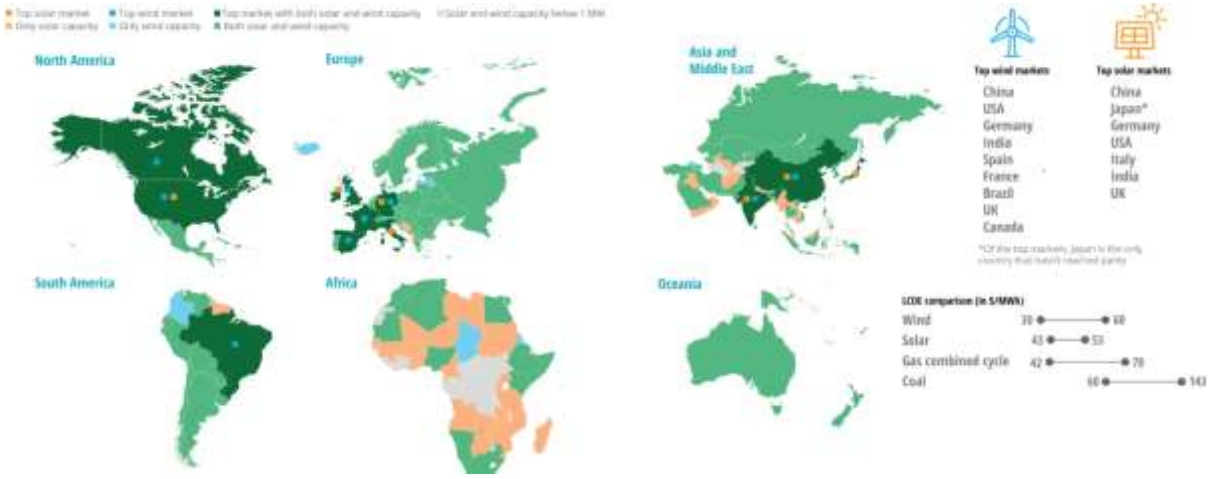

Figure 6. Levelized cost of energy analysis-Capacities calculated from IRENA, *Renewable capacity statistics 2018*

In Figure 6, in terms of prices, utility-scale solar is hot on onshore wind's heels, as the second-cheapest energy source with an LCOE range (US$43-53/MWh) lower than that of any other generation source, and has reached price parity in all leading markets, except Japan. Globally, Australia has the lowest costs for solar PV, and Africa has the highest due to investment costs, the report reads.[9]

As a result of research, when it comes to self-generation, commercial solar power plants have reached grid parity with the exception of India, while tax cuts and incentives have made residential solar PV competitive in these markets. As of 2020, the use of solar panels in new buildings in California has become mandatory in the USA.

Developing or re-powering wind turbines around the world in the future will increase their capacity factors and lower their global average costs. As a result, it will be possible to obtain energy from wind power plants in harmony with the poorest environmental conditions. They will also ensure that costs are reduced as global developers and international organizations come together to jointly develop projects.

More specifically, such partnerships will help resolve the resource mismatch created by the fact that sun-poor countries such as Japan, Germany, and the United Kingdom are global solar energy leaders, while continents such as Africa and South America have the richest solar and wind resources.

As wind and solar capacities increase, many conventional energy sources will start to operate at lower capacity factors, causing the LCOEs of both existing and newly established conventional power generation plants projects to increase. The cost of new solar and wind farms may not only be lower than the cost of new conventional plants, but also the cost of continuing to operate existing plants.

6. OPPORTUNITIES FOR REINVENTION

The new energy ecosystem offers reinvention opportunities to many energy companies whose revenues have dwindled over time. New potential avenues for growth will await energy companies that are ready at the right time in the future. The best thing to say in general is "change cannot be considered a threat". Some items stand out for rediscovery. These will be discussed in the next issues.

6.1. Rethink Generation

For the new energy ecosystem, it will mean investments in new technologies and new distribution route alternatives to support distributed energy sources and include the flow of electric vehicles. On the other hand, it should be understood that energy purchase agreements will become more intense and, as a result, it will be easier to establish direct relations with renewable power plant developers.

6.2. Rapid E-Mobility

e-Mobility is a general term for the development of electrically powered powertrains designed to move vehicle design away from the use of fossil fuels and carbon gas emissions. Electromobility includes all-electric vehicles, hybrid electric vehicles and those using hydrogen fuel cell technology. As electric vehicles become more common, energy companies will need to provide solutions for e-mobility. In addition, automotive and technology companies will work with governments and regulators to make electric mobility sustainable.

Figure 7. E-Mobility A European Perspective

In Figure 7, in collaboration with the European Commission and the European Green Vehicles Initiative Association, European countries and regions set up the Electric Mobility Europe Call 2016 (EMEurope Call 2016) to further promote and advance electric mobility in Europe. In total 14 projects were selected for funding in the EMEurope Call 2016 address the following 5 key areas of electric mobility:

1. System Integration (transport, (sub)urban areas);
2. Urban Freight and City Logistics;
3. Smart Mobility Concepts and ICT Applications;
4. Public Transport;
5. Consumer Behavior and Societal Trends.[10]

6.3. Connecting with Customers

There is a high probability that power generation companies will change from supplier to partner soon. These companies need to redesign their communications with their customers. While suppliers focus on improving the experience with their customers, major gains will be made as they can expand their work in areas such as smart home appliances, solar energy, and electric vehicles with external providers.

7. CONCLUSION

Some analysis methods need to be developed in order to determine the course of electrical power generation power plant projects and to comment on which alternatives should be directed. Grid parity is instructive with some limitations, but grid parity can be a complex and potentially misleading concept as currently thought. A simple concept of grid parity is not sufficient when considering the dynamics of electricity pricing. The clearer the price signal for end users, the more economical, for example, solar or wind power generation systems.

The concept of grid parity remains a useful metric for system builders, but more complex definitions are needed as an indicator of market competitiveness.

With the increase in population density in the future, self-production systems are likely to develop. For this, multi-faceted studies are required. It is difficult to make a decision with only one LCOE analysis, and it is necessary to work together globally. With self-manufacturing, we can get rid of the complexity of the traditional distribution network.

Today, we are alone with the climate crisis. The results of obtaining energy bring multifaceted problems. Due to the rapid depletion of fossil resources, increasing population and carbon emissions, it is necessary

to establish a working network for new technologies. We need to change some habits in our daily life by making radical decisions.

CONFLICT OF INTEREST

The authors stated that there are no conflicts of interest regarding the publication of this article.

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