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Decarbonising Energy Systems: Electrification and Regional Integration

Abstract

Electrification is emerging as an alternative to oil dependency with countries setting ambitious targets to achieve 'transport electrification'. This will generate the involvement of new actors and new business models replacing the earlier energy systems based on the fossil fuel economy. China and India are implementing a low-carbon transition in their transport systems, moving towards zero emissions. In 2020, China's per capita carbon emission was 8.2 Mt and India's per capita carbon emission was 1.74 Mt. The focus of clean transport policies encompasses: e-mobility, urban mobility and fuel economy. Decarbonization requires strategies such as connecting mobility options. There is also a bottom-up trend related to digital technologies. This digitalization when intersected with the electric mobility trend, has the potential to promote an infrastructure with clean energy solutions including microgrids, vehicle to grid, renewable power generation as well as charging facilities and smart infrastructure for electric vehicles. Since the uneven distribution of fossil fuels has been a major security concern, there is an emerging thrust on 'supergrids', 'mega-grids' and 'supersmart grids' that would facilitate in exporting of renewable energy by interconnecting countries and regions with a high voltage direct current (HVDC) power grid. One such vision is the 'Global Energy Interconnection project', envisioned by China in 2015. It aims to build upon a worldwide network of high-voltage transmission lines that can help countries access greater volumes of renewable power from a more diverse array of sources, for a greener and more reliable grid. Similarly, India's mega plan "One Sun, One World, One Grid" which aims to supply solar power across the globe, represents the increasing political competition over renewable energy. These trends are reimagining the global energy systems through the geopolitics of connectivity. This paper seeks to assess how this aimed connectivity will enable the transition towards a cleaner fuel economy. It will further unfold the debate on the 'centralization' of electrification systems and the need for 'decentralized' renewables. The paper will undertake an analysis of regional integration in India and China. It will further address the concerns posed by the issues related to cybersecurity in this context.

Keywords: electrification, decarbonisation, China, India, fossil fuel, renewable energy

Introduction

The world has witnessed a rapid decline of fossil fuels, accompanied by their impact on the environment that has raised concerns regarding gas emissions, atmospheric effects and public health (İnci and Türksoy 2019). Particularly, Asian countries have gradually recognised that the conventional path of encouraging economic growth at the expense of the environment could not be sustained (Zhang 2011). Hence, the focus shifted to alternative sources of energy that are sustainable, environment-friendly and clean (İnci and Türksoy 2019). Accordingly, environmental goals and environmental performance requirements were set up (Zhang 2011). Two prominent Asian countries with a billion-plus population, namely China and India pledged their support towards achieving carbon neutrality and net zero ambitions. Net zero is similar in principle to carbon neutrality. Carbon neutrality specifically refers to the amount of carbon being removed from the atmosphere is equivalent to the amount of carbon emitted. While net-zero goes a step further- it refers to the amount of all the greenhouse gasses that are removed from the atmosphere being equal to those emitted by human activity (National Grid n.d.). China stressed that it would reach carbon neutrality by 2060 (Tay 2022) and India aims to reach net zero emissions by 2070 (Birol and Kant 2022). To achieve such goals, targeted action is required to decarbonise the transport sector. It is not possible to stop climate change without decarbonising transport because it emits around 23 per cent of the energy-related carbon dioxide that causes global warming and it is estimated to reach 40 per cent by 2030 (International Transport Forum n.d.).

Electricity Grids and Transportation

Electricity grids are at the centre stage of the fossil fuel debate because of their multifaceted roles. From running vehicles and trains on electricity to providing power to industries and households, electricity grids are related to every sphere of economic activity. Conventionally, electricity grids were powered with fossil fuels and these grids transmitted power derived from fossil fuels. Now, due to the adverse effects of climate change, the focus is on powering the electricity grid with renewable sources (Timmons n.d.). Renewable sources can be divided into dispatchable and non-dispatchable or Variable Renewable Energy (VRE) categories. Dispatchable categories include biomass, concentrated solar power, geothermal and hydropower. Non-dispatchable or VRE category includes ocean power, solar photovoltaic and wind. The structure and operation of the existing grid infrastructure have to be revisited to integrate renewables into power grids. So, power sector transformation is required to catalyse transport sector transformation (IEA-ETSAP and IRENA 2015). There is a direct linkage between the demands for transport sector electrification and powering electricity grids with renewable sources. The combustion of fossil fuels in vehicles would be replaced by electricity provided by these grids. This highlights the need for grid integration of electric vehicles (EVs). Grid

interaction can be bifurcated in two ways, namely unidirectional controlled charging (V1G) and vehicle-to-grid (V2G) systems. V1G systems represent the unidirectional flow of power from the grid to the EV while the V2G system provides for a bi-directional flow of power, from the grid to the EV and vice versa. So, the needs and the capacities of the national electric grid get timely addressed due to the V2G technology. It replaces the additional power generation that would have been required to feed the national electric grid, thereby presenting a sustainable solution. Here, the batteries of the EVs also act as storage for grid balancing and system services (REN21 and FIA Foundation 2020). This charts the pathway for decarbonisation of the transport sector using renewable energy. However, integration of a large number of EVs into the electric grid would be a challenge for the time being as it requires an intensive assessment and observation of factors like economic impacts, operation and control benefits at optimal costs. The EV charging infrastructure has to be made public and commercial, apart from being home-based only. This would place an additional load on the existing grid systems. Moreover, the battery composition and capacity of the EVs would also be impacted due to frequent charging and discharging cycles. Finally, a real-time advanced communication system is a vital requirement for the exchange of information related to pricing, energy forecasts and EV driving characteristics among parties (Mwasilu, et al. 2014). Another aspect of this grid connectivity is the regional integration of grids for developing cross-border power interaction to support electricity trade between countries and regions. It is a critical infrastructure for allowing renewable energy resources to be traded across borders. An interconnected power grid has the potential to solve the trilemma of energy security, affordability and sustainability. Some such examples of **multi-country interconnected power systems** include the ASEAN Power Grid and the Energy Super Ring of North East Asia (UNESCAP 2018). Besides, China has been undertaking such projects through its ‘Belt and Road Initiative’ (BRI) (JACKSON 2020) and India along with the UK has launched the ‘Green Grids Initiative- One Sun One World One Grid’ (GGI-OSOWOG) to provide clean power to the world (Roy 2021).

However, before exploring the facets of this interconnectedness, two essential dimensions of energy distribution emerge. Historically, centralised energy systems have had an important role to play in ensuring access to urban populations throughout the world. Centralized generation refers to the large-scale generation of electricity at centralized facilities. These facilities are usually located away from end-users and connected to a network of high-voltage transmission lines. Much of the primary energy of fossil fuels burned at power plants is wasted during generation and delivery to end-users. However, electrification through grid extension, especially in rural areas, involves huge investment and risk and is usually taken up by governments, rather than private enterprises. Therefore, for grid-connected access to be effective in providing access to the majority of people, there needs to be sustained commitment and a **long-term vision** from governments to build lasting institutions that **plan**, **regulate**, **implement** and **monitor electrification**. Electricity also needs to be affordable and dependable for maximum uptake, and thus maximum impact, as providing limited electricity to a limited number of people defeats the purpose of electrification. A decentralized energy system is characterized by locating energy

production facilities closer to the site of energy consumption, allowing for more optimal use of renewable energy as well as combined heat and power, reducing fossil fuel use and increasing eco-efficiency. A decentralised energy system is a relatively new approach in the power industry in most countries. As Energypedia classifies, 'These are generally locally managed and supply smaller loads, such as households. There is an increased interest in decentralized power supplies because, unlike the extension of the centralized electric grid, smaller-scale grids can be set up as viable businesses using local investment.' (EPA 2022)

Obeid (2021) argues, 'Decentralized renewable energy models offer an opportunity to circumvent political bottlenecks, provide affordable electricity, and reduce reliance on imported fuel. These models entail the implementation of renewable energy technologies on-premise, such as rooftop solar power systems, or close to the electricity load, such as solar microgrids that can power entire communities.' She further puts, 'Distributed renewable energy generation would **enhance security and economic indicators through reduced dependence on fuel imports, lower outflows of foreign currencies, and improved business competitiveness.** Yet, it would challenge the existing governance structure by empowering local authorities and diluting political interference and vested interests. Reliable electricity is the main driver of economic growth, but its affordability is also a critical factor. Decentralized systems would also grow the local market of small and medium-sized energy enterprises, which do not stand a chance of competing for centralized large-scale projects.'

The debate on Regional Integration: A case of India and China

Today as countries are shifting towards renewable energy, grid connectivity among countries has emerged as a new topic. International electric grid connections bring political benefits to partner countries. These include political comfort with international cooperation, harnessing good relations with neighbours, increased democratisation and internal political stability. However, a wide range of political issues is also related to such projects as one country gaining leverage over the other, agreements on power and cost-sharing, sharing of information, and agreements on the governance of the interconnection operator. So, there are geopolitical concerns and issues entangled with grid connectivity (UNDESA 2006). Keeping this as the background, let us understand China and India's journey toward grid connectivity projects.

China's energy mix is dominated by fossil fuels. In 2014, coal accounted for 66 per cent of total energy consumption. A clear shift took place in 2005 with the establishment of the renewable energy law. It developed pioneering measures ranging from targets in installed capacity to direct financial support policies. Since then, China has grown comprehensive renewable energy policies and included RET targets in its Five-Year Plans (FYPs), the government's critical strategic social and economic development initiatives. In India, numerous mechanisms are in place to support RET development and deployment, such as grants to develop technologies, tax

incentives, and generation-based incentives (Hogg and O'Regan 2010). The wind has been receiving support since the early 1980s, and support for solar has taken off since 2008.

In 2017, China announced the formation of the 'Global Energy Interconnection (GEI)' to achieve green and low-carbon development. GEI acts as a giant system aimed at the co-construction, sharing, interconnection and openness of energy resources to promote fundamental changes in productivity and production relations in the energy sector (Huang 2020). On the other hand, India's initiative of the International Solar Alliance and the subsequent announcement of regional integration through *One Sun, One World and One Grid* have put into focus its political effects.

An article in the *Hindustan Times* mentions that "One Sun, One World & One Grid' is aimed to bring together the worldwide grid; clean energy can be transmitted anywhere & anytime. According to the One Sun declaration, the main areas of work of the initiative will be: investing in solar, wind, storage and other renewable energy generation in locations endowed with renewable resources for supporting a global grid; building long-distance cross-border transmission lines to connect renewable energy generators; developing and deploying cutting edge techniques and technologies to modernise power systems; supporting the global transition to zero-emission vehicles through incorporating the **role of electric vehicles to help improve grid flexibility**; attracting investment into solar mini-grids and off-grid systems to help vulnerable communities gain access to clean, affordable, and reliable energy; developing innovative financial instruments, market structures for solar grid infrastructure." In 2016, China initiated the establishment of the GEI Development Cooperation Organisation. In China, the cost of energy production has continuously reduced and the market competitiveness has continuously enhanced. This points out China's capacity for the large-scale application of renewable energy and the greater interconnection of power grids (Huang 2020).

Downie (2019) adds, "Interconnection, done right, is a worthy project. It can deepen regional cooperation while reducing both emissions and costs for member states. Moreover, as intermittent generation sources like wind and solar expand their footprint, transmission operators can strengthen grid stability by using interconnection to access more diverse power sources for covering shortfalls in supply. The world requires an interconnection agenda that focuses on multilateral institution-building and frames power trade as a tool for states to shore up their grid systems in the renewables age."

Both GEI and OSOWOG can offer much for this agenda, building support for interconnection and promoting important elements of the global energy transition like smart grids and clean energy. But the contributions are limited by the complications of its industrial policy bent. Also, the partner countries need to have political will behind them to cooperate.

Further, China's own mixed signals on power trade with its neighbours raise questions about the legitimacy of GEI. International power trade is in its infancy in most of the world; GEI's ambition for the coming decades far outstrips what can be achieved. China's interconnection

push lies in its own participation in power-trade institutions. Cross-border trade at scale requires multilateral institutions to coordinate regional planning and oversee the exchange. In the case of China, it helps to expand the global footprint of Chinese companies like the State Grid Corporation of China (SGCC) and aims at establishing them as technology leaders in their respective spheres. GEI's sponsorship by SGCC raises political suspicions over Chinese utilities and expansionism. China's own participation in power trade institutions like China's hardline stance in the Asian Development Bank's Greater Mekong Subregion (GMS) power trade initiative (Downie 2019).

In the case of OSOWOG, Jawar (2020) writes, "the value of time-shifting could come from a place with large, cheap land, such as an enormous solar farm in North Africa for Europe. But the transmission costs will usually outweigh the benefits of land and solar radiation. Supply of energy through this grid, in a time zone with a six-hour difference, will require thousands of kilometres of transmission of the electricity, which will add up to a huge cost. The economic benefits of such cross-border transmission lines are truly maximised when they are constructed within a political union formed around common objectives, such as the EU or Scandinavia, etc. There are many better solutions to integrate solar with the existing grid without a huge Capex on the transmission proposed by this vision."

Jawar quotes Arijit Ghosh, Managing Director, SAP Automations India Pvt Ltd, in a *Down to Earth* article. He argues, "Energy supply is necessary for a range of activities including defence and essential services like hospitals, etc." Through regional integration, these will be exposed to this common grid. He adds, "Any disruption caused due to any bilateral or multilateral issues can potentially affect critical services in multiple continents and countries. Hence, not many countries may be willing to participate." Yarkoni (2022) points out another possible fallout in regional integration. He writes, "Electric vehicles are an exciting step forward in Smart Mobility, improving the quality of the air that we breathe, tackling issues such as noise pollution and greenhouse gas emissions, and working towards better energy security for the future. In order to meet its target, India will need to rely heavily on foreign exports such as Chinese manufacturers. According to PwC India, electric vehicle makers are forced to import as much as 80% of an EV, from the battery itself to the battery management system. With this reality, the opportunities are ripe for manufacturers to leave backdoor entry points for malicious intent or collecting sensitive data."

He adds, "Many of the charging stations that are being used today use an out-of-date Open Charge Point Protocol based on HTTP, which does not encrypt data or communications. This could lead to relay or man-in-the-middle attacks where attackers leverage a seemingly legitimate signal such as WiFi. This vulnerability could also allow attackers to rewire charging requests altogether, and gain root access to the station." McCarthy (2021) argues, "Smart EV chargers were partly created to help stabilize the grid… however, the security flaws….create the opposite. Hackers take control and switch large power loads synchronously by turning large numbers of

chargers on and off….Blackouts may result." Ercbacher (2022) further argues, "Smart grids are increasingly becoming the norm because they allow the integration and balancing of multiple, small, geographically-distributed power generators, including renewable energy types. This contrasts strongly with traditional systems that were based on large, centralized power stations. But managing and balancing this 'power generation diversity' depends on the smart grids' intelligence and communications capabilities – the same capabilities that open up cyber-attack vulnerabilities."

Conclusion

To conclude, countries have to undertake reforms in the electricity sector if they want to transform their transport sector- decarbonise the transport sector to shift towards renewable energy. Grid connectivity comes as a viable option given the bottlenecks are addressed and balanced regional development takes place. Regional grid connectivity is not a new idea but the present climate scenario brings it to the centre stage. China and India both have launched their respective plans for grid connectivity. However, there are geopolitical issues attached to such connectivity projects which are worth pursuing given its wide array of benefits. Apart from political issues, there are concerns regarding cyber security. The success of the EVs would also lie in the advancement in cyber security in deterring the new and emerging threats to keep the system clean.

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