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DISCUSSION PAPER

Solving Pakistan's Energy Crisis: Is Decentralization of Electricity Transmission a Solution?

Exploring Energy Wheeling and its Opportunities in Pakistan

The efficiency of a country's electricity transmission system is critical to the overall performance of its power sector, influencing both economic productivity and energy reliability. Pakistan's electricity transmission system is grappling with persistent challenges, causing significant financial and operational strain.[1] In Fiscal Year (FY)24, transmission and distribution (T&D) losses reached 18.31%, contributing Rs. 276 billion to the country's already massive power sector debt of approximately Rs. 2.3 trillion[2] . These losses are driven by a mix of technical inefficiencies, such as frequent outages and transmission line losses, and non-technical issues, including energy theft, faulty meters, inaccurate billing, poor administrative practices, and weak financial management. Non-technical losses alone account for an alarming 16.6%, further exacerbating the sector's inefficiencies and economic repercussions.

To address these systemic issues, Pakistan must explore innovative solutions such as energy wheeling alongside a decentralized electricity transmission model. Energy wheeling involves using the existing transmission network to deliver power from private generators to consumers, bypassing the inefficiencies of centralized systems. By enabling direct transactions between local power producers and underserved areas, energy wheeling can reduce transmission losses, improve grid reliability, and attract private investment in renewable energy. This decentralized approach not only strengthens the power sector but also promotes a more efficient and resilient energy system to meet Pakistan's growing electricity demands.

Energy Wheeling

Energy wheeling is a mechanism that facilitates decentralized electricity transmission, enabling distributed generation and localized consumption. For this purpose,improving transmission infrastructure efficiency has become increasingly critical.

Efficient and flexible transmission systems are also essential to maximize the benefits of the abundantly available renewable energy resources and increase their integration in the sector.

Energy wheeling offers a practical solution to this challenge. It enables the transmission of electricity between private generators and consumers using shared infrastructure, often governed by long-term Power Purchase Agreements (PPAs), as they provide the legal structure and financial certainty for electricity transactions across grids. As noted by the National Renewable Energy Laboratory (NREL), "Wheeling allows load to search for, and potentially find, generators that offer lower prices or other characteristics that better serve their needs."[3] By promoting direct connections and efficient energy flow, wheeling supports the transition to a decentralized and resilient energy system.

1 *https://www.researchgate.net/profile/Gbenga-Apata/publication/361094202_Transmission_Losses_in_Power_Systems_An_Overview/links/629eedb2a3fe3e3df8638f0a/Transmission-Losses-in-Power-Systems-An-Overview.pdf*

2 *https://thedocs.worldbank.org/en/doc/7008031a15959f10bde28b6c56767d59-0310062024/original/Pakistan-Development-Update-The-Dynamics-of-Power-Sector-Distribution-Reforms-Oct-24-FINAL.pdf*

3 *https://www.nrel.gov/docs/fy16osti/65660.pdf*

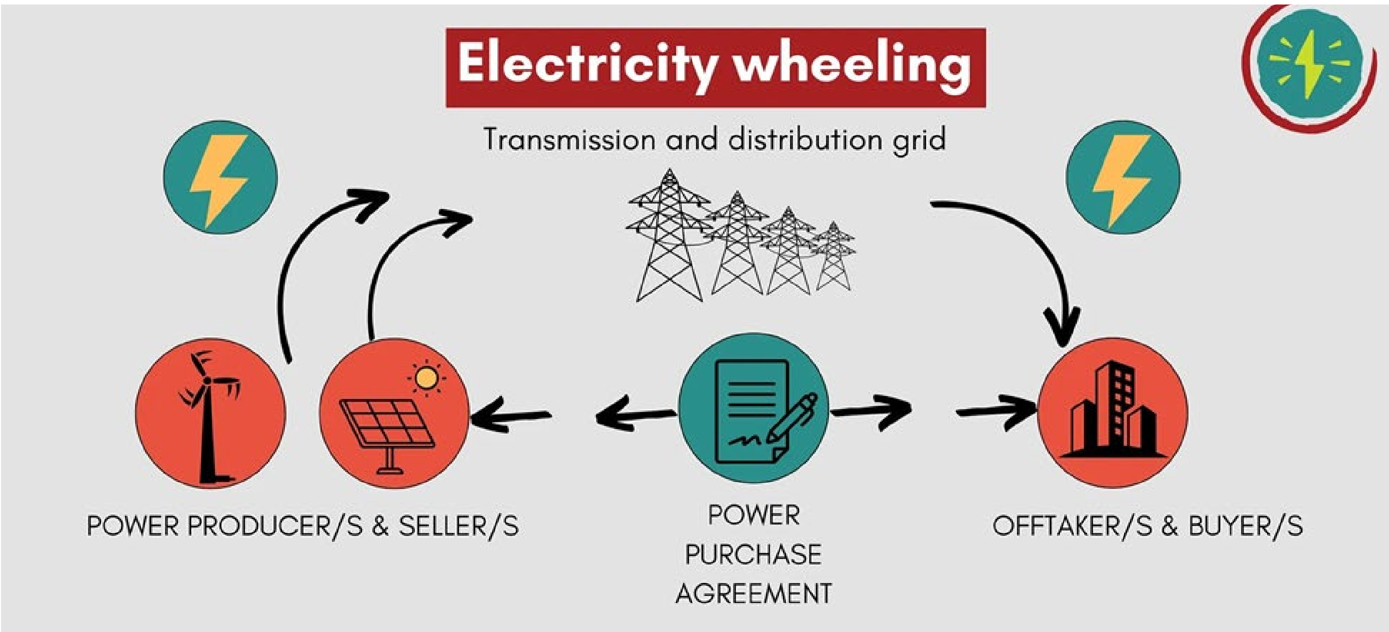

Figure 1. Electricity Wheeling Mechanism

Energy wheeling relies on several key features that enable its efficient implementation and operations which are as follows:

- **Third-Party Infrastructure**: Electricity is transmitted using grids owned by entities other than the generator or consumer.

- **Specific Agreements**: Contracts such as Connection and Use of System Charge (UoSC), Electricity Supply Agreements (ESA), and Wheeling rules and regulations that govern the process.

- **Wheeling Charges**: Generators and consumers pay fees to use the shared infrastructure, enabling multiple buyers and sellers to operate in a competitive electricity market.

Pakistan's Regulatory Framework of Energy Wheeling

Pakistan began implementing energy wheeling mechanisms with National Electric Power Regulatory Authority's (NEPRA) "Wheeling of Electricity Regulations, 2016." These regulations established the foundation for wheeling by covering critical aspects such as tariff design, grid code compliance, licensing, metering, billing, and dispute resolution. Generators and consumers were licensed to participate in wheeling arrangements, while NEPRA determined wheeling charges for grid usage.[4]

In 2022, NEPRA introduced the "Open Access Interconnection and Wheeling of Electric Power Regulations," which granted open access to transmission and distribution networks, including those operated by public sector companies and K-Electric. This move ended the exclusive rights of these entities requiring them to ensure non-discriminatory access for new entrants and submit annual compliance reports to NEPRA. Under the new regulations the generators, bulk consumers, or captive power producers, can apply for a network license, provided they meet NEPRA's legal and technical requirements.

The regulations also set clear guidelines for financing and wheeling operations. In the case of energy wheeling, we have Bulk Power Consumer, seeking agreements to access the transmission systems that had to be made with

4 https://riaabarkergillette.com/pk/news-story/wheeling-of-electricity-nepra-approves-regulations/

distribution license holders within their jurisdiction. These reforms promote third-party access, encouraging private sector participation, and ensuring regulatory transparency.[5]

Energy Wheeling in the Context of CTBCM

In the Competitive Trading Bilateral Contract Market (CTBCM), energy wheeling allows power producers to supply electricity directly to large consumers (Bulk Power Consumers or BPCs) through DISCOs' existing transmission and distribution networks. The power producer feeds electricity into the DISCO grid, which then delivers it to the BPCs. While the DISCO charges a "Use of System Charge" (wheeling charge) for using its infrastructure, the energy producer bills the BPC directly.

This model supports CTBCM's core objectives by promoting competition and encouraging private-sector participation. It allows BPCs (consuming 1 MW or more) to negotiate bilateral contracts with power producers, securing electricity at competitive rates and reducing reliance on centralized procurement.[6]

NEPRA's guidelines since 2015 have allowed limited wheeling arrangements within the same DISCO. However, the CTBCM framework aims to expand this model, facilitating energy wheeling across different DISCO networks. The CTBCM framework works by opening up Inter-DISCO transactions, allowing multiple power producers to sell electricity to different consumers, promoting competition and offering more options for energy buyers, ensures proper wheeling charges and transparency in the trading of electricity between different networks.[7]

Power Purchase Agreements for Energy Wheeling

Power Purchase Agreements (PPAs) are long-term contracts that define the terms of electricity sales, including price, volume, delivery point, and duration. In energy wheeling, PPAs allow independent power producers (IPPs) to sell electricity to distant consumers, with the transmission network operator charging a wheeling fee included in the PPA price. These agreements ensure price stability, predictable revenue for producers, and cost certainty for consumers.

The Use of System Charge (UoSC), paid by consumers to access the transmission and distribution network, helps recover grid maintenance and upgrading costs. It is calculated based on factors like electricity volume, transmission distance, and peak demand. In Pakistan, DISCOs have proposed UoSC rates between 5 and 11 cents/kWh, which are considered high due to sector inefficiencies. Reducing the UoSC to 1–1.5 cents/kWh could lower costs for industries, enhance competitiveness, and boost exports, benefiting the economy. Transparent, standardized UoSC frameworks are key to fostering competitive electricity markets and efficient energy wheeling.[8]

Case Study: South Africa's Energy Wheeling Model

The South African Energy Wheeling Model is a useful example for Pakistan, as both face similar energy challenges like supply reliability, high fossil fuel dependence, and weakly served demand, with outdated, inefficient grid systems. South Africa's wheeling approach can help Pakistan optimize its existing grid, reducing the need for new infrastructure. According to the International Trade Administration, South Africa's grid mix includes around 3% renewable energy, with the remainder met from non-renewables like coal (about 80%) and nuclear (6%). Aging infrastructure and Eskom's (Grid Operator) financial challenges remain significant concerns. Eskom's debt levels

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5 *https://propakistani.pk/2022/11/04/nepras-new-regulations-to-facilitate-new-entrants/*

6 *https://aptma.org.pk/wheeling-charges-do-or-die/?utm_source=chatgpt.com*

7 *https://www.researchgate.net/publication/363800887_What_is_CTBCM*

8 *https://aptma.org.pk/wheeling-charges-do-or-die/*

and the risk of a "utility death spiral" due to rising electricity prices are worrying. Efforts to reform Eskom's business model are ongoing.[9]

The South African Energy Wheeling Model enables private renewable energy generators to transport electricity through Eskom's national grid to consumers across regions, allowing businesses to purchase power directly from Independent Power Producers (IPPs) while bypassing traditional utility channels. Eskom charges wheeling fees to both the IPPs and consumers, facilitating access to renewable energy and overcoming geographical barriers for cleaner energy.[10]

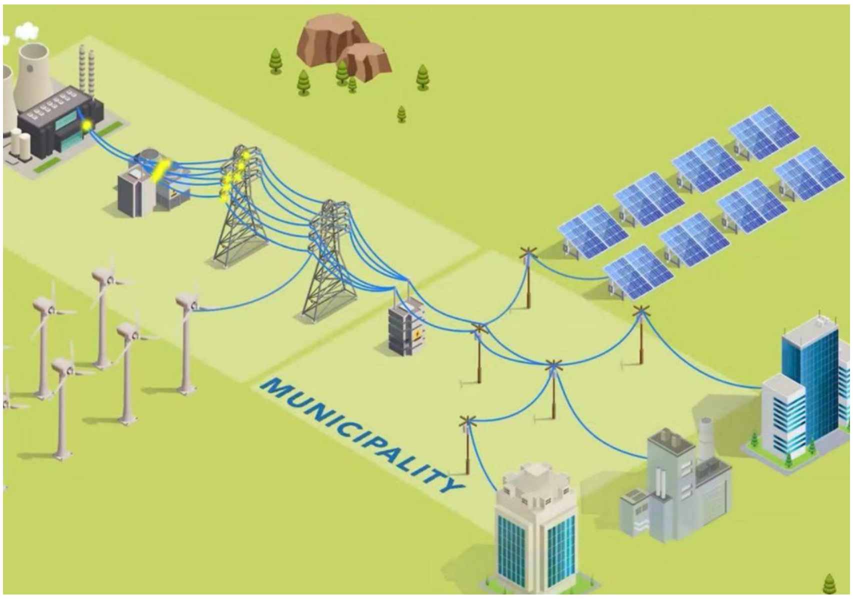

Figure 2. South African Model of Energy Wheeling

The advantages of this model include cost savings, reduced reliance on the national utility (Eskom), price certainty, and fostering local economic growth. The local investments are stimulated, creating jobs and boosting the community wellbeing and use of clean energy. This table below, includes notable renewable energy wheeling projects in South Africa that highlight the increasing use of clean energy and wheeling arrangements to enhance grid sustainability and reliability.

Table 1. Notable renewable energy wheeling projects in South Africa[11] [12] [13]

#	Project Name	Location	Capacity
1	SOLA & Tronox Mineral Sands Partnership	Lichtenburg, North West	200+ MW (Solar), generates around 593,721 MWh annually.
2	Terra Firma Solar PV Projects	Hammanskraal & Rietfontein, Gauteng	87 MWp (Hammanskraal) + 23 MWp (Rietfontein)
3	Impofu Wind Power Farms Complex & Air Liquide S.A.14	Kouga Municipality, Eastern Cape	330 MW (Wind) to be operational by 2026
4	Amazon Solar Energy Wheeling Project	Northern Cape	28 GWh annually
5	Redstone Solar Thermal Power Plant	Northern Cape	100 MW (Solar Thermal)
6	Scatec Solar PV and Battery Projects	Northern Cape, Western Cape, Limpopo	Over 500 MW (Solar & Storage)
7	Enel Green Power South Africa Projects	Free State, Eastern Cape, Northern Cape	Over 700 MW (Wind & Solar)

9 *https://www.trade.gov/country-commercial-guides/south-africa-energy*
10 *https://www.eskom.co.za/distribution/wp-content/uploads/2022/07/20220721-Wheeling-concept_Introduction.final_.pdf*
11 *https://aiimafrica.com/media/media-centre/nersa-approves-flagship-energy-wheeling-project-for-amazon*
12 *https://techfinancials.co.za/2024/10/16/sas-terra-firma-announces-110mwp-wheeled-energy-projects-worth-r1-3-billion/*
13 *https://www.esi-africa.com/news/sola-and-tronox-pioneer-200mw-renewable-energy-project-in-sa/*
14 *https://www.news24.com/news24/community-newspaper/kouga-express/impofu-wind-farms-sas-largest-private-renewable-energy-plant-gets-green-light-20240228*

The South African model emphasizes regulatory clarity and cost-reflective wheeling tariffs, which would be vital for Pakistan's energy market. It would require regulatory changes to allow private producers (IPPs) to sell directly to consumers via the national grid, promoting competition and lowering prices. A clear framework for contracts, billing systems, and ensuring that wheeling fees support infrastructure maintenance would be necessary. However, it would require substantial regulatory reforms, market structure adjustments, and infrastructural development. These efforts could lead to a more competitive and diversified energy market, which benefits both businesses and consumers, particularly in the renewable energy sector.

Recommendations

1. Determine transparent, cost-reflective wheeling charges that mirror market realities in such a way that they do not deflect industrial consumers from the national grid but, instead, encourage broader participation in energy markets.

2. Prioritize the strengthening, digitization and modernization of the national grid to mitigate its congestion and improve its inter-regional and inter-provincial connectivity so that it can handle market-based electricity transactions efficiently.

3. Equip the National Electric Power Regulatory Authority (NEPRA) with robust, real-time market monitoring and enforcement capabilities. The regulator should have the capability to implement a clear, transparent tariff-setting mechanism to gain investor confidence, ensure financial sustainability of the grid and promote fair competition.

4. Develop a structured plan for transition from costly take-or-pay contracts with electricity generation companies and, instead, move towards the take-and-pay contracts so that the burden of capacity payments on the national grid can be reduced.

5. Gradually phasing out older, inefficient and costly power plants.

6. Introduce competitive bidding processes for new entrants in power generation to optimize efficiency and minimize capacity costs.

7. Focus on restructuring government-owned power plants to align them with the market realities rather than just renegotiating power purchase agreements with private power producers. This change will reduce the burden of capacity payments and offer electricity consumers with financially sustainable and competitive solutions for their electricity needs.

8. Invest in forecasting and monitoring technologies (to develop a data pipeline) for accurate projections and planning so that a balance can be developed between electricity generation and electricity demand. This should help the system avoid the problems of load-shedding (caused by higher than usual demand and the grid's inefficiencies) and curtailment of cheaper and renewable sources of electricity (caused by low demand).

9. Offer targeted incentives for hybrid (solar-wind-battery) power projects to enhance the system's reliability, reduce its reliance on imported and costly fossil fuels and improve the national grid's stability.

10. Invest in energy storage technologies to bridge the gap between intermittent renewable energy generation and energy demand to increase the grid's reliability.

11. Foster stronger federal-provincial coordination to resolve governance and market design conflicts. Establish an independent market governance structure to ensure transparent decision-making and prevent undue interference from vested interests.

12. Develop a clear transition plan for subsidies to lifeline consumers, ensuring that they are not left behind in the transformation of energy markets.

13. Protect residential consumers from tariff increases to ensure that market manipulations or distortions do not disproportionately benefit larger, bulk consumers.