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Turning Distributed Energy Assets into a National Grid Resource

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The power system in the country is transforming as most of the demand is being met with distributed generation. It is no longer driven solely by government policy or utility planning; rather, consumers are changing the structure of the electricity system. The traditional power system was built around centralized generation, one-directional electricity flows, and predictable demand patterns. These assumptions are increasingly being disrupted by rooftop solar, batteries, flexible demand, electric vehicles and other distributed energy resources (DERs).

As a result, the challenge for Pakistan is no longer simply how to accommodate these technologies, but how to convert the assets already emerging at the consumer level into resources that can support the wider grid. In this regard, the discussion around energy storage and grid flexibility at the IPS webinar, **Energy Storage and Grid Flexibility for Renewable Integration,** underscored the significance of this transformation. Contributions came from Hamza Naeem, Project Manager Electronics, Agora; Dr. Fiaz Chaudhry, Chairman National Grid Company; Dr. Naveed Arshad, Professor and Director, LUMS Energy Institute; Sameer Raza, Solutions Manager, BESS, Huawei Digital Power; Omar Haroon Malik, Executive Director, ISMO; and Umer Khan, Joint Director, PPIB.

From Consumer Adoption to Grid Transformation

The rapid adoption of rooftop solar initially represented a response to the country's electricity affordability problem. Consequently, consumers sought to reduce their dependence on an expensive and unreliable grid by generating electricity themselves. However, the cumulative effect of these individual decisions is now reshaping system-level electricity flows. Growing solar generation reduces demand from the grid during the day, while demand rises sharply after sunset when solar output declines. This creates the familiar *duck curve,* requiring the system to ramp up generation rapidly during evening hours and potentially increasing operational costs and system-stability pressures.

This transformation is moving beyond solar. Battery storage is increasingly being installed behind the meter, while industrial consumers, captive generators and electric vehicles are creating additional sources of flexibility. These assets already exist or are emerging within the country, but their system-wide potential remains largely untapped.

The Grid Has a Resource It Cannot Utilize Yet

Pakistan may already possess significant flexibility resources in the form of consumer-owned assets. Yet an asset installed behind the meter remains largely invisible to the

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system operator unless its capacity, location and availability are known. Therefore, flexibility requires more than the physical availability of batteries or solar panels. These assets need to be visible to system operators, technically capable of responding when required, and appropriately valued for the services they provide.

This creates an important policy opportunity. Instead of treating distributed solar and battery storage exclusively as a challenge to grid revenues and conventional utility operations, the country can develop mechanisms through which individual assets contribute to system needs. Battery storage, for instance, can shift surplus solar generation from the daytime to the evening peak, while demand response can reduce consumption when the system is under stress. Aggregated, thousands of small assets could provide services that would otherwise require expensive generation or network investment.

The same principle applies to electric vehicles. As EV adoption grows, the batteries embedded in these vehicles could eventually represent a substantial distributed storage resource. Given appropriate policy and market instruments, these batteries could support grid stability rather than simply constitute an additional source of electricity demand.

Realizing this potential requires a change in the role assigned to consumers. Consumers can no longer be viewed simply as the endpoint of electricity supply. A household or business with solar, battery storage, flexible demand or an EV can simultaneously be a consumer, producer, storage owner and potential provider of grid services.

This transformation also requires a corresponding change in the role of distribution companies. DISCOs have traditionally operated largely as passive networks delivering electricity to consumers. In a DER-rich system, they would increasingly need to manage where distributed resources are connected, identify whether a network problem can be solved more efficiently through distributed flexibility rather than conventional grid reinforcement, assess available hosting capacity, and coordinate their operation. In this regard, privatization of DISCOs can provide an anchor for building a broader reform layer, making them more active managers of the system.

The Equity Question Cannot Be Ignored

However, turning distributed assets into a national resource also raises a critical question of who benefits from the transition. The benefits of solar adoption have not been evenly distributed. Higher-income consumers have been better positioned to finance rooftop solar using their own resources, while lower-income consumers have largely remained outside this transition, leaving them to bear the rising cost of the grid that is already unaffordable.

This creates a potential paradox. If battery storage and other flexibility mechanisms are designed primarily around consumers who can afford distributed technologies, public policy could end up rewarding those who have already benefited from the energy transition while leaving other consumers to bear a disproportionate share of grid costs. Therefore, the objective should not simply be to maximize the deployment of battery energy storage systems (BESS) or distributed solar. The policy objective should be to maximize their system-wide value while ensuring that the benefits of flexibility are not restricted to those who can afford to own the assets.

From Distributed Assets to an Integrated Flexibility Framework

Consequently, the government needs to move from an asset-by-asset approach towards an integrated flexibility framework. The first requirement is visibility: mapping existing DERs and identifying high-penetration feeders and assessing the available capacity. The next step is to create appropriate price signals and market mechanisms. Static time-of-use tariffs may encourage some demand shifting, but a more flexible system will eventually require mechanisms through which consumers and aggregators

can be compensated for providing specific services at specific locations and times. Virtual power plants and aggregation could allow numerous small assets to function collectively as a significant system resource.

Conclusion

The grid transformation is already underway, driven substantially by consumers rather than planned exclusively by utilities. The emergence of rooftop solar, batteries, flexible demand and EVs has created a distributed resource base that the power system cannot afford to ignore. The central policy challenge is therefore to move from managing distributed energy resources as a disruption to mobilizing them as a system resource.

This requires visibility, coordination, appropriate incentives, market access and regulatory reform. Equally important, it requires an equity lens to ensure that the transition does not create a system in which those who can afford to leave the grid receive increasing benefits while those who cannot are left with increasing costs. If Pakistan can connect consumer-level assets with system-level needs, the same technologies that are currently disrupting the traditional grid could become instruments for making it more flexible, efficient, affordable and resilient.