Perspective

Variable generation, flexible demand

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The rising proportion of variable renewable generation in the electricity system is creating the need for more flexibility to balance supply and demand. Demand-side flexibility, or flexible demand, has become a vital aspect of maintaining a safe and functional network.

In this *Energy Perspective*, we look at the issue of flexible demand as covered in the book *Variable Generation, Flexible Demand*, edited by Fereidoon Sioshansi and published in November 2020. The book comprises of 22 chapters from contributors from different disciplines and from all over the world. As we discuss, harnessing flexible demand makes a compelling business sense for key market participants.

What is flexibe demand?

Sioshansi describes flexible demand as the solution to the "feast or famine" situation often experienced on electricity networks resulting from the abundance or disappearance of variable renewable generation. Turning flexible thermal plants – typically gas-fired peaking units – up or down is the traditional solution to accommodate renewable generation. In most instances, however, flexible demand can serve the same purpose at lower cost, with zero emissions, and often at a much faster response rate. Moreover, since solar and wind generation cannot be adjusted, managing demand flexibility becomes critical as networks approach 100% renewable targets.

The proliferation of flexible demand solutions has been enabled by three main developments:

- Smart meters are becoming the norm in many places.
- Smart tariffs providing incentives to respond to price signals.
- Smart connected devices becoming easier to monitor and manage.

As we discuss, further advancements in digital technologies will be important to maximise the potential of flexible demand.

Commercial and residential

The key to harnessing flexible demand, especially in the commercial and residential sectors, is scale. Small customers have flexible demand, but it comes in small increments, which only become worthwhile if they can be aggregated across many customers.

Commercial and residential buildings show increasing potential for flexibility because of their gradual electrification. This phenomenon increases load as well as the ability of energy consumers to shift their energy demand. While the potential for flexibility in heavier industry relies on production processes, the potential for less energy-intensive activities lies principally in the management of buildings. Access to real-time metering, pricing, and billing is the most important condition that must be met to enable demand-side response and other forms of demand participation.

Aggregation

Small consumers (households and SMEs) can provide little individual contribution to balancing the grid. They may have a much greater impact, though, through aggregation. The sustainability of aggregators' business model relies critically on two features of the market design: relatively low barriers to entry in the wholesale markets, and the customers' trust in the market functioning.

Sioshansi highlights three companies that have developed approaches to engage customers and aggregate and monetise the resulting flexible demand: Enel X, French flexible demand innovator Voltalis and San Francisco-based start-up OhmConnect. Enel X is mainly focused on the large I&C segment of the market,

where the marketing, customer acquisition, and transaction costs are low relative to the potential to generate and deliver value. Companies are broadly trying to identify niches in the market. This has been assisted by the falling cost of sensors, telecommunication, data processing, and artificial intelligence.

Industrial demand

Much in the same way as enabling greater aggregation for small consumers, progressing digitalisation and cooperative approaches are "game changers" to integrate flexible industrial demand in VPPs.

Virtual power plants

Cloud-based distributed power plants that aggregate the capacities of heterogeneous distributed energy resources.

Authors Sabine Löbbe, André Hackbarth, Heinz Hagenlocher and Uwe Ziegler, use a German case study to demonstrate the viability and profitability of industrial demand in virtual power plants (VPPs). The authors present a research project that aimed at connecting SMEs to a VPP via a specific communication platform.

Three potential business models are identified under the presumption of flexibility marketing via the spot market:

- The orchestrator – a municipal utility administers specialised service providers from the energy and IT sector.
- The integrator – which combines the activities of third parties with its own service provision.
- White label user – purchases a ready-to-use VPP product, whose technical and operational aspects are handled by the white label provider.

All three business models open further opportunities for cross-selling. This could be further products or sector coupling, which might provide a basis for regional expansion.

Regulatory barriers

Lynne Gallagher and Elisabeth Ross, in their chapter on empowering consumers to deliver flexible demand, use examples from Australia's National Electricity Market (NEM). The chapter explains how third-party intermediaries, or demand aggregators, have an important role to play in extracting the value of demand flexibility. The value that intermediaries can offer consumers to reward flexible demand is often limited by the lack of access to markets. The ability to "value stack" across markets is a critical factor in the development of flexible demand.

The authors also argue that consumers must be rewarded and incentivised to provide flexibility in a way that they understand and can respond to. This requires more than standard financial incentives and price signals. David Robinson, in his chapter on energy communities and flexible demand, explains two ways of delivering demand-side flexibility in addition to efficient economic signals: technology – especially automation – that facilitates consumer participation and willingness to be flexible, and business models – involving aggregation – that enable the consumer to benefit from providing flexibility.

Robinson presents several policy reforms to provide efficient price signals to consumers behind the meter:

- Fiscal reform – to eliminate incentives to generate one's own electricity simply to avoid paying taxes and policy-related levies that are collected through the variable component of regulated electricity tariffs.
- Network access tariffs to provide incentives to invest in, and operate, distributed energy resources that contribute to lowering the overall costs of the system as well as the costs of the individual consumer owning the DER.
- Wholesale markets for energy and flexibility services, especially the flexibility markets where margins are typically higher.
- Local markets for congestion.
- Reforming entire electricity systems, starting with a new energy market design.

Removing regulatory barriers is necessary to get small customers engaged in flexibility services. But it is important to remember that one of the main challenges lies in the margins and cash-flow shift that is implied in a greater involvement of small customers. Another barrier to demand participation in flexibility markets comes from the market design itself.

Market design

Authors Laurens de Vries and Gerard Doorman, in their chapter on valuing consumer flexibility to electricity market design, describe the notion of capacity subscription. This, they say, provides an economically efficient, transparent, and stable reward for consumer flexibility.

Capacity subscription

Consumers buy the amount of generation capacity that they expect to need during moments of system scarcity. They buy capacity subscriptions from providers of firm capacity (generation and storage).

When a consumer buys a capacity subscription, they are given a guarantee to consume electricity up to a capacity level under all conditions. When the energy market is short of generation capacity, the system operator activates so-called load limiting devices (LLDs) that are installed at each consumer site. These force consumers to restrict their consumption to the levels that they contracted. In return, the consumer has the certainty that capacity is available at a price close to the marginal cost of generation. When there is no shortage of generation capacity consumption is unrestricted. Recent capacity shortfalls in California in August 2020 and the more recent crisis in Texas in February 2021 illustrate the need for some sort of capacity subscription service when demand exceeds supply and must be efficiently rationed.

An important feature of capacity subscription is that demand for capacity is based on the individual consumers' preferences for uninterrupted supply. The consumer demand for capacity subscription provides wholesale suppliers of flexible generation capacity a market-based, but stable revenue for their capacity. Generators receive the benefit of providing the required capacity at a lower cost of capital.

One of the challenges for the market design of the future is how to remunerate storage facilities. Small-scale storage may be attractive with capacity subscription, as it can help consumers to stay below their subscribed limit, even during longer periods of LLD activation by allowing them to consume more than their capacity limit if the storage unit lasts. Some form of real-time pricing for consumers appears to be a necessary feature of a future electricity market design.

Carlo Stagnaro and Simona Benedettini, in a separate chapter, note the crucial role of retail market design. As mentioned earlier, for small customers to trust aggregators and become enrolled in a demand-side response, there must be a widespread understanding of what a consumer's rights are. The authors also allude to the notion of capacity subscription, claiming consumers should understand that electricity is a service rather than a commodity.

Electric vehicles

As the transportation sector is electrified over time, it offers a new and unexplored opportunity for demand flexibility. Sioshansi explains how EVs are the "ultimate" flexible demand. Moreover, vehicle-to-grid (V2G) functionality unlocks the potential of EVs, not only as a flexible load but also as a balancing resource.

For large-scale EV demand response, the following must happen:

- The development of a vast charging infrastructure that is convenient and accessible.
- The development of an intelligent EV charging network that encourages charging at times and locations where supplies are abundant and prices are low while discouraging the opposite.
- Regulatory, pricing and policy support and coordination from all stakeholders to manage the operation and control of the entire value chain from the generation source to the chargers without overwhelming the distribution network.

California and Texas

The book is timely coming after two major episodes of power shortages in California and Texas, where having more flexible demand at scale could have made a difference, certainly in the former case where the supply shortages were relatively small – 1GW in a 40GW system – and limited to a couple of hours. Even in Texas, where the shortages were huge and lasted for a good part of the week, customers could have responded by keeping the lights on while turning off showers, dishwashers and dryers. With wholesale prices at $9,000/MWhs, many large and small customers would have found ways to conserve, thus reducing the need for indiscriminate rolling blackouts. Having more flexible demand and knowing how to use it will become more important not only in emergencies but in day-to-day operation of networks that are marching towards 100% renewable targets.