Unlocking value from demand-side flexibility in the European power system
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Significant shifts are under way in how electricity is produced and consumed in Europe. On the demand side, adoption of electric vehicles (EVs) and the switch to electricity for heating and cooling of residential and commercial buildings are gaining momentum. On the supply side, wind and solar power are accounting for a growing share of electricity generated in Europe. The net impact of these shifts will be higher demand peaks, but of shorter duration. The industry is being challenged to find new ways to match supply and demand.

Flexibility is the ability to manage variability and volatility to balance supply and demand, within constraints of infrastructure. This report quantifies the growing need for flexibility in the European electricity system, and discusses how new sources of flexibility can be unlocked from consumers to contribute to meeting this need.
DEMAND-SIDE CHANGES

By 2030, the adoption of EVs and electric heating and cooling is expected to have significant impact on electricity demand. At the same time, commercial and industrial (C&I) energy consumers will continue to pursue energy-efficiency initiatives, among others, to meet commitments to reducing greenhouse gas (GHG) targets of European economies. These conservation efforts will only partly compensate for the increase in total demand from EVs, electric heating and cooling and new appliances and the load shape will look very different in 2030, particularly during demand peaks.

TRANSPORT

EV sales in the EU rose by 39 percent in 2017.\(^1\) With technology improvements, growing investment by a range of companies and decreasing prices of batteries, annual EV sales are projected to grow by 30 percent annually between 2020 and 2030, when EVs could account for 9 percent of the European fleet (see Figure 1).

Figure 1. EU-28 EV fleet (millions).

\begin{center}
\begin{tabular}{|c|c|}
\hline
\textbf{0.7\% share of EVs in car fleet} & 2 \\
\textbf{9\% share of EVs in car fleet} & 22 \\
\hline
\end{tabular}
\end{center}


BUILT ENVIRONMENT

There is a shift toward electric heating and cooling (e.g., heat pumps) and district heating to reduce GHG emissions. Between 2020 and 2030, the number of heat pumps in Europe could increase from 1.6 million to 10 million, growing by 18 percent per year (see Figure 2). The role of combined heat and power (CHP), which captures heat from electricity generation to heat buildings and industrial processes, is also expected to grow. District heating and CHP accounted for 4 percent of final energy demand in Europe in 2015, and this is expected to grow by 11 percent by 2030.\(^2\) At the same time, households and businesses are increasingly using more devices, but the increasing efficiency of devices broadly compensates, making the impact on total electricity demand neutral.
Figure 2. Number of electric and hybrid heat pumps in Europe (millions).


COMMERCIAL AND INDUSTRIAL USAGE

Companies are looking for cost-effective ways of reducing emissions. The primary focus is on energy efficiency (see Figure 3), with companies also participating in demand-management programs to save on operating costs and to help meet European targets for reduction of GHG emissions. They are also investigating options for switching more to electricity and assessing alternative low-carbon solutions such as hydrogen and renewables-based fuels.

Figure 3. Energy use per unit of value added (index: year 2000 value).

SUPPLY-SIDE CHANGES

The story on the supply side is about the growing role of renewables and the pressure on fossil-fuel generation. By 2030, wind and solar could provide as much as 29 percent of the electric power generated in the EU (see Figure 4). In Germany, wind and solar could contribute up to 31 percent of total generation by 2030, 36 percent in Ireland, and 20 percent in France.

Figure 4. Wind and solar electricity production in the EU-28 (TWh).

European energy providers have been scaling investments in renewable energy. Unlike in the past, these investments are less driven by subsidies. In 2018, we saw the first tender bids for building offshore wind without subsidy, and more will follow.³

In addition to centralized renewables operated by energy companies, European businesses and residential energy users are installing their own renewable electricity generation, such as rooftop solar systems. With the cost of photovoltaic (PV) panels falling, rooftop solar is increasingly affordable. Solar capacity in the EU increased from 2.3 GW in 2006 to 101 GW in 2016.⁴

The rise of renewables is part of a transition toward a low-carbon energy supply. The switch to renewables will gain additional momentum from the retirement of plants now powered by fossil fuels, as European economies try to meet climate change goals by reducing GHG emissions.
MORE FLEXIBILITY NEEDED

These changes in supply and demand raise the need for more flexibility to provide electricity consistently and reliably (see sidebar: Flexibility explained). This involves managing variability and volatility in supply and demand; for instance, stemming from the growing share of wind and solar generation. At times of full production—when the sun is shining and the winds are steady—renewable sources already fill a significant share of demand in many European countries and sometimes produce more than is needed. At night or when winds are weak, there may be large shortfalls.

Flexibility gaps emerge in different situations. At times of demand peaks and little renewable electricity generation, available flexible generation capacity may not be sufficient to meet demand. This problem can be exacerbated if large numbers of EVs and heat pumps are used at peak times, rather than being managed to connect during times of low demand. Secondly, rapid fluctuations in demand can create situations where it is technically difficult or costly to adjust production in response—such as when demand spikes just as solar supply goes offline. Lastly, overproduction can occur when renewables produce more electricity than is needed. At these times, there is an opportunity to create additional value by using this low-cost excess electricity for additional consumption or storing it for later use, or by transporting it to areas of high demand.

This study explores the role of flexibility in managing deviations in supply and demand in electricity markets in Europe, with a focus on the demand side. We address three key questions:

1. **HOW LARGE WILL THE NEED FOR FLEXIBILITY FOR BALANCING SUPPLY AND DEMAND BE IN THE EUROPEAN POWER SYSTEM BY 2030?**

2. **HOW CAN MARKET PARTICIPANTS STIMULATE GREATER USE OF DEMAND FLEXIBILITY AND CONTRIBUTE TO FULFILLING THE INCREASING NEED FOR FLEXIBILITY?**

3. **WHAT ARE THE PRINCIPLES FOR A REGULATORY FRAMEWORK TO ENABLE ADDITIONAL FLEXIBILITY?**
FLEXIBILITY EXPLAINED

Flexibility is the ability to manage variability and volatility to balance supply and demand, within infrastructure constraints (see Figure 5).

Flexibility use for balancing supply and demand occurs in wholesale and balancing markets. Wholesale market participants seek to ensure that their portfolios are in balance with their forecasted positions over the balancing settlement period, and use flexible resources to do so up to market closure (portfolio balancing). After market closure, the system operator uses flexible resources to adjust for any deviation from the forecasts in balancing market (system balancing). The system operator also considers technical dimensions of system stability, such as frequency and voltage levels. To perform these tasks, the system operator procures ancillary services from flexible resources, such as fast reserve (the ability to ramp up generation during peaks) or “demand turn-up” to raise consumption during times of oversupply.

Flexibility is also used for managing network constraints. Operators of the high-, medium- and low-voltage networks can use flexible resources locally to lower the network load where grids have become congested (congestion management).

There are various types of flexibility sources in the electricity system. Each has its strengths; for instance, in terms of response time, duration and up and down regulation it can provide. A mix of flexibility resources is therefore needed for a reliable, and resilient flexibility capability.

Historically, flexibility has mainly been supplied by generators, such as gas-fired power plants and pumped hydropower plants. These generation sources are well-suited to adjusting production to respond to changes in the rest of the system. Active control of renewable generation technology also can provide some flexibility. For instance, the increase and decrease of production of a wind farm can be slowed down to mitigate impacts on the balance of the power system.

Demand-side resources can provide flexibility through demand response. Industrial consumers are already offering flexibility this way to the system operator, by agreeing to reduce or increase consumption as needed, in return for compensation. Residential or small commercial consumers can also provide demand response, but the relatively small scale of the flexible loads of these consumers and relatively high costs per site have limited its use.

Storage provides flexibility by creating a buffer between times of shortage and oversupply of electricity. Different types of storage technology are being applied in different parts of the electricity system—at end-user sites, in the network or close to generators.

Transmission networks, including cross-border network interconnections, also play an important role in facilitating the use of flexibility in the electricity system, by allowing for balancing surpluses and shortages over larger areas.
**Figure 5. Flexibility uses and sources.**

<table>
<thead>
<tr>
<th><strong>FLEXIBILITY USES</strong></th>
<th><strong>FLEXIBILITY SOURCES</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand-supply deviations</td>
<td>Large industrial demand response</td>
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<tr>
<td></td>
<td>Network interconnections</td>
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<tr>
<td></td>
<td>Conventional generation</td>
</tr>
<tr>
<td>Technical constraints</td>
<td>Renewables system optimization</td>
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<td></td>
<td>Grid-scale storage</td>
</tr>
<tr>
<td>Constraints in network</td>
<td>Behind-the-meter solar plus storage</td>
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<td></td>
<td>Electric vehicles</td>
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<td></td>
<td>Community storage</td>
</tr>
<tr>
<td></td>
<td>Heat pumps</td>
</tr>
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Source: Accenture.
SECTION 1.

INCREASING VOLATILITY IS EXPECTED TO DRIVE GREATER NEED FOR FLEXIBILITY

The transformation of electricity usage and generation will result in higher and steeper peaks of demand, and more flexibility will be required to manage them. More rapid responses are needed to match greater volatility in supply and demand. With rising adoption of renewables, instances of oversupply will be more common. Impacts will vary by country.
THE EMERGING GAPS THAT INCREASE THE NEED FOR FLEXIBILITY

Our modeling indicates that 55 to 90 GW of additional flexible capacity will be needed by 2030 across six European electricity markets, in a scenario without new measures to develop additional flexibility (see sidebar: Our modeling methodology). This is an increase of 30 to 45 percent over current peak and mid-load capacity (see Figure 6). Of this additional capacity, 25 GW to 40 GW is peak capacity (needed for less than 1000 hours per year), and 30 GW to 50 GW is mid-load capacity (needed for 1000 to 7000 hours per year).

Figure 6. More flexible capacity is needed by 2030.

The amount of additional flexible capacity needed depends on the speed of electrification (of transport and heating/cooling) and the adoption rate for renewables, mainly wind and solar. Sensitivity analysis suggests that the need for flexible power capacity could be 20 percent greater if electricity demand from transport and heating/cooling is 30 percent greater in 2030 in an accelerated transition scenario as compared to our base scenario. Smart charging of EVs and smart control of electric heating/cooling could partly mitigate this effect, by shifting electricity use to off-peak hours.

Source: Accenture analysis based on EU energy reference scenario of 2016.
OUR MODELING METHODOLOGY

We modeled the requirements for flexibility in the electricity system from 2015 to 2030 across six European countries (France, Germany, Great Britain, Ireland, the Netherlands, and Spain). The model is based on existing projections of supply and demand, which we use to perform a gap analysis to assess the additional flexibility need.7

The model estimates increased demand using projections for adoption of EVs and electric heat pumps in each country. From this demand figure, we subtract projected generation from wind and solar. This leaves the residual load that must be filled, and the model does so by activating the available flexibility generation capacity hour by hour, starting with the technology with the lowest costs. The gaps where generation capacity falls short of satisfying demand or where renewable production overshoots total demand indicate the need for additional flexibility.

The model is a deterministic scenario model. It performs a gap analysis to assess the need for flexibility in existing scenarios, assuming no additional investment in new flexibility sources on top of the scenario assumptions. It is not meant to create an optimized result, nor project what will happen. The model evaluates supply and demand situations in different, “regular” weeks during the year, and does not encompass extreme situations; for example, caused by unforeseen events or extreme weather.

The assessment considers each country individually, assuming that no additional interconnection capacity will become available for balancing supply and demand across borders. However, increasing cross-border capacity could be one of the options for filling the need for flexibility.
Flexible capacity will need to respond to fluctuations in supply and demand that are not only of greater magnitude, but also of shorter duration, resulting from the sum of changing demand patterns and renewable supply. The amplitude of peaks (and troughs) could be 55 to 95 percent larger than today, requiring the equivalent of 10 GW to 20 GW of additional capacity (see Figure 7).

Because of sudden shifts in demand and supply, the slope of fluctuations could be 40 to 75 percent steeper in 2030 than in 2015, requiring faster ramp up and ramp down of flexible generation.

**Figure 7. Changes in supply and demand will increase volatility.**

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**Figure 8. In 2030, flexible capacity will be needed for 20 to 30 percent fewer hours during the year than in 2015.**

We estimate that in 2030, flexible capacity will be needed for 20 to 30 percent fewer hours during the year than in 2015—a decline of 1000 to 1700 hours per year (see Figure 8). Moreover, situations of oversupply will become more common, and could occur as much as 10 percent of the time in 2030, in the accelerated transition scenario in countries with high penetration of renewables. This will reduce the need for energy supplied by non-renewables by 10 to 25 percent by 2030, despite greater need for flexible power in peak periods.
OUTLOOK FOR FLEXIBLE POWER NEEDS IN SIX COUNTRIES

The impact of these new patterns of demand and supply will vary considerably between countries (see Figure 9).

**Figure 9. Outlook for flexible power in select countries.**

<table>
<thead>
<tr>
<th>Country</th>
<th>2015 Flex cap. need (% of total capacity)</th>
<th>2015 Operating hours (% of year)</th>
<th>2015 Volatility (Max. ramp % of peak)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>50-60, &gt;70</td>
<td>50-60</td>
<td>45-60, &gt;75</td>
</tr>
<tr>
<td>France</td>
<td>40-50, 50-60</td>
<td>&lt;40</td>
<td>30-45, 45-60</td>
</tr>
<tr>
<td>Spain</td>
<td>40-50, &gt;70</td>
<td>40-50</td>
<td>30-45, 45-60</td>
</tr>
<tr>
<td>Netherlands</td>
<td>40-50, 60-70</td>
<td>60-70</td>
<td>45-60, &gt;75</td>
</tr>
<tr>
<td>Ireland</td>
<td>50-60, &gt;70</td>
<td>50-60</td>
<td>45-60, &gt;75</td>
</tr>
<tr>
<td>Great Britain</td>
<td>50-60, &gt;70</td>
<td>50-60</td>
<td>45-60, &gt;75</td>
</tr>
</tbody>
</table>

**Legend**
- Flexible capacity need: percentage of installed capacity that is required fewer than 7000h per year.
- Operating hours: average percentage of the year that installed generation capacity is operational.
- Volatility: size of the largest single increase or decrease in capacity (ramp) within a week, as percentage of the absolute system peak.

**Impact**
- Small
- Mid
- High
- Very high

**Source:** Accenture modeling.

**GERMANY:** As Germany’s large share of renewables continues to grow, so will its need for flexibility.

Germany already has a relatively high share of renewable generation, and wind and solar power are still growing quickly. We estimate that by 2030, peak demand could be 60 to 100 percent higher than the 2015 level. This would be accompanied by a 25 to 50 percent reduction in average operating hours of all generators. Partly due to the increase of solar, daily fluctuations in demand could grow by 55 to 105 percent. Germany has extensive interconnectivity, providing access to cross-border power exchanges, but this solution could become limited as surrounding countries install more solar capacity. German coal plants provide flexibility in the near term and Germany also has the most diverse set of storage technologies being tested.

**FRANCE:** France has good sources of flexibility, which will be more in demand with growing use of solar PV.

Due to the electrification of transport and heating in France, the slope of the fastest fluctuations in residual demand could increase by 55 to 75 percent by 2030. We project large spikes in demand in the early evening as people return home, raise the thermostat and start charging their EVs. Growth of solar in France will also contribute to steep evening demand spikes. Even so, there will be less need for additional flexibility and the need will arise more slowly than in other countries due to more modest wind and solar uptake. France has also a good mix of flexible resources, including pumped hydro, new nuclear power plants and residential electric boilers, which can be turned off for a half-hour at a time while keeping the house comfortable.
IRELAND: In Ireland, the challenge will be meeting flexibility needs with limited cross-border supplies.

The need for flexible capacity in Ireland could increase by 40 to 65 percent, even as required base capacity falls by 40 to 70 percent, mainly due to increased use of wind power. The average operating hours for all plants could fall by 25 to 40 percent. Our model shows limited impact from electrification of transport and heating. Because it is an island with limited access to cross-border electricity supplies, Ireland will have to manage the growing need for flexibility largely on its own. And, while the gaps to be addressed with flexibility may be smaller than in other countries, they will likely emerge sooner.

NETHERLANDS: The Netherlands will have the greatest need for flexible capacity among the six countries studied, due to large increases in wind and solar generation as well as rapid uptake of EVs.

The need for peaking capacity could jump by 165 to 190 percent by 2030 and the amplitude of fluctuations could increase by 60 to 85 percent. The Netherlands already has significant fossil fuel-based flexible capacity, including gas combined cycle gas turbines (CCGT), which will be able to accommodate much of the growing need for flexibility. However, a high carbon-allowance cost could raise the need for alternative sources of flexibility. Moreover, the government has put forward proposals for accelerating phase-out of the use of coal and gas to reduce reliance on the Groningen gas field and decrease emissions. This would raise the need for new sources of flexibility.

GREAT BRITAIN: Higher demand peaks, driven by EV adoption, and the reduction of current flexible capacity (from gas-fired plants) will force Great Britain to find new sources of flexibility.

The largest amplitude of daily ramps that flexible capacity needs to accommodate in Great Britain could increase in size by 55 to 65 percent (20 to 24 MW) by 2030, driven largely by EV penetration. Flexible demand could increase by around 50 percent due to increasing shares of renewable generation. Great Britain has a relatively flexible power mix, including gas-fired power plants that can be used to address flexibility needs in the near term. In the medium term, additional low-carbon flexibility sources will be needed, as providers try to meet emissions goals and rely less on gas. Like Ireland, Great Britain has limited access to interconnections, and will need to rely mostly on domestic solutions.

SPAIN: Spain’s flexibility challenges will be volatility and a decline in the need for base-load capacity running throughout the year.

With adoption of wind and solar, required base-load capacity could decline by 45 to 75 percent by 2030, so power plants that run continuously today will need to become more flexible in their production. The size of demand fluctuations could increase by 30 to 70 percent, with the slope of fluctuations rising by 55 to 95 percent. Spain has pumped hydro power plants to manage variability and volatility, but it has relatively few interconnections beyond the Iberian Peninsula.
SECTION 2.

THE GREATER NEED FOR FLEXIBILITY CREATES A VARIETY OF NEW OPPORTUNITIES FOR ENERGY PROVIDERS

Current flexibility sources can only partly fill the emerging gaps, so unlocking additional sources is essential. This is an opportunity for energy providers and new players to create value from new flexibility solutions in power markets.
CURRENT FLEXIBILITY SOURCES ARE NOT SUFFICIENT

A range of existing and new flexibility solutions can be called upon to meet the growing supply and demand matching challenges that will arise in the European power industry over the next decades. This will require wider use of current proven solutions as well as new flexibility sources (see Figure 10).

**Figure 10. Existing and new sources of flexibility: illustrative examples.**

<table>
<thead>
<tr>
<th>SCALE</th>
<th>Residential</th>
<th>Commercial</th>
<th>Large-scale/industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Solar PV</td>
<td>Medium-size CHP</td>
<td>Centralized power plants (gas CCGT, pumped hydro)</td>
</tr>
<tr>
<td></td>
<td>Micro-CHP</td>
<td>On-site generators</td>
<td>Industrial CHP</td>
</tr>
<tr>
<td></td>
<td>Building-integrated PV</td>
<td></td>
<td>Renewables curtailment</td>
</tr>
<tr>
<td></td>
<td>Electric vehicles</td>
<td>Batteries</td>
<td>Pumped hydropower</td>
</tr>
<tr>
<td></td>
<td>Home batteries</td>
<td></td>
<td>Grid-based battery storage</td>
</tr>
<tr>
<td>Storage</td>
<td>Electric vehicles</td>
<td></td>
<td>Large-scale mechanical storage</td>
</tr>
<tr>
<td></td>
<td>Electric heating/cooling (warm water boilers)</td>
<td>Smart buildings</td>
<td>Manufacturing installations</td>
</tr>
<tr>
<td>Demand-response</td>
<td>Electric vehicles</td>
<td>Heating/cooling installations</td>
<td>Steam/heat generators</td>
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</tbody>
</table>

Source: Accenture.

The most commonly used flexibility sources—centralized, large-scale solution in generation and demand-response programs for industrial users—will still be used, but can only partly accommodate the flexibility needed. Moreover, investing in additional flexible (fossil-based) generation capacity may be less attractive, with increasingly stringent GHG emissions policies and a decrease in the average number of operating hours of flexible capacity. The potential for building new pumped-hydropower capacity is also limited for geographic reasons.

Technical solutions to make base-load and renewable generation more responsive can also help mitigate the growing need for flexibility. Advanced control of steam turbines and nuclear power plants, for example, allows them to respond more easily to changes in the system, and renewable generators can slow down the increase and decrease of production.
CONSUMERS HOLD SUBSTANTIAL POTENTIAL

Consumers can provide flexibility at scale through demand-response programs. In mature energy markets, like the US-based PJM market, C&I consumers can already provide around 9 percent of peak load.9 The European leader in aggregation, REstore, aggregates demand from C&I and residential users in several markets. It has over 2.5 GW of contracted capacity, of which 840+ MW can be activated when needed. These resources are complemented with co-generation appliances and large-scale batteries, like site of Terhills with an 18 MW battery, a cooperation with Tesla, contributing to the primary reserve in Belgium.10 Significant new flexibility capacity could become available among larger C&I consumers if they invest in large electric manufacturing installations that allow them to optimize costs with changing gas and electricity prices.

Flexibility propositions for residential consumers have existed for some time. In France, for example, automated storage water heaters are incentivized to switch on at night to reduce peak load and take advantage of low off-peak tariffs.11 In Germany, electric heating represents a large and growing pool of residential flexibility, with close to 900000 heat pumps installed in 2015.12

The potential to source flexibility from residential and commercial demand response will grow steadily over the next decade with wider adoption of electric heating systems, EVs and smart appliances that can be controlled remotely. Currently, appliances represent only a small source of flexibility. But loads from EVs and heat pumps are large enough to play a significant role in flexibility schemes in the coming years.

Advances in low-cost technology will be key to tapping the demand-side flexibility potential. With the spread of sensors and other devices, an expanding variety of machines, appliances, vehicles and other equipment can be brought into flexibility plans at low costs. By 2025, there will be 100 billion connected devices globally, with the greatest growth is expected in vehicles, connected wearables, home devices and building sensors.13 At the same time, advances in artificial intelligence (AI) will make it possible to efficiently manage large portfolios of consumers, by using real-time monitoring, predictive analytics and automated response.
SECTION 3.

CRAFTING FLEXIBILITY BUSINESS MODELS STARTS WITH UNDERSTANDING CONSUMER VALUES AND PREFERENCES

Success in demand flexibility services starts with understanding the energy consumer. This requires deep understanding of needs, preferences and obstacles to participation of various types of consumers to be able to develop adequate flexibility value propositions.
There is a growing universe of consumers with flexible resources (demand that can be adjusted to provide capacity and electricity), each with specific needs, motivations, and behaviors. To create compelling propositions, it is critical to understand the differences among different types of energy consumers—residential, small and medium-size businesses (SMB) and C&I.

WHAT RESIDENTIAL CONSUMERS AND SMALL AND MEDIUM-SIZE BUSINESSES WANT

Residential and SMB consumers vary widely in their motivations and needs. Many households are happy to remain passive consumers. But a sizable share of consumers is ready to go further: In Accenture's New Energy Consumer survey, we found that 26 percent of consumers would be willing to pay for a “connected home” service bundle to manage electricity usage—if it lowered energy costs and made the home more comfortable.\(^\text{14}\)

Price elasticity is key for all consumers. They will only participate if it is worth changing a specific electricity use for a given price incentive. This depends on price elasticity of each specific use. Additionally, residential consumers could also respond to non-monetary incentives, such as comfort, reduced environmental impact or local community contribution. Some consumers can also be motivated by gamification and fun—competing for rewards by controlling consumption.

Ease of participation is vital. Consumers will more likely participate in flexibility schemes if it is easy and there is no comfort trade off. In our New Energy Consumer research, nine out of 10 residential consumers indicate that they want an effortless experience.\(^\text{15}\) The most important program design criterion has to be simplicity—automated processes, intuitive user interfaces and set-and-forget programming. Consumers also want to be in control, with simple opt-in/opt-out functions.

WHAT C&I CONSUMERS WANT

Large C&I consumers are certainly ahead of residential and SMB consumers when it comes to knowledge and readiness to participate in flexibility programs. However, these consumers are also diverse. For large industrial companies, for example, energy is critical to business processes. These are among the most sophisticated users and typically have professional energy-procurement and energy-management functions. Among these industrial consumers, those with the most energy-intensive processes (such as steel making, electrolysis, and paper and pulp) have substantial loads, but also very strict production constraints. Smaller businesses, like water treatment plants, also have considerable flexibility in load, but the nature of this flexibility is determined by very different business processes. Then there are owners of office buildings and large retail facilities, and housing. These consumers are motivated to reduce heating and cooling costs, and typically employ professional facilities managers.
Nevertheless, C&I companies have much in common. Above all, C&I will want to get optimal value for their flexibility. Increasing volatility in electricity prices, higher costs of GHG allowances and energy-efficiency mandates may encourage a greater pool of C&I consumers to participate.

Participating in flexibility schemes should not disrupt their core businesses. C&I consumers need to be assured that load management actions will not be intrusive for their operating processes and will only happen within predetermined operating boundaries.

There are other motivational factors to embracing flexibility schemes. For some C&I consumers, participation could be motivated by the aim to reduce their carbon footprints or to meet corporate sustainability goals. For example, the RE100 initiative unites more than 100 businesses committed to working toward 100 percent renewable electricity consumption.16

**CHOOSE AN APPROACH AND DEVELOP AGGREGATION OR ENERGY SERVICE PROPOSITIONS**

We distinguish two major ways to offer flexibility services: as an aggregator or as an energy optimizer (see Figure 11). Companies may choose one or both approaches, depending on how the company is positioned in the market, its assets and capabilities, and the type of energy consumers it serves.

*Figure 11. Business model approaches.*

<table>
<thead>
<tr>
<th>Demand aggregators</th>
<th>Energy managers and consumption optimizers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selling a flexibility product with commitment to change load</td>
<td>Consumption optimization with dynamic pricing</td>
</tr>
</tbody>
</table>

Source: Accenture.
With the aggregator approach, the energy consumer commits upfront to alter the load within pre-defined boundary conditions; for example, the maximum length of time that a load can be switched on or off. This is also known as “explicit demand response.” In return for this commitment, the energy consumer gets paid for the consumption that the business or household foregoes as well as an additional charge for providing flexibility. Aggregation has a significant scale advantage, and a large portfolio of diverse demand resources allows the aggregator to offer predictable, stable output for a longer period, while avoiding the cost associated with frequent or long dispatch of individual resources. This helps to fit demand flexibility to the requirements of different power markets.

Under the energy management and optimization approach, energy consumers sign a variable pricing energy-supply contract, agreeing to pay whatever the cost is at any given moment, instead of paying a fixed price per kWh. This is also known as “implicit demand response,” because the choices about changing loads are implicitly made through consumer response to price signals. The amount by which consumption is reduced is a function of price elasticity—the consumer will voluntarily cut usage whenever the price is too high.

With either type of flexibility arrangement, energy consumers may have the option of offering their demand flexibility directly to the market. This practice is commonly used by large industrial consumers with professional trading desks.

For both approaches there are many potential propositions for demand flexibility solutions emerging for various consumer segments. Experimentation with innovative consumer propositions across both approaches is needed for all consumer segments to arrive at viable business models. (See sidebar: Innovative demand flexibility value propositions for energy consumers). A critical element for success in emerging models will be minimizing per-site cost, particularly for serving residential consumers, who have modest loads to work with.
Propositions for aggregation

Entelios is a German-based company whose main business is aggregating and managing C&I consumers’ loads, storage, and decentralized generation to participate in energy markets for flexible resources, including the ancillary services markets. Entelios built a technology platform that meets the requirements of all four transmission system operators in Germany to deliver demand-response resources to help manage system imbalances.17

OhmConnect, a US-based startup, is a residential demand-response aggregator. Its service is designed to make demand response easy, fun and user-friendly. During peak grid consumption times, OhmConnect sends #OhmHours notifications, alerting consumers that there is an opportunity to earn credits that can be redeemed for monetary compensation. Consumers can earn $100 to $130 per year.18

eMotorWerks, a North American supplier of EV charging stations that was recently acquired by Enel, offers a service called JuiceBox, an IoT-based system for EVs and other distributed energy storage facilities. Through the JuiceNet platform, charging stations can be controlled remotely and their demand aggregated for grid-balancing purposes. It manages unidirectional and bidirectional electricity flows.19

Propositions for energy management and optimization

Virta is one of the largest independent EV charging companies, specializing in smart charging service. In Finland, for instance, Virta offers a smart home charging service for EVs that automatically sets the EV charging time to the cheapest hours of the night using spot market prices and sends a push notification to user to opt-out.20

Octopus Energy, a small UK-based energy retailer, has launched a new tariff under which a consumer can be paid to use its electricity when demand is low. The tariff tracks wholesale electricity prices, allowing consumers to take advantage of low rates at times of negative demand. When demand exceeds supply and the wholesale price rises, users will be charged the higher price. The company has capped the maximum amount consumers can be charged at 35 pence per kWh—about three times its standard electricity price. To sign up, consumers must have a smart meter and agree to variable pricing.21

Griddy, based in Texas, gives its customers access to real-time energy prices, letting them observe rate changes in five-minute intervals over convenient mobile channels. Griddy also reminds customers that consuming energy when prices are low not only saves them money but also assures use of pollution-reducing renewable energy.22
SECTION 4.

STRATEGIC MOVES TO EMBRACE THE FLEXIBILITY OPPORTUNITY

Service providers must carefully decide which business models are best suited to their situation, and build the necessary capabilities. Players in the ecosystem will need to consider their own strengths as well as the benefits of partnerships, recognize the physical limitations of infrastructure when delivering digital flexibility services and engage in an open and constructive dialogue with stakeholders to help define a supportive regulatory environment.
DEVELOP KEY CAPABILITIES TO SUCCESSFULLY UNLOCK DEMAND FLEXIBILITY

Successful propositions for demand flexibility require very different capabilities than needed for traditional energy supply business. We have identified six capabilities for consumer-centric, digitally enabled business models (see Figure 12):

Figure 12. Six capabilities for consumer-centric, digitally enabled business models.

- **Human-centered design** and a design-oriented culture to understand consumer journeys and overcome behavioral challenges to joining flexible electricity schemes.

- **Invest in advanced analytics** capabilities to gain a deep understanding of consumer usage patterns, determine the most effective ways to get consumers to modify energy usage, and accurately predict at what point consumers will react to price signals.

- **Build in-depth consumer insights** and knowledge of energy use and operating processes among C&I consumers. This gives the commercial salesforce the expertise and authority to source flexibility from business consumers.
• Differentiate through **smart orchestration**, managing a large portfolio of flexible assets and trading across markets. Today, energy providers typically work with a limited number of assets, which have a large capacity and are optimized for the long term. Demand flexibility involves optimization at hundreds of points daily, which requires sophisticated tools and trading approaches. IoT and AI are essential for the management, orchestration, and optimization of a large and diverse pool of consumers in demand-management programs.

• **Bolster digital trust** with strong data privacy and cybersecurity measures to protect business operations and give consumers confidence and peace of mind.

• Develop **seamless installation and maintenance services**, including set-up of communication and control capabilities at consumer premises. Contract with the most reliable manufacturers, logistics operators and installers.

**TAKE YOUR STRATEGIC POSITION IN THE ECOSYSTEM**

For both new and established players, it is important to choose an appropriate position in the emerging flexibility ecosystem. Companies will need to find partners to develop more attractive value propositions for energy consumers. This starts with understanding the company’s own strengths and competitive advantages to make the wisest build/buy/borrow choices.

European energy providers are uniquely positioned in the ecosystem, they have long-established relationships with consumers and have the ability to bundle flexibility with other services for energy management and smart home offerings. Many consumers find such service bundles attractive. When asked why they would consider purchasing energy, energy-efficient products, and/or related services from a provider other than their current energy provider, 41 percent of consumers cited the ability to “bundle products and services to receive a discount.” Energy providers also have unrivaled expertise in energy management and trading, as well as decades of experience working with regulators.

Service providers from different industries are already competing with energy providers in flexibility services and new players are entering the market. Each of these has its own unique strengths or complementary strengths to energy providers.

**Oil and gas providers**, for example, are starting to invest in the utilities industry. Total has agreed to purchase French gas and electricity supplier Direct Energie for approximately €1,4 billion to get into gas and electricity service in France and Belgium.
Automotive players are ramping up their investments in EVs and setting up partnerships for energy and other services for EV buyers and exploring the potential for using car batteries in the power system. Together with energy providers, they can connect EVs to energy markets through advanced energy management systems. For instance, BMW has teamed up with California-based energy provider PG&E on the ChargeForward Project, which is developing new technologies for EVs and batteries.

Chemical companies are developing strategies and making investments in energy storage to develop new energy technologies, leveraging their deep knowledge in chemical process techniques.

Digital giants such as Amazon are building smarthome services on their platforms. Amazon has invested in Ecobee, a smart thermostat maker, which can be controlled by voice with the Amazon Alexa “home assistant.” These platforms are open to providers of energy management services. For example, the EDF Energy Alexa Skill service connects to customers’ MyAccount, allowing them to ask Alexa to check account balances and payment dates, submit a meter reading, and determine when a tariff is due to end, making it easier for consumers to manage energy usage.

Appliance/equipment manufacturers are building intelligence and connectivity into a growing array of products. This enables remote energy monitoring and control. A boiler manufacturer in the Netherlands, for example, is partnering with REstore to offer residential demand-flexibility services, taking advantage of embedded intelligence.

Construction companies are important new entrants into the energy management space.

Startups and scaleups: There are hundreds of startups developing and testing new energy management propositions. Sympower, for example, is a demand-response aggregator from Estonia that provides demand-response solutions for the business and residential sector. Wapo, a Greek startup, has developed an AI-based chatbot that can communicate with building management systems, IoT sensors installed in the building, and automation controllers. Startups are attractive partners for rapid prototyping and testing of new flexibility propositions in the market. For instance, Eneco partnered up with Peeeks, a Dutch startup focused on finding, accessing and unlocking flexibility in energy portfolios of electric companies, to launch a smart boiler that uses surplus solar energy so consumers can shower using sustainable energy.
DEAL EFFECTIVELY WITH PHYSICAL CONSTRAINTS

While change in demand and supply creates opportunities for flexibility services, companies developing flexibility propositions must recognize constraints of operating physical infrastructure.

The digital services of demand aggregation and energy optimization sit on top of the physical infrastructure, which limits what can and cannot be done. Flexibility services direct flows in the physical power system, which can have positive effects, such as reducing demand at peak times. But adjustments in demand can also have negative effects, such as creating congestion. Indeed, bottlenecks both the transmission and distribution grid can restrict the use of flexibility. Also, load management actions can create an imbalance and result in penalties.

SEEK ENGAGEMENT WITH STAKEHOLDERS

Despite liberalization, regulators still oversee effective functioning of the energy system and market, and regulatory measures can advance or deter the profitable expansion of flexibility. Indeed, existing and new players in flexibility need to work with the full range of stakeholders—transmission system operators, distribution system operators, energy retailers, electricity generators, balance-responsible partners, independent aggregators, regulators, policymakers and consumer groups—to arrive at a regulatory framework that makes it possible for a flexibility solutions and services to thrive.

We have identified five principles on which to build the regulatory framework: equal treatment, market-based pricing, transparent information, accountable actors and standardized solutions.

EQUAL TREATMENT

The most fundamental principle for regulation should be non-discriminatory treatment of different options. Both regulation and market design should be technology-agnostic. Different sources should have equal and easy access to markets for flexibility services, and the physical system should be accessible to many actors to facilitate liquidity.
MARKET-BASED PRICING

Price signals for flexibility should accurately reflect the value of the flexibility to the system. This implies that prices vary more over time, either in set periods or dynamically throughout the day. Exposing retail consumers to wholesale prices can be a way to involve more participants in demand-side flexibility programs.

TRANSPARENT INFORMATION

Market actors need to have visibility around the amount of flexibility available at specific times, and its location, so that they can make effective decisions about the use of different flexibility sources. Information about availability, location and use of flexible sources needs to be shared with system and network operators to enable trading in the physical system, while respecting data privacy and safeguarding cybersecurity. Expanding digital infrastructure (smart grids, smart meters) is key to increasing visibility of demand-side flexibility resources. The needs and protocols for sharing information about the availability and use of flexibility between market actors and system and network operators need to be defined more thoroughly to enable effective coordination.

ACCOUNTABLE ACTORS

Market actors need to be accountable for completion of trades and the impact of their trades. To this end, balancing responsibility needs to be assigned clearly, so that either the provider of demand-side flexibility or another party acting on its behalf can be held accountable for deviations. Baselines to verify the extent of demand-response actions need to be defined accurately for consumers with demand-response contracts and should reflect the dynamics of demand over time, rather than using standard consumption profiles, which is common practice today.

STANDARDIZED SOLUTIONS

An efficient market benefits from technology standards for interoperability and harmonized market rules. To unlock demand-side flexibility capacity, it is especially important to create universal standards for smart energy management technologies. A harmonized set of market rules for trading flexibility across Europe would make it easier for providers of flexibility to monetize the value of their resources.
More flexibility is needed in the transition to a low-carbon power system. The good news: much of it already exists—among electricity producers, consumers and throughout the system.

**THE KEY IS TO BECOME BETTER AT UNLOCKING IT.**

Success hinges on a clear strategic vision for the critical role flexibility will play in the European power system, and the leadership required to bring it to execution. It presents tremendous opportunities for those companies that will capitalize on their strengths and take advantage of the ecosystem, forming new partnerships.
THE FUTURE BELONGS TO THOSE WHO WILL EMBRACE THE OPPORTUNITY WITH FOCUS AND AMBITION, AND PUT CONSUMERS AT THE HEART OF THEIR CHANGE JOURNEY.
REFERENCES

5. The analysis only assesses the need for flexibility for matching supply and demand in terms of capacity and generation. Flexibility may also be needed to provide ancillary services or to help resolve network congestion, but this is not included in the analysis.
6. In this report, we consider a facility that operates 1000 or fewer hours per year to be peaker capacity; mid-load (also known as mid-merit) is 1000 to 7000 hours, and above that are base-load facilities.
15. Ibid.
30 Ibid.
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