IEEE
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for electric power professionals

# Empowering Customers

## Regulatory Challenges in Energy Markets

## *Remembering*
Hyde Merrill

## *2023 Elections*
Meet the Candidates!

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# IEEE POWER & ENERGY SOCIETY (PES)

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Innocent Kamwa

# consumer empowerment: much talk, little progress

## *new findings in market design and experiments*

OVER THE LAST FEW YEARS, I have usually started any keynote I have been invited to give with a pitch about the 4D transformation of the electric energy industry toward "decarbonization, digitalization, decentralization, and democratization." While most agree on the first three Ds, some energy specialists simply ignore the last D, while others give it another meaning like "diversification." Deloitte Canada states that diversity and redundancy in energy supply chains aim at ensuring reliability and resilience of the electrical system. In my case, and I share this viewpoint with many, the last D means "democratized," defined as follows: "Consumers are increasingly empowered to challenge the status quo." So, the power will be turned to the consumers? Really? Based on the findings in this issue, empowering the consumers by opening the retail market to competition has generally resulted in mixed results if not failures.

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The residential consumer does not understand enough about the market-based price mechanisms to benefit from the competition when multiple choices exist. The government is also keen to play the role of a grandpa, not refraining from disrupting the market by forcing postage stamp rates across the board or capping any price spiraling out of control. In my service territory, the law was to let the price follow

### In This Issue

The electricity market, which has long been lopsided, has hit a bottleneck in responding to new goals such as decarbonization. It is a consensus that unlocking end-user flexibility is the key to changing this situation, which means end users must have sufficient rights to participate in the electricity market.

Opportunities often come with challenges. Devolved power inevitably needs to be accompanied by sound mechanisms for regulation. Therefore, this issue with seven articles focuses on regulatory regimes, market tools, and solutions to promote consumer empowerment based on the practical experiences of various countries.

In the "In My View" column [A1], Jaume Loffredo describes the European Union's experience and lessons learned in consumer empowerment and discusses the critical steps needed to ensure consumers actively participate in the electricity market.

The first article, by Stephen Thomas [A2], presents valuable lessons from the United Kingdom to discuss the obstacles faced by fully competitive electricity market reforms in the United Kingdom, especially involving competition. It provides a reference for countries in the process of retail liberalization.

The second article, by Cunha et al. [A3], provides a broader discussion of the Brazilian circumstances, constraints, and successes in achieving retail market liberalization that can apply to many middle-income countries facing similar challenges.

The third article, by Nicolò Rossetto [A4], focuses on the energy communities explicitly mentioned for the first time in the new European legal framework. The author summarizes why European policymakers decided to promote the emergence of an energy community, analyzes the similarities and differences between citizen energy communities and renewable energy communities, and illustrates the emerged critical issues and the opportunities that Europe's current energy crisis may represent.

The fourth article, by Ellen Beckstedde and Leonardo Meeus [A5], points out the congestion problems that result from new grid users, such as electric vehicles or renewable energy, connected to the distribution network. With


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See the difference at sandc.com/reliability20 a focus on Europe, the authors explore the demand, organization, and openness issues of distribution network congestion management.

Unlocking the full potential of bottom-up flexibility for electricity consumers can help move toward a low-carbon energy system. The fifth article, by Avramidis et al. [A6], discusses the challenges and potential solutions for consumers to actively contribute to a low-carbon energy system, focusing on the chain of improving sustainability: pure consumers, passive prosumers, smart and sustainable buildings, local energy communities, and finally, smart sustainable distribution grids underpinning a clean energy transition.

Integrating demand resources adds complexity to the design of capacity mechanisms. The sixth article, by Rodilla et al. [A7], defines a comprehensive framework for the participation of demand resources in capacity mechanisms, identifies all potential participation modes, highlights the inefficiencies that could arise from certain designs, and makes regulatory recommendations.

The lack/insufficient availability of long-term hedging in the power market has led to the current affordability issues in Europe. The last article, by Tim Schittekatte and Carlos Batlle [A8], explains how to proactively mitigate affordability concerns by complementing the long-term market. The authors recommend adding affordability options to the long-term market and explain how to procure these options within the current regulatory framework.

*—Yanli Liu*

the inflation, which was an incentive to install self-generation as a shield from future electricity price increases. Suddenly, the government changed the law to cap the increase to 3% after the inflation exceeded 6.5% last year. This situation is not unique. As shown by an article in this issue, from 2021 to 2023, European governments earmarked and allocated up to 8% of their gross domestic product to shield households and industry from high energy prices.

Again, the power is not in the hands of the customer but in those of the government. To hedge against this sudden energy pricing turmoil, without disrupting the spot price signals, the authors of an article in this issue propose a new financial instrument, called "affordability options," as a complement to long-term markets.

Regarding self-production, we have learned promising stories from Australia, Germany, or California in the United States. The high cost of electricity in certain areas of those countries, combined with government financial incentives for decarbonizing electricity, has made the rooftop solar photovoltaic a no-brainer choice for customers seeking affordable green electricity. This situation has brought the penetration rate of intermittent renewable resources to +50% at times, with the side effect of negative wholesale electricity prices or green energy curtailment becoming a major issue. With a holistic viewpoint, Enedis, the French distribution system operator (DSO), published a few weeks ago a new five-year network development plan. It focuses on "electric sobriety, clean mobility, acceleration of renewable energies, and self-consumption." This DSO reported a minimum reliability score of 99.9% (i.e., a time period with no service interruption), while the average reliability stands at 99.99%. Empowering the consumer should not come at the price of reducing the remarkable level of reliability and resulting comfort to which we are accustomed. A paper in this issue has termed this tradeoff "fit-and-forget" versus "flex-and-regret."

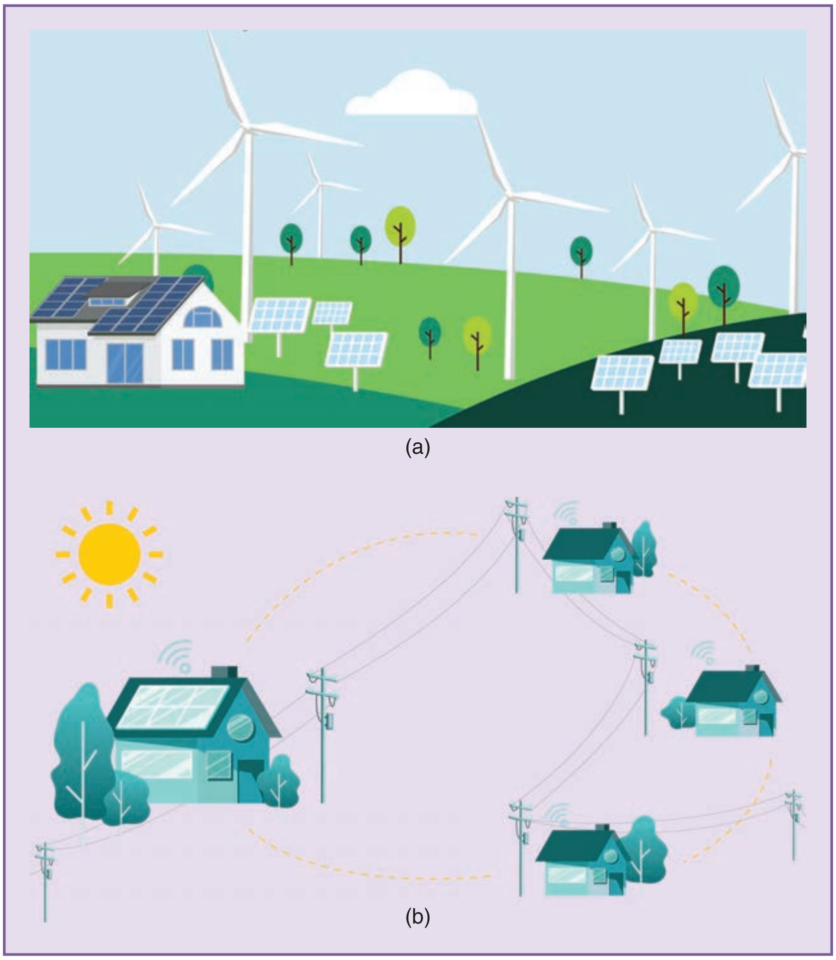

**figure 1.** Energy communities: (a) distributed energy resources in a green district and (b) a solar social club. (Source: http://www.sunleavs.com; used with permission.)

In this same context, there is an interesting experiment going on in the sunny Mediterranean in the south of France, with the romantic name of "Solar Social Club" (http://www.sunleavs.com): you can produce your solar energy, share it with the members of your Solar Social Club, and consume your own energy. This concept is essentially a use case for the energy community described in one of the articles of this issue. Thanks to a sensor associated with a Solar Social Club, a real social network between inhabitants of the same district, spanning not more than 2 km and sitting on the low-voltage side of the grid, allows the consumers to better manage energy consumption and create links with neighbors. Connected between the meter and the electrical panel of the home, the individual sensor allows for real-time monitoring of the consumption and energy distribution in different appliances. The data collected allow the dynamic distribution of the self-generated local electricity, between each member of the Solar Social Club, while still being connected with the main grid for energy security and power balancing.

Another advantage is virtual storage; for example, during vacation, the solar energy produced is stored virtually (consumed by the neighbor, in fact) and is returned to the homeowner when needed. A kind of transactive energy optimized at the district level, which may include building automation and energy management systems, leads into a broader discussion underscored in one of the papers in this issue: not only "*what the building can do for the network*" in terms of grid services, for example, but also "*what the building can do for the people in the district*" by giving back the economic efficiencies, achieving the feeder-level resiliency of their energy provision under harsh climates hazards, and more importantly, rewarding the community's efforts toward a green society.

This long overdue issue on markets and regulatory designs and experiments to put more power in the hands of the consumer addresses all facets of the problem, considering the return of experience from a representative subset of jurisdictions around the world. In Europe, the recent focus on energy communities (Figure 1) is highlighted by two papers that address their barriers and enablers from both the smart building integration and regulatory viewpoints with the recourse of research and field experience. The integration of flexibility in the planning tools of DSOs to achieve the same reliability level while enhancing resiliency in the face of more frequent climate hazards is discussed in another paper and in the "In My View" column. The after-the-fact analysis of the retail market liberalization in Great Britain, the bellwether of this trend, will convince several public energy commissions worldwide to stick with their postal stamp tariffication approach and leave their citizens outside

**figure 2.** The IEEE PES Technical Council Resources Center: https://ieee-pes.org/technical-activities/technical-council/.

market-based dynamic pricing. It is time for further studies.

The case of Brazil is also interesting as a social laboratory where energy poverty, large centralized generation from cheap hydro, and a new appetite for distributed energies are mashed up to create a difficult market design environment. When you try to empower some consumers, usually the richer, you risk doing that by putting the cost on another, sometimes the vulnerable, reinforcing social inequalities and energy justice problems. This situation is no longer an engineering problem, of course.

## Leader's Corner

Vice President of IEEE Power & Energy Society (PES) Technical Activities Dr. Hong Chen also serves as the chair of the PES Technical Council and oversees PES technical activities. Dr. Chen took to the pencil to remind us of the central mission of the council in PES, along with some statistics that make us all proud of our achievements, in terms of reports and standards publications, that advance the science and technology in our field. Who remembers that PES is organized into 17 technical committees and four coordinating committees? Who knows the number of publications or the number of downloads from the PES resource center last year (Figure 2), broken down by technical committee? This month's "Leader's Corner" column [A9] by Dr. Chen provides some facts and insights about PES technical activities' performance to satisfy the curiosity of the common IEEE members. Dr. Chen further reported on certain major initiatives currently under implementation, such as the creation of a new standing committee, the Localized Technical Activities Committee, under the vice president of technical activities. Working closely with local Chapters, its goal is to encourage more global participation by mitigating language and geographic barriers, which some PES members have faced when getting involved in formal technical committee activities.

## News From the Magazine Desktop

We are currently completing the planning of the 2024–2025 calendar of special issues. Three special issues were approved at the spring editorial board meeting, which was held online on 23 March 2023. When the next year's list is finalized, the calendar will be posted on the magazine website (*IEEE Power & Energy Magazine*; https://ieee-pes.org/). In case you are interested to know more about how this magazine is run, you are cordially invited as a guest at the next editorial board meeting to be held in Orlando, FL, USA, during the PES General Meeting scheduled for 16–20 July 2023 (https://pes-gm.org/).

## "History" Column

In this issue's "History" column [A10], we welcome back Joseph Cunningham as he shares with us the insight into a view of New York City at the early stages of commercialization of electric lighting and power systems in an article titled "City of innovation: NY City at the birth of electrical systems." In this treatment, Cunningham covers technologies, installations, the business, and the people of New York City in these pioneering early days.

## In Memoriam

We are sad to report the passing of Dr. Merill Hyde, a past contributor to this magazine and a leader of our Power Industry Computer Applications Conference for many years. His obituary is included in this issue. At the request of many readers, we would like this column to continue, and therefore, we invite the submissions of obituaries through the assistant editor desk (sherryvhensley@gmail.com). We suggest that authors of such an obituary must consider only widely known people in our community for their technical or leadership achievements or who were benefactors of PES.

## Wrap-Up

I want to thank the editors and this team of authors for their tireless work in making this issue happen. Dr. Luis Barroso deserves a special mention because of his overnight responsiveness during the critical and often stressful stages of the review cycle, which we started in early December 2022. The magazine often focuses on the engineering aspects of our discipline. It is thus more than good news to see this issue shedding more lights on "citizens'" interactions with the grid through market mechanisms mediation. My only regret is that energy poverty and justice, which are highly correlated with market mechanisms and the regulatory environment, were not addressed. The viewpoints of underdeveloped countries and indigenous populations who are often located in off-grid zones were not discussed. We had a special issue last year (2022 September/October) on smart villages, which is worth rereading in this respect. However, our future goal is to put out a dedicated issue on energy poverty and energy equity, which fits nicely with the last of the four Ds, i.e., a more democratized and inclusive access to electricity, not only by empowering the rich consumer but also by providing energy access and energy security to the underprivileged.

In addition to energy poverty, I am always looking for new topics for special issues that can be timely and of interest to a broad audience, including policymakers. I also welcome new ideas for spontaneous articles, which have nothing to do with any special issue, to give anyone who is interested in this magazine an equal opportunity to have his/her views published. Feel free please to forward any concerns or questions to me: innocent.kamwa@gel.ulaval.ca.

## For Further Reading

"Bright ideas 2022: The future of Canada's power and utilities sector." Deloitte. Accessed: Apr. 29, 2023. [Online]. Available: https://www2.deloitte.com/ca/en/pages/energy-and-resources/articles/the-future-of-canadas-power-and-utilities-sector.html

"Plan de développement de reseau." Enedis. Accessed: Apr. 29, 2023. [Online]. Available: https://www.enedis.fr/sites/default/files/documents/pdf/plan-de-developpement-de-reseau-document-preliminaire-2023.pdf

## Appendix: Related Articles

[A1] J. Loffredo, "Consumer empowerment lessons from the European Union," *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 98–100, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269548.

[A2] S. Thomas, "Allowing British electricity consumers to choose their supplier: Was it worth it?" *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 18–25, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269543.

[A3] G. Cunha, P. Valenzuela, G. Siciliano, A. M. Gomes, M. Cavaliere, and L. Barroso, "Achieving retail liberalization in middle-income countries: Challenges and successes of the Brazilian experience," *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 26–35, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269550.

[A4] N. Rossetto, "Beyond individual active customers: Citizen and renewable energy communities in the European Union," *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 36–44, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269541.

[A5] E. Beckstedde and L. Meeus, "From 'fit and forget' to 'flex or regret' in distribution grids: Dealing with congestion in European distribution grids," *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 45–52, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269545.

[A6] I.-I. Avramidis, F. Capitanescu, G. Deconinck, H. Nagpal, P. Heiselberg, and A. Madureira, "From the humble building to the smart sustainable grid: Empowering consumers, nurturing bottom-up electricity markets, and building collaborative power systems," *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 53–63, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269538.

[A7] P. Rodilla, P. Mastropietro, and P. Brito-Pereira, "The challenge of integrating demand response: Providing a comprehensive theoretical framework," *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 64–71, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269551.

[A8] T. Schittekatte and C. Batlle, "Assuring a sustainable decarbonization: Affordability options," *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 72–79, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269540.

[A9] H. Chen, "Achieving the PES mission through technical activities," *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 12–15, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269539.

[A10] J. J. Cunningham, "City of innovation New York City at the birth of electrical systems," *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 81–88, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269552.

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Hong Chen

# achieving the PES mission

## *through technical activities*

THE POWER AND ENERGY INDUSTRY is at its most exciting time, undergoing many transformational changes: transition to clean and sustainable energy, high penetration of inverter-based resources, energy storage, electrification, and grid edge technologies, just to name a few. Our industry is having more innovation than in any generation since Edison, and playing a key role in combating climate change, facilitating decarbonization, decentralization, and digitization. The IEEE Power & Energy Society (PES), as the world's largest forum for sharing the latest in technology developments in our industry, is well situated to lead the charge towards net-zero 2050

As the vice president of IEEE PES Technical Activities, I serve as the chair of the PES Technical Council and oversee PES technical activities: lead technical committees for the evaluation and dissemination of technical information in its field of interests and coordinate with other societies and professional organizations.

The PES Technical Council coordinates the activities of 17 technical committees and four coordinating committees. The masthead of this magazine has the names of the current committee chairs. The committee details are available at each technical committee's website and from the PES technical activities website (https://ieee-pes.org/technical-activities/). The committees and their subcommittees lead the creation and maintain the standardization of technical documents related to the committee's scopes of activities, including technical reports, white papers, and notably IEEE standards.

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Close to 50% of IEEE standards were developed by the PES technical committees. In 2022, PES created 47 new standards and revised 36 existing standards. This year up to March 2023, PES created six new standards and revised six existing standards.

The technical reports, white papers, and webinars produced by PES committees are archived in the PES Resource Center. Table 1 shows the technical committees with the most products and Table 2 lists the technical committees with the most product downloads.

All PES members receive monthly *PES Trending Technology* and *PES eBulletin* emails. *PES Trending Technology* emails highlight influential industry subjects, related papers, articles, presentations, webinars, tutorials, and which committee(s) cover the subjects. The "Technical Activities" section of the *PES eBulletin* also has technical committee-related information, such as upcoming technical committee meetings and newly published technical reports.

### PES General Meeting

One of the responsibilities of the Technical Council is the design and planning of the technical program of the annual IEEE PES General Meeting (GM), including the planning of the super sessions, panel sessions, technical paper sessions, and poster sessions. The conference paper review is coordinated by the technical committees and the panel sessions are also planned by the technical committees. For 2023 PES GM, the following four supersession topics were selected:

- ✔ transmission advancement for decarbonization
- ✔ communications and cybersecurity
- ✔ novel approaches and emerging technologies to support system operation
- ✔ integration of distributed energy resources, electric vehicles, and behind-the-meter resources.

**table 1. Technical committees with the most products.**

| Rank | Committee | Number of Products |
|---|---|---|
| 1 | Power System Operations, Planning & Economics (PSOPE) | 100 |
| 2 | Energy Development & Power Generation (EDPG) | 73 |
| 3 | Transmission and Distribution (T&D) | 60 |
| 4 | Analytic Methods for Power Systems (AMPS) | 60 |
| 5 | Power Systems Dynamic Performance (PSDP) | 51 |

**table 2. Technical committees with the most product downloads.**

| Rank | Committee | Number of Downloads |
|---|---|---|
| 1 | Industry Technical Support Leadership Committee (ITSLC) | 10,936 |
| 2 | Power Systems Dynamic Performance (PSDP) | 6,823 |
| 3 | Power System Relaying and Control (PSRC) | 5,130 |
| 4 | Transmission & Distribution (T&D) | 3,452 |
| 5 | Power System Operations, Planning & Economics (PSOPE) | 2,890 |

Based on these supersession topics, the theme for the 2023 PES GM is “Meeting the Energy Needs of a Dynamic World.” Our technical committees also planned more than 140 panel sessions. I look forward to seeing everyone at this year’s GM, in the center of the Sunshine State in Orlando, Florida, USA.

## Goals for Technical Activities

In later 2022, we set the following three goals, aligning with PES’s Strategic Direction for 2022–2025.

- ✔ *Improve industry engagement*: Develop stronger engagement with the industry and increase industry participation by increasing industry-focused panels, increasing utility members to attend technical committee meetings, and increasing practical-oriented conference papers.
- ✔ *Increase global participation*: Improve and strengthen our global presence, diversity, and participation in technical committees by encouraging virtual technical committee meetings to enable global participation.
- ✔ *Engage young professionals*: Recruit young professionals into technical committee work, and encourage young professionals to attend technical committee meetings.

## Localized Technical Activities

IEEE PES is a global organization, and technical activities are for all PES

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members around the world. Due to language and geographic barriers, some PES members have difficulty getting involved in technical committee activities. As a result, satellite technical committees were created under Chapters Councils. Recently, these satellite technical committees have been moved from Chapters Councils to a newly created standing committee, the Localized Technical Activities Committee, under the vice president of technical activities. This change brings important localized technical activities under the vice president of technical activities, to improve governance and interaction with technical committees, increase transparency and visibility, as well as provide additional support to local volunteers. *The Satellite Technical Committees Organization and Procedures Manual* was created and approved early this year to formalize the process. This effort supports the goal of "increase global participation."

## Getting Involved in Technical Activities

All IEEE PES members can get involved in technical committee activities through different avenues, such as:

- ✔ Attend technical committee, subcommittee, working group, and task force meetings. The PES technical activities website and *PES eBulletin* have the upcoming committee meeting information.
- ✔ Volunteer to review conference papers, and chair paper or panel sessions at PES conferences and GMs for technical committees by contacting the technical committee program chair.
- ✔ Participate in writing standards or technical reports through technical committees.

I want to take this opportunity to encourage you all to get involved in PES technical activities: learn, serve, and contribute, help PES further our mission of "being the leading provider of scientific and engineering information on electric power and energy for the betterment of society." Together, we foster innovation and produce solutions for reliable electricity! Together, we work to create clean, affordable, and sustainable energy solutions worldwide! p&e

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Luiz Barroso and Carlos Batlle

# empowering consumers

## challenges and opportunities

SINCE THEIR INTRODUCTION decades ago, electricity markets have been largely one-sided. In most cases, end users have not even played the role of passive observers of market price fluctuations, they have directly ignored them.

There are many reasons why this has been the case. First, it is not easy to change consumer attitudes when electricity prices have been the direct responsibility of governments in one way or another for more than a century. Even today, the European Union (EU) energy crisis of 2022 is its best example: when electricity bills skyrocket, consumers look to their governments rather than regret not having secured their future price with contracts. But at the same time, governments and regulators have been reluctant to expose end users to short- and long-term market signals: the costs of demand-side imbalances are generally socialized, and governments quickly and abruptly intervene in the markets as soon as prices reach high levels.

However, there is a consensus that an efficient decarbonization process requires the active participation of end users. Providing them with the regulatory tools, technology, and information needed to make smart and informed choices about when and how to consume electricity, is then a big challenge. These regulatory tools should also enable end users to become service providers for the system, for example, by unlocking their flexibility potential and thus facilitating the deployment of renewable energy sources and making it easier to achieve decarbonization targets.

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This idea of giving individuals or households more control over their energy consumption, costs, and choices has been labeled *energy consumer empowerment*. As said, it does not come without its regulatory challenges, and they are the focus of this special issue of *IEEE Power & Energy Magazine*. Our aim in this issue is to discuss regulatory and market tools and solutions to optimize end users' engagement in the decarbonization of power systems, based on practical experience. This issue features a carefully selected international group of authors with broad experience from both academia and industry, focusing on the regulatory and market challenges that lie ahead. We asked them to focus on the challenges that the goal of consumer empowerment poses for regulation and the barriers that need to be overcome. We asked them to be provocative in their writing, to stimulate a pragmatic debate about what has been learned and what is missing.

We start searching for lessons from full retail liberalization. Not many experiences exist in which the process went all the way. The United Kingdom case is undoubtedly a key reference. So, we invited Thomas [A1] to develop his assessment of the benefits of removing regulated end-user tariffs, pushing British electricity consumers to choose their suppliers. He took up the challenge and delivered an article with good food for thought, particularly for countries considering a retail liberalization process.

It is in this context that the analysis developed in our second article is set. The team led by Cunha [A2] discusses the challenges of achieving retail liberalization in middle-income countries, using Brazil as an example. Middle-income countries often have a high proportion of socially and economically vulnerable consumers, relatively young institutions, and immature markets for hedging risk and/or raising finance. In addition, "legacy costs" from 20th century reforms can pose further challenges. The article highlights the challenges the country is facing on its road to full retail liberalization.

We then deep dive into business models for consumer engagement, examining engagement as a collective action, where a plurality of consumers chooses to act together. This is the concept of energy communities in Europe, the counterparts of community choice aggregation in the United States. Rossetto [A3] discusses how energy communities work and illustrates some of the critical issues that have emerged, as well as the opportunity that the new energy reality in Europe may represent.

We then focus on the new role of end users as system service providers. Beckstedde and Meeus [A4] discuss the potential of demand-side flexibility and how to unlock it, addressing the interactions between decentralized energy resources and distribution system operators (DSO) in the European context. DSOs face challenges connecting these new grid users to their networks, leading to an increased need for grid investments and new and complex coordination processes. These challenges entail potential cost increases but also opportunities for DSOs to manage their networks more efficiently. The authors did an outstanding job describing the need, organization structures, and open issues in congestion management in distribution grids.

Based on concepts of nearly zero energy building and smart building, Avramidis et al. [A5] analyze a smart sustainable building archetype. The authors, benefitting from the results of a multicountry and multiyear international research project, show the potential for smart sustainable building applications and the role market products and regulation have on it.

We complete the review by tackling the long-term dimension. Empowering customers necessarily requires exposing them not only to short-term but also to long-term price signals. The essential nature of the electricity service implies that this process cannot be realistically undertaken without designing the necessary safeguards against extreme price scenarios. With this in mind, we requested Rodilla et al. [A6] to draw regulatory recommendations for the participation of demand resources in capacity mechanisms. They identified all potential participation modes, highlighted the inefficiencies that could arise from certain designs, and provided guidelines for regulators who are currently addressing this type of mechanism.

We could not complete a discussion about consumer empowerment without tackling the severe energy crisis Europe has faced since the summer of 2021. Governments intervened in markets and spent billions of euros to shield consumers and industry from high electricity prices. Schittekatte and Batlle [A7] reflect on the European energy crisis and the overall market design, and on how consumers should hereafter be protected in a market-based way. They elaborate upon a proactive regulatory-driven solution, named *affordability options*, to protect (certain tranches of) end users from periods of sustained high electricity prices.

Wrapping up this issue, we invited Loffredo [A8], who represents the European Consumer Organization, to walk the talk: that is, to reflect on whether the current legislation in Europe adequately empowers consumers to become active participants or not. In the "In My View" column, he brings a perspective on the status of consumer participation in EU power markets, its hurdles, and how they can be overcome.

We would like to thank the authors for the time, dedication, and articles provided, which shed light on the key topics related to this discussion, which is very relevant. We thank *IEEE Power & Energy Magazine* for the opportunity to reflect on and analyze such challenging and relevant matters, which have taken us out of our comfort zones and made us reflect on them as well. We thank the editor-in-chief, Innocent Kawma, for continuing to provide the conditions for *IEEE Power & Energy Magazine* to remain an IEEE flagship publication. A special thank you goes to the past editor-in-chief, Steve Widergren, who supported our proposal and gave us all the conditions to improve it through fruitful discussions with the magazine board members. And, last but not least, thanks go to all reviewers and the IEEE editorial staff, for their usual brilliant work.

With these articles, we aim to give a contribution to the important debate of how to foster the active participation of end users in power markets. We hope the reader enjoys the reading as we enjoyed planning and organizing this issue.

## Appendix: Related Articles

[A1] S. Thomas, "Allowing British electricity consumers to choose their supplier: Was it worth it?" *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 18–25, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269543.

[A2] G. Cunha, P. Valenzuela, G. Siciliano, A. M. Gomes, M. Cavaliere, and L. Barroso, "Achieving retail liberalization in middle-income countries: Challenges and successes of the Brazilian experience," *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 26–35, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269550.

[A3] N. Rossetto, "Beyond individual active customers: Citizen and renewable energy communities in the European Union," *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 36–44, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269541.

[A4] E. Beckstedde and L. Meeus, "From 'fit and forget' to 'flex or regret' in distribution grids: Dealing with congestion in European distribution grids," *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 45–52, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269545.

[A5] I.-I. Avramidis, F. Capitanescu, G. Deconinck, H. Nagpal, P. Heiselberg, and A. Madureira, "From the humble building to the smart sustainable grid: Empowering consumers, nurturing bottom-up electricity markets, and building collaborative power systems," *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 53–63, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269538.

[A6] P. Rodilla, P. Mastropietro, and P. Brito-Pereira, "The challenge of integrating demand response: Providing a comprehensive theoretical framework," *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 64–71, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269551.

[A7] T. Schittekatte and C. Batlle, "Assuring a sustainable decarbonization: Affordability options," *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 72–79, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269540.

[A8] J. Loffredo, "Consumer empowerment lessons from the European Union," *IEEE Power Energy Mag.*, vol. 21, no. 4, pp. 98–100, Jul./Aug. 2023, doi: 10.1109/MPE.2023.3269548.

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# Allowing British Electricity Consumers to Choose Their Supplier

## Was it Worth It?

**By Steve Thomas**


IN 1990, BRITAIN WAS A PIONEER OF THE PACKAGE of measures for the electricity industry, variously described as *privatization*, *liberalization*, and *marketization*: in short, *the British model*. Britain has often been seen as the example other countries should follow. The vision of the proponents of this package of measures was that, in a competitive system, electricity could be bought and sold efficiently in the same way as other products, with no need for sector-specific regulations. However, 30 years later,

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this vision seems no nearer to being achieved. The current dominance in this sector of climate change considerations over economic efficiency means the market cannot be left alone to function. So, this vision will not be achieved in the short- to medium-term.

## Introduction

To understand why the vision of a fully competitive electricity market has not been achieved in Britain, we look at the elements of the reforms, especially those that involve competition. We then look at developments since 2021 when high gas prices put a spotlight on the way the sector operated and exposed failings.

By 2002, the British electricity sector appeared to have met the requirements of the ideal model:

- ✔ A wholesale market had existed since 1990.
- ✔ Consumer choice was extended to all by consumers by 1999.
- ✔ A generation duopoly had been broken up and there were six major competing generators.
- ✔ There were six large competing energy retailers.
- ✔ Networks had been unbundled from ownership of competitive activities in the sector.
- ✔ A regulatory body, the Office of Gas & Electricity Markets (Ofgem), had been set up.

By February 2010, the government and the regulator agreed the existing system was not working and was not going to work. The Energy Minister said: "We are going to need a more interventionist energy policy," while the Chief Executive of Ofgem said: "There is an increasing consensus that leaving the present system of market arrangements and other incentives unchanged is not an option." As a result, a three-year government review, the *Electricity Market Reform*, was undertaken, leading to a package of measures intended to address the issues.

This article focuses on the period from 2013 onward when the electricity market reforms were implemented. There is particular emphasis on the period since 2021, when rising gas prices caused major problems of welfare and survival of businesses and brought the industry structure and mechanisms into the spotlight. The British government has brought in a range of short-term subsidies and payments to try to ensure that consumers are able to afford enough energy to ensure their welfare. These measures are temporary; they do not have a long-term impact on the market and are not discussed in this article.

The United Kingdom electricity system is undergoing a period of significant change as it transitions from a fossil fuel-dominated generation mix to intermittent renewable generation. Over the past few years, we have seen a marked increase in output from wind and solar farms and reduction in coal generation, as shown in Figure 1. In the first quarter (Q1) of 2022, 43% of the electricity supply within the United Kingdom was produced by renewables.

## The Competitive Wholesale Electricity Market

The promise that a competitive market would produce lower prices than a regulated monopoly was the rationale for the liberalization package: without a competitive market there would be little for a field of retailers to compete over; without competition, there would be no reason to unbundle the networks; and there is a need for regulation regardless of whether there is competition.

The wholesale market, or *power exchange*, has a spot market and a range of instruments, such as futures and derivatives. Prices in the spot market are set every 30 min with the price being set for all successful bidders by the highest price paid needed to meet demand. If generators have a hedging contract and need to generate to fulfill it, they need not bid; they merely need to inform the system operator of their intention to generate in the given 30-min period.

By 2010, the sector was dominated by six integrated generator–retailers, widely known as the *Big Six*. Most of the power they generated was transferred internally to their retail divisions with a small amount sold under long-term contracts on terms known only to the two parties. This left negligible quantities available for the power exchanges.

This integration meant that the Big Six could make easy profits by keeping prices high with no need for more than tacit collusion. The lack of a liquid spot market meant they were secure from entry by new generators and retailers who might challenge this cozy existence. As a result, by 2013, the Big Six had a lower level of public trust even than the British banks. However, the lack of new entrant retailers gave consumers no avenue to action their dissatisfaction, and the market share of the Big Six with small consumers was still 97% in 2014.

Two developments changed this situation. New capacity was overwhelmingly renewables, paid at fixed prices outside the market. Renewable capacity is built based on the outcome of capacity auctions run by the government. Winning bids are given contracts of 15 years or more to buy all their power at fixed real prices. There was no strategic advantage to the Big Six in owning a plant built based on capacity auctions because all its output had to be sold to a government entity, so it could not be used to meet its own consumers' demands.

The "Secure & Promote" market liquidity program was introduced in 2014. This program required the Big Six to post bids and offer prices in the power exchanges for a range of contracts up to two years ahead, for two one-hour trading windows each day. This policy immediately made the power exchanges liquid and opened the way for many new retail companies to buy at apparently reliable prices and offer power to small consumers at prices that undercut the Big

> In a competitive system, electricity could be bought and sold efficiently in the same way as other products, with no need for sector-specific regulations.

Six. These liquidity measures seemed to be successful, and by the time the gas crisis began to be felt, new suppliers had a market share of about 25%.

Capacity auctions and liquidity measures meant the advantages of integration of generation and retail disappeared and, by 2019, five of the Big Six had split into separate generation and retail companies. The Big Six integrated companies became the Big Five retailers, with two retailers merging their businesses. The liquidity measures were abandoned because the market power of integrated companies, which was the justification for applying liquidity measures, no longer existed.

A third measure was the introduction of capacity payments. These payments were intended to ensure there was sufficient generation to meet peak demand. The assumption under the power exchanges was that just enough capacity to meet peak demand reliably would be profitable enough to justify the owners keeping it in service. This assumption was not credible. Peak demand is weather-dependent, and peaking capacity needed in a cold winter would not be needed in most years, would earn no income, and its owners would close it. While the focus was on peak plants, capacity payments are payable to enough dispatchable plants: that is, plants that are available to generate regardless of weather conditions, to meet expected peak demand. They were expected to be enough to justify keeping a peaking plant online even if it was not used at all. Capacity payments are not available to capacity covered by take-or-pay contracts with the government.

While these three measures had a clear rationale, they overrode market mechanisms and compromised the efficiency of the market. Market signals should determine entry and exit to the market, and companies should participate in the spot market because it is to their advantage, not because they are forced to.

## The Competitive Retail Market

From 2002 onward, the level of switching among small consumers was higher than in most European Union countries, albeit only a few percent per year, but most British consumers still did not switch. As a result, by 2014 about 97% of the retail market for small consumers remained in the hands of the Big Six.

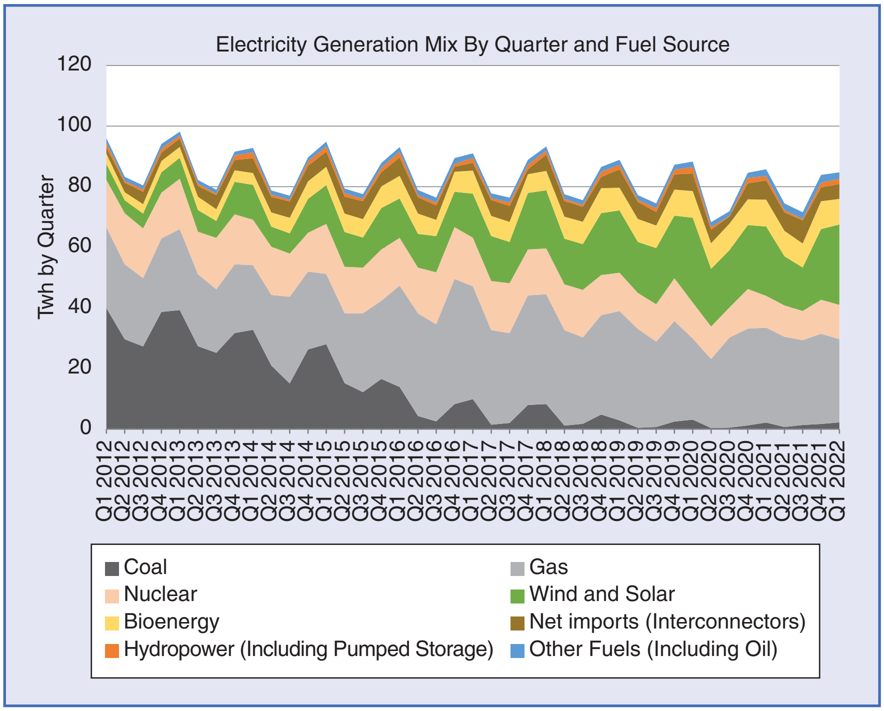


**figure 1.** Electricity generation mix. (Source: Department for Business, Energy, and Industrial Strategy, Energy Trends, and Ofgem.)

The liquidity measures led to new entrant retailers increasing their market share to 14% in 2016, resulting in the Big Six deintegrating. Despite this and despite their unpopularity, the brand name of these companies compared to that of the new retailers gave them significant market power, with many consumers reluctant to shift away from an established name to a company with unknown credentials.

The business model of the new retailers was to buy options on the power exchange typically for a year forward, and then undercut the Big Five in the residential consumer market. Their selling point was their price, and they relied on price comparison websites to flag them as cheap. The risk with this strategy was that when they came to renew power purchase contracts, if the wholesale price was too high to be recovered from their consumers, they would collapse.

> Market signals should determine entry and exit to the market, and companies should participate in the spot market because it is to their advantage, not because they are forced to.

Hedging strategies were a luxury they could not afford. Together, internal and external switching rates provide a more comprehensive indicator of how engaged consumers are in the domestic retail energy market. Figure 2 shows that internal switching rates among the six largest suppliers have been consistently higher than external switching rates.

By 2017, public dissatisfaction remained because, while new entrants had taken a significant share of the market, the majority remained with the Big Six, at best on a fixed duration contract (more expensive than those offered by new entrants) and at worst on the default standard variable tariff, invariably the highest tariff available. In addition, more than 15% of consumers used prepayment meters also at high prices. The high prices paid by the standard variable tariff and prepayment meter consumers meant the companies were seen as exploiting the loyalty and inertia of the standard variable tariff consumers and exploiting the difficulty for prepayment meter consumers of switching to a better deal.

As a result, a temporary price cap set by the regulator for prepayment meter consumers was introduced in 2017 and for standard variable tariff consumers in 2019. The cap was initially to apply until 2020 when it was assumed that "smart meters" would have been installed with nearly all consumers. Smart meters were expected to make switching much simpler and would obviate the need for the price cap because consumers would switch away from expensive suppliers. The target completion date for smart meter installation has continually slipped and was pushed back to mid-2025 in August 2021, and the cap has been renewed annually.

The widespread use of prepayment meters is a particular feature of the British reforms. In 2016, about 16% of consumers used them. Their use dates to 1993, when policy became that consumers struggling to pay their energy bills had little choice but to switch to prepayment meters. In some cases, retail suppliers break into consumers' premises to replace the standard meter with a prepayment meter. From a very low base, the number of consumers on prepayment meters increased to about 15% in only a year. From an industry point of view, prepayment meters were an ideal solution to the issue of consumer debt. With a prepayment meter, consumers that could not afford to buy energy cut themselves off, so there was no possibility of further debt. Companies were allowed to recover debt as a per kilowatt hour surcharge on new consumption by the consumer, and meter reading and billing costs were reduced. Like other retail tariffs, prepayment meter tariffs are unregulated. Prepayment meter consumers could switch but in practice it was not easy, and it was difficult to find cheaper deals. A Competition and Markets Authority's investigation in 2016 found that the cheapest available prepayment deals were £260 to £320 a year more expensive than those available for direct debit households, the consumers who received the cheapest tariffs. High energy prices in 2022 led to an increase in prepayment meter consumers of about 10,000 consumers per month.

The price caps were intended to deal with a real problem, but their use overrode the market and inevitably further reduced its efficiency.

## Developments Since 2021

By selling off generation, the Big Five had lost some of their market power but their brand names still gave them strong advantages. The withdrawal of the liquidity measures raised the issue of whether the market would remain liquid if there was no obligation to use it, or whether generators would seek the financial security of long-term contracts outside the market. Regardless, the wholesale electricity market appeared likely to wither away as fossil fuel generation was replaced by low-carbon sources commissioned by government and sold at nonmarket prices.

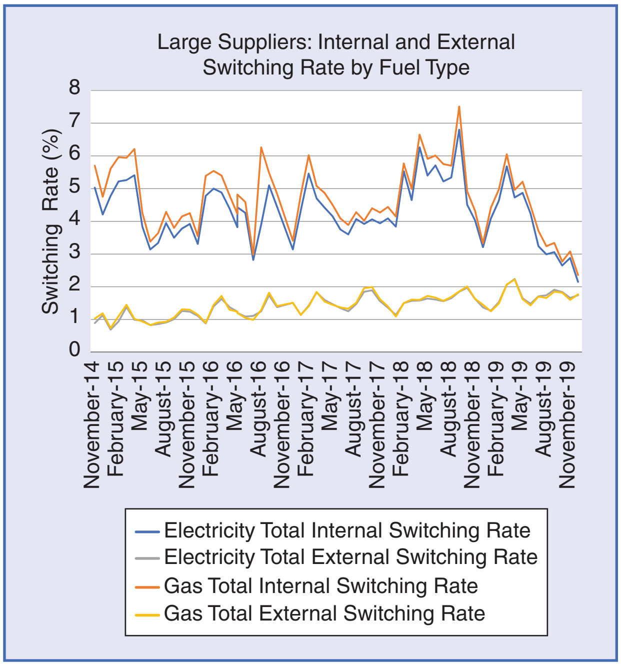


**figure 2.** Switching rates (internal and external). (Source: Ofgem.)

### *The Price Cap*

The price cap was to be set based on costs in the previous six-month period, so there was a built-in lag between increases and decreases in market prices and changes in consumer prices. The cap meant prepayment meter and standard variable tariff consumers could not be charged more than the price cap. However, given that most of the consumers affected had either shown little appetite for switching or there was little scope for them to switch, the price cap quickly became the level set for virtually all standard variable tariff and prepayment meter tariffs. The market for small consumers not on prepayment meters could be divided into three: those on standard variable tariffs with the Big Five, those on fixed price and duration deals with the Big Five, and those on fixed price and duration deals with the new entrants. The price cap initially had no impact on the new entrants because their consumers were all on fixed price and duration tariffs.

### *The Market for New Generation*

The offshore wind capacity auction program proved successful, with prices falling from about £150/MWh in 2014 to less than £40/MWh in 2021. With projections that the electricity sector could be decarbonized by the mid-2030s, the prospect was that, within a decade, most power would be accounted for by renewables sold entirely outside the market to a government entity, which would sell it on to retailers who would be obliged to buy their share at cost, based on their market share. Increasingly retailers are losing control of their power purchasing.

### *Gas Price Rises*

In 2021, the world gas wholesale price rose by about 400%. These high prices were exacerbated by Russia's invasion of Ukraine, which led to Russia reducing gas supplies to Europe. From the point of view of diversity of gas suppliers, the United Kingdom is in an enviable position. It receives a significant proportion of its supplies from the United Kingdom sector of the North Sea; it has pipeline connections to Norway, The Netherlands, and Belgium; and it has three liquified natural gas terminals that allow it to import liquified gas. While it received negligible quantities of gas from Russia, its strong connections to Europe mean the United Kingdom must pay world gas prices and it is at risk of gas shortages. The high gas prices are a strong incentive to gas producers to increase supplies, and additional supplies to Europe from the United States and Norway have allowed Europe to reduce its dependency on Russia for gas from about 40% to less than 10%.

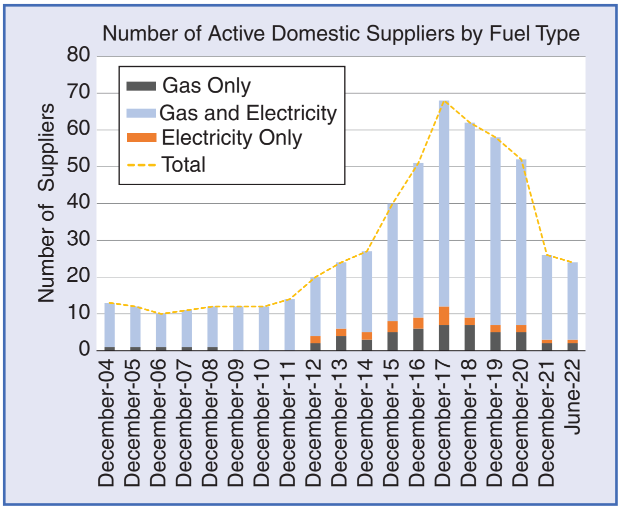


**figure 3.** Number of active suppliers. (Source: Ofgem.)

### *Failures Among Energy Retailers*

Figure 3 shows there were 24 active suppliers in the domestic gas and electricity retail markets as of June 2022. This number included 21 suppliers active in both gas and electricity, two in gas, and one in electricity only.

The gas price rises coincided with the failure of about 30 of the new energy retailers. However, about one-third of failures happened before gas price rises set in. It is difficult to determine how far these early failures were down to normal company failure or failure to be able to renew power purchase contracts at costs they could recover. If the latter, how far was this down to the withdrawal of the liquidity measures?

Many of the failed companies had fewer than 100,000 consumers; 14 had between 100,000 and 600,000 consumers but the largest, Bulb, had 1.7 million consumers. For consumers, there was no interruption in service when a supplier collapsed. When a company fails, there is a bidding process with other companies stating how much they would pay or need to be paid to take on the consumers. In most cases, the new company was one of the Big Five and transferred consumers would go on to the standard variable tariff. While taking on these consumers would increase their market share, it would require the new company to procure additional power from a difficult market. Because these consumers were with new entrant companies, by definition they were likely to be cost-sensitive, and if the new company does not offer a cheap deal, the consumer is likely to switch. Increasingly, replacement suppliers had to be paid to take on the failed company's consumers, a charge that fell on consumers.

The size of Bulb made its rescue problematic. It collapsed in November 2021 and was placed in special administration and allowed to continue trading, with loans from the government expected to cost taxpayers about £4 billion. In October 2022, a new entrant company, Octopus, was reported to be paid £1 billion to take on Bulb's consumers.

The standard variable tariff doubled in 2022, with more rises expected. Cheap fixed-price deals have been withdrawn and consumers have had to move on to the standard variable tariff as their existing fixed-price deal expires. So, the United Kingdom now has many competing retailers all offering the

Additional supplies to Europe from the United States and Norway have allowed Europe to reduce its dependency on Russia for gas from about 40% to less than 10%.

same price. Effectively, retail prices for households are set by the price cap, not the market.

### *The Wholesale Market*

There has been criticism of the wholesale market and the extent to which its design has contributed to the high wholesale electricity prices. The price is set by the highest price producer needed to meet demand and all successful bidders can sell at about that price even if their costs are significantly lower. The rationale for this model is that high prices should motivate generators that can produce at less than the market price to build new capacity, earning them attractive levels of profit. So, generators might earn extra profits when the market is tight but might not cover their full costs when there is surplus capacity.

Concern exists that the price is being set by high-priced gas and that other producers that have lower costs are receiving large profits that they have not earned. However, since 2020, the United Kingdom wholesale market has been behaving in the way it was designed to with the price set by gas-fired generation, with all producers that bid into the market getting that high price. Gas accounts for about half of generation, with the rest covered by renewables at 30% and nuclear at 15%. Gas generators are paying high gas prices and will need the high wholesale electricity prices to cover their costs. Most renewables are sold at prices independent of the market price, so they are not earning any more than normal. Nuclear is technically and economically inflexible and exposing it to market prices would be risky, and it is sold mainly under hedging contracts. It would therefore appear that generators are not making excessive profits. The market is working as it is designed to do and the problem is choice of market design, not market failure.

Figure 4 shows the day-ahead electricity and gas baseload contracts, which mirror the price evolution in their spot markets. Factors influencing power prices include gas prices, carbon prices, and renewable generation. The main drivers of the gas price increases relate to low gas storage levels across Europe and lower-than-usual pipeline imports from Russia into Europe.

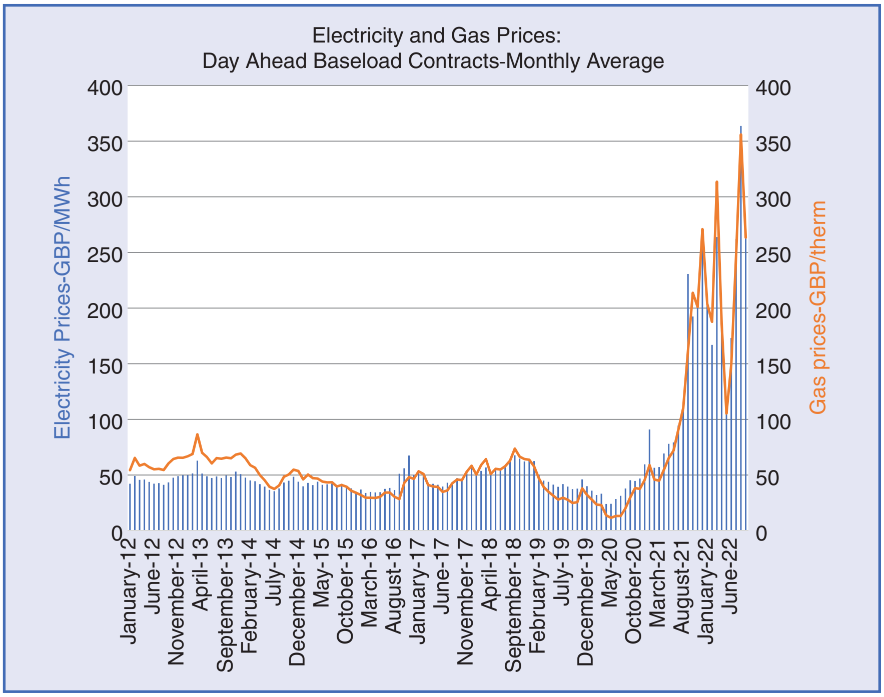


**figure 4.** Power and gas day-ahead contracts. (Source: Ofgem.)

## The Regulator

The regulator, Ofgem, has failed to deal with long-running problems. These include the following:

- ✔ *Prepayment consumers:* These consumers were exploited by the retail suppliers for two decades until, on the instruction of the Competition and Markets Authority, Ofgem introduced a price cap in 2017.
- ✔ *Market liquidity:* For the first two decades after the reforms were implemented, the wholesale market was too illiquid for it to perform any useful function. On the instruction of government, in 2014 Ofgem forced liquidity into the market, allowing large numbers of new entrant retail suppliers to enter the market.
- ✔ *Ofgem's failure:* Ofgem's failure to properly assess the credentials of the new entrant retailers was exposed from 2019 onward, resulting in the collapse of about 50 companies imposing huge costs from switching the failed companies' consumers to a new supplier.

There is no sign that Ofgem has understood that the switch from fossil fuel generation to low-carbon generation will need a fundamental change in the design of the sector.


## The Future

While it is difficult to predict when the war in Ukraine will finish, it will be a long time before Russia will be trusted by Europe as a supplier of natural gas. Nevertheless, there are several factors that mean the current high United Kingdom energy prices will fall relatively soon. On the supply side, the high world gas price is motivating suppliers to produce as much as they can. On the demand side, consumers are cutting their consumption to a bare minimum to ensure their bills are affordable. These two factors should significantly reduce electricity prices. Renewable capacity, at prices not related to gas, is expanding rapidly (more than 3 GW of off-shore capacity came online in 2022), replacing gas, and reducing the influence of gas prices on electricity prices.

### *Review of Electricity Market Arrangements*

In July 2022 the government announced a new review. Despite government claims it would be the "biggest electricity market reform in a generation," judging by the three areas identified as likely to be addressed, this reform is less ambitious than electricity market reforms of only a decade ago. The retail side of the business is mostly not covered, despite the issues raised by the increasingly criticized price cap and despite the fall-out from the large number of retail supplier collapses. The government identifies the following three areas for reforms:

1) introducing incentives for consumers to draw energy from the grid at cheaper rates when demand is low or it is particularly sunny and windy, saving households money with cheaper rates
2) reforming the capacity market so that it increases the participation of low carbon flexibility technologies, such as electricity storage, which enable a cleaner, lower-cost system
3) decoupling costly global fossil fuel prices from electricity produced by cheaper renewables, a step to help ensure consumers are seeing cheaper prices because of lower-cost clean energy sources.

The first area foreshadows the use of smart meters to allow time-of-day pricing, under which the price paid by consumers would vary according to the price of the marginal generation source. Time-of-day pricing raises a serious issue of welfare. Prices will be highest when demand is highest and when consumers need power most. If consumers see a high price, they are likely to cut back demand for applications, like heating and cooking that are vital for their welfare. There will need to be a higher level of demand response to accommodate the variability of renewables and the inflexibility of nuclear, but this must not be at the expense of consumer welfare.

The second point seems common sense, that variable renewable sources will need to be complemented by storage capacity. The third point is the only one that seems directly related to the crisis of 2022. However, as argued above, the wholesale market is working as it was designed to do and it would require a comprehensive redesign to achieve what the government wants. Renewables at nonmarket prices are taking an increasing share of the market and the influence of the gas price on the wholesale power price is declining. If targets to decarbonize the electricity sector are met, the gas price will have little influence within a few years. It is questionable whether designing a short-term fix to the market is worth it.

### *Policy Priorities*

The most serious policy barrier may be the political and commercial difficulty of replacing market mechanisms with planning mechanisms. It will be difficult to convince consumers they are better off with a well-regulated monopoly than a competitive market. There are also many powerful bodies, such as energy retail companies, commodities traders, and price-comparison websites that have a strong interest in retaining competitive markets, even if they are not in the interests of consumers.

#### The Wholesale Market

The current wholesale market is not fit for purpose if it ever was, so the priority must be to design a set of mechanisms that will ensure sufficient new low-carbon capacity is built to meet any demand growth and replace retired plants, and ensure sufficient existing capacity remains available when needed.

Market optimists believe that, as renewable technology matures, a well-designed competitive wholesale market will meet these conditions. However, such a market has never existed for fossil fuel generation and, because of their high upfront costs, low-carbon sources seem less likely to fit into such a market design. Capacity auctions have proved successful in reducing renewables prices. There are strong competitive forces on the bidders but there is full public control. Major challenges exist ahead. Up to now with renewables a minority part of the generation mix, take-or-pay contracts have been suitable, but as renewables' market share increases, there will need to be flexible contracts that recognize that not all the available power can be used, while still giving developers sufficient guarantee of their income to justify the investment costs.

Capacity payments may need to be retained but they are not suitable in their present form under which only dispatchable sources are eligible. Mechanisms must be designed so that variable renewable sources can receive incentives to remain in service after their initial power purchase agreements have expired.

#### Retail Competition

The economic case for retail competition is weak. Without a competitive wholesale electricity market that would allow retailers to buy more cheaply than their competitors, there would be nothing for competing retailers to compete on other than their own costs. Network costs will be the same for all retailers.

The costs of retail competition are significant. These include: the loss of scale economies because of the duplication of functions not needed in a monopoly, the cost of marketing and switching, and the cost to consumers when retail suppliers collapse.

The high prices of 2021/2022 and the collapse of more than 30 retailers will have damaged the credibility of the sector. Consumers of collapsed companies are dumped on to another supplier in which they had no choice, usually with higher prices. There is also the farcical situation of large numbers of companies to choose between, all of which are offering the same price. The energy retail business has been revealed to be fragile and it is not clear there will be any appetite to back new companies entering the market. So, the market may subside back into a small number of retailers under little threat of competition from new entrants.

## In Summary

The problems experienced from 2021 onward raise several questions.

### *Do Consumers Want to Choose an Electricity Supplier?*

The assumption behind allowing consumers choice of supplier was that consumers would grasp the opportunity to switch to the cheapest supplier. This choice would ensure their bills were as low as possible and force suppliers to buy from the wholesale market cheaply, increasing competitive pressure in that market. While Britain has a higher consumer switching rate than most countries, a majority remains on expensive tariffs. There are several factors behind this inertia, such as lack of confidence in their ability to find the best deal, distrust of the market, and lack of time. Hard-pressed, low-income consumers have done badly from the option, facing high tariffs that effectively pay for the benefits of those with the resources to switch.

### *Could Markets Have Worked?*

Under the British model, sufficient new power plants to ensure security of supply would be built prompted only by market signals. This situation never happened when fossil fuel plants were still an option. The high upfront costs of low-carbon sources make it less likely that developers will take the risk of investing in new capacity with no guarantee of income.

### *How Will It Be Possible to Remove Competition?*

There is a growing consensus that the existing electricity industry structure needs a major overhaul, and the logic is that the wholesale and retail competition markets will, at most, be a minor element in the new design. Removing competition will not be easy. Strong vested interests to retain markets exist from organizations that are there because of competition. Politicians of all persuasions have peddled the philosophy that competition for all purchases was the best answer, so telling consumers they would be better off with a planned system will not be easy.

### *What Role for Regulation?*

In 2000, the prime duty of Ofgem was changed from promoting competition to protecting the interests of consumers. However, the mentality of Ofgem still seems to be that a free market is always the best answer, and if left alone, the market will automatically solve any problems. Regulatory interventions are seen as counterproductive and a last resort. It seems likely that this mentality can only be changed by a fundamental rebuilding of the organization that breaks this mentality.

### *What Are the Alternatives?*

Britain has, for several decades, been in an enviable position with respect to energy resources. From the mid-1970s until around 2000, it was self-sufficient in coal, oil, and gas. It now has a range of cheap renewable resources, especially offshore and onshore wind, and solar energy. The new system should be designed to take advantage of these resources rather than the resources fitted into a one-size-fits-all model.

### *Was Allowing Consumer Choice Worth It?*

The simple answer is "no." It has been a costly waste of time and money.

## For Further Reading

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## Biography

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# Achieving Retail Liberalization in Middle-Income Countries

## Challenges and Successes of the Brazilian Experience

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ELECTRICITY MARKET LIBERALIZATION INITIATIVES have swept the world since they were first proposed and thoroughly studied in the 1980s, finding significant buy-in from middle-income countries. Many of these countries embarked in the wave of electricity liberalization in the 1990s following the United Kingdom's market reform and have, as of today, successfully implemented wholesale competition. Generally speaking, most middle-income countries have interrupted the process before reaching full retail liberalization, and thus consumer choice is still mostly restricted to industries. The technological and social advances of decarbonization, decentralization, and digitalization have brought back the full retail liberalization agenda so that consumers can be empowered to freely select their own supplier, type of energy, and hence be active players in the power market.

The core challenges of retail liberalization that policymakers need to tackle are well known, among which it is possible to highlight the following:

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- increasingly active clients of all consumer classes
- novel business models
- growth of distributed energy resources
- the need to accommodate new types of agents
- ensuring a fair treatment of both newcomers and already existing players.

Middle-income countries in particular face all of these challenges while also facing

- a high proportion of socially and economically vulnerable consumers
- relatively young institutions
- immature marketplaces for hedging against risks and/or procuring financing
- "legacy" costs from the reforms of the 20th century may impose further challenges to liberalization.

Brazil in particular is a fascinating case study. The country has historically relied on large-scale centralized generation (mostly hydropower) but recently has seen increased initiatives for distributed energy resources, highlighting the fundamental role of consumer choice in the electricity market. As a consequence, retail liberalization is being discussed in the country via legal and infra-legal pathways. In this article, the Brazilian conjuncture, constraints, and successes along the way toward retail market liberalization are used as a backdrop for a broader discussion that can apply to a range of middle-income countries facing similar challenges.

## Highlights of the Brazilian Context and Retail Liberalization

This section introduces the Brazilian regulatory context, existing initiatives toward full retail liberalization, and the options available to smaller "regulated consumers" that allow them to de facto choose a supplier to some extent. Finally, we draw attention to the socioeconomic complexities of the country as an important background for the challenges faced.

### *Recent Liberalization Efforts in Place*

Large Brazilian consumers may opt to participate in the free market and have the freedom to choose their suppliers; in contrast, "regulated consumers" must be supplied by the concession holder in the area where

> The country has historically relied on large-scale centralized generation (mostly hydropower) but recently has seen increased initiatives for distributed energy resources.

they are located (i.e., the distribution companies or *Distcos*). The Brazilian free market accounts for 35% of the country's consumption and is currently fully accessible to consumers who have a peak load of at least 1 MW. Special rules exist that apply for consumers with a peak load of at least 0.5 MW who purchase energy from nonconventional renewable generation sources (wind, solar, small hydros, and bioenergy, known as *incentivized energy*). From 1 January 2024, the free market will be expanded, and any consumer connected to the system at a voltage level of 2.3 kV or more will be eligible to access it and, hence, bilaterally negotiate its supply contracts from any source. Consumers may always choose to continue to be supplied by regulated tariffs in a distribution company if they prefer.

In 2022, a public consultation was launched proposing full retail liberalization: that is, encompassing the segment of low-voltage consumers, connected at voltage levels below 2.3 kV. According to this proposal from the Ministry of Energy, most low-voltage consumer classes (including commercial services and public services) would be able to opt for the free market from 1 January 2026, while rural and residential consumers would also have access to this choice from 1 January 2028. A bill (number 414/2021) is also being discussed in the Brazilian parliament for the same purpose. Government institutions have shown with these initiatives that they are indeed committed to the idea of liberalization, while at the same time conceding that there are obstacles that will need to be surmounted, particularly with regards to the level of cross-subsidies and distortions currently present in the Brazilian electricity sector.

The topic of full retail liberalization has been under discussion in Brazil since at least 2015, in line with international trends of consumers becoming increasingly aware of their electricity management. Indeed, even in the context of the regulated market, consumers have been empowered to make some level of choice with regards to electricity supply, which has been used as an argument for full retail liberalization in the discussions. The options available to regulated consumers are discussed next.

### *Regulated Consumers Being Not so Regulated*

Even though regulated consumers cannot choose their retailer, over the years the rules governing this market have provided regulated consumers menus of options they could choose from, representing some level of de facto liberalization. Coupled with technological advancements and cheaper control equipment, these regulatory initiatives have been enabling regulated consumers to arbiter between the regulated tariff and other supply options.

The first layer of freedom that regulated consumers have is to play with the tariff structure. As illustrated in Table 1, low-voltage consumers can opt for the conventional tariff (flat) or for the "white" tariff (peaked), whereas high-voltage consumers can opt for the "blue" tariff (flat) or for the "green" tariff (peaked). More accurately, only medium-voltage consumers up to 69 kV have the choice between the green and the blue tariff (not all high-voltage consumers), and the blue tariff is in fact not quite "flat" (though significantly flatter in nature than the green tariff). These available choices are, in essence, standard time-of-use tariff designs, which should allow consumers that have a greater propensity to respond at peak hours to opt-in, while shielding consumers that are not interested.

A direct consequence of the time-of-use tariffs is that consumers will follow the incentives set by the mechanism and either change their behavior or invest in new assets in a way that makes financial sense for them. The magnitude of the incentive implied by the green tariff is so high that it has often been profitable for medium-voltage consumers to maintain a generator on site to dispatch it during the peak hours. The associated fixed costs of this investment can be fully covered by the difference between the green tariff and the fuel cost of operating the generator during peak hours for its entire useful life. The green tariff design brings distortions that should be eliminated as the country revisits its tariff structure framework. A silver lining is that tariff

**table 1. Summary of Brazilian tariff structures and time-of-use incentives.**

| Voltage Level | Name of Tariff Mode | Nature of Tariff Mode | Typical per-kWh Tariff Ratio: Peak Versus Off-Peak |
|---|---|---|---|
| Low-voltage | Conventional | "Flat" | 1 |
| | "White" | "Peaked" | 2 |
| High-voltage (medium-voltage) | "Blue" | "Flat(ter)" | 1.5 |
| | "Green" | "Peaked" | 6 |

distortions have created a culture that may facilitate the dissemination of new distributed energy resources among these medium-voltage consumers in the context of the energy transition. Economics today usually favor diesel-fired generators, but battery storage systems have proved competitive in some cases.

Finally, the most relevant case in which regulated consumers have a choice are small-scale distributed generation (DG) arrangements. Regulation introduced in 2012 allows clients to benefit from a net metering subsidy (paying the Distco a volumetric tariff only in proportion to their net consumption) in case they have a DG installation in their own consumer unit, or if they adhere to a consortium of consumers who deploy these units elsewhere within the concession area of its Distco. The market for DG in Brazil has been booming since around 2016, when it started to become economically attractive for low-voltage consumers to purchase a small-scale rooftop solar system rather than paying the distribution company tariff. Such installations have been more than doubling each year since, as illustrated in Figure 1: distributed solar capacity has surpassed utility-scale installations by over 100%, reaching over 15,000 MW installed.

These initiatives highlight the variety of options the regulated Brazilian electricity consumers already have, given the limited amount of choice available to them, which are made possible by consumers' resourcefulness, but also by the economic incentives and distortions imposed by the regulation. However, if the economic incentive is miscalculated, market imbalances can emerge, a topic that will be addressed next.

### *Socioeconomic Complexity Is an Issue*

Brazil has 54 major electricity Distcos, comprising 88 million consumers, 530 TWh of total demand, and 3.8 million kilometers of distribution network. As highlighted earlier, Distcos operate as retailers for around 65% of the Brazilian electricity market.

Distcos are very heterogenous, especially in terms of market size, population density, and socioeconomic conditions. Households with average income less than roughly US$120 per capita per month (half of the country's minimum wage) represent 27% of the country's population on average, reaching 50% in the poorest states. Low-income households benefit from the "social tariff" program, which lowers their power bills by up to 60%.

In addition to household income levels, areas also exist in which the social environment is institutionally disorganized, and the state has difficulty providing public services and security. This anomie environment has particularly impacted Distcos' energy theft levels, as shown in Figure 2, that shows energy theft can vary from less than 5% to more than 100% of low-voltage formal consumption, depending on the region and concession.

Electricity theft and income levels are relevant indicators of Brazilian socioeconomic complexity, which must be taken into consideration when designing and evaluating new regulatory and market trends related to retail liberalization. In addition, the fact that concessions are very different from one another

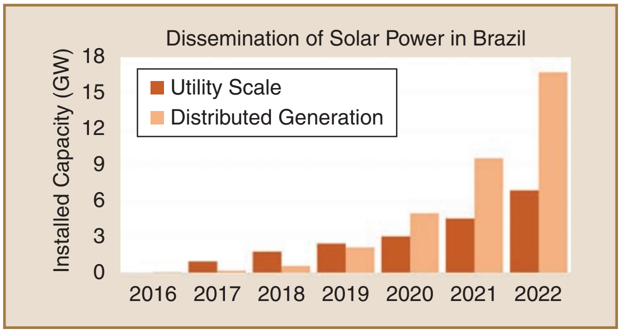


**figure 1.** Evolution of cumulative solar installed capacity in Brazil; 2022 data refer to installed capacity at the end of October

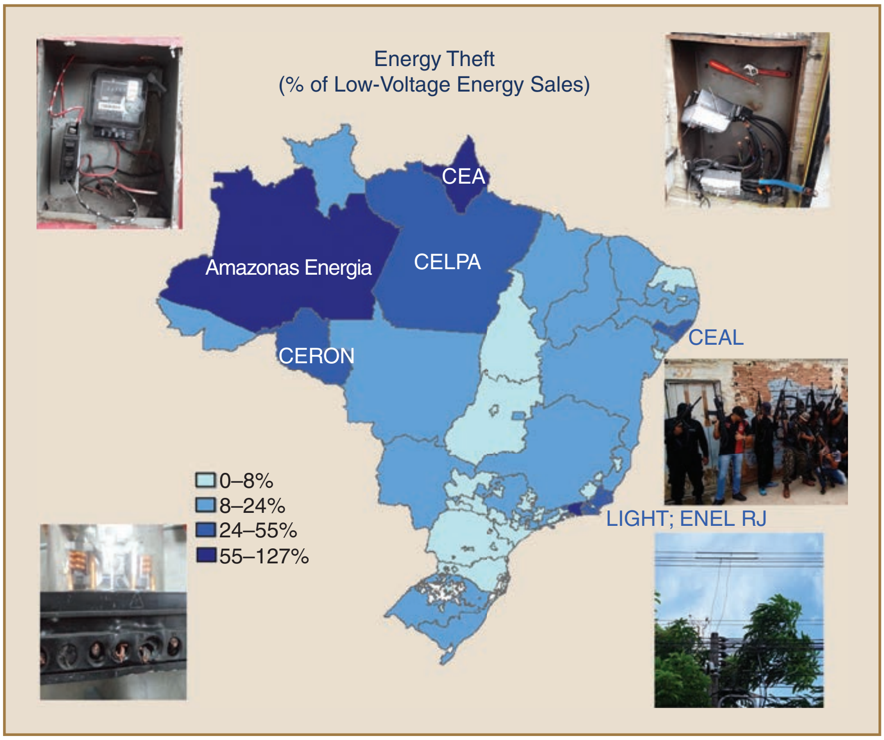


**figure 2.** Concession areas of the most important Brazilian Distcos, highlighting average energy theft levels.

> The Distcos themselves are responsible for setting the demand for the centralized auctions, but it is up to the government to determine which types of contracts (and/or products) will be offered.

requires a more flexible regulatory framework to better accommodate heterogeneities.

## Challenges to Full Retail Liberalization

This section addresses key financial "legacies" of the electricity sector in Brazil that might make the transition toward a full retail liberalization more challenging. While the particulars of these so called *legacies* can differ from country to country, the resulting distortions can make it more challenging to find a healthy balance in the retail market once full liberalization is introduced.

### *Legacy Contracts and the Cost of Purchasing Reliability*

Brazil has a legal obligation that all electricity consumption, whether in the free or in the regulated market, must be backed by energy purchase contracts, and these contracts must in turn be supported by physical energy generation facilities (measured by a firm energy certificate). Based on this rule, the procurement of a new power generation project in Brazil is accomplished in two ways: 1) centrally, through regulated auctions organized by the government, in which Distcos purchase energy contracts to meet the growth of regulated consumers' consumption; and 2) in a decentralized way, as the result of bilateral negotiations between sellers and buyers on the free market.

Even though new generation capacity based on free-market contracts has been an increasing presence in the Brazilian market, for several decades the regulated market has been one of the major drivers of system expansion. The Distcos themselves are responsible for setting the demand for the centralized auctions, but it is up to the government to determine which types of contracts (and/or products) will be offered, what generation sources will be able to participate, and what the ceiling prices will be. Thus, the government has used these technology-specific auctions to procure the kind of new-generation supply that will bring desirable "attributes" to benefit the system as a whole, even if costs of some auction-winning technologies are higher than others.

Therefore, whereas buyers of electricity in the free market will typically purchase electricity exclusively from the least-cost options available (typically solar and wind), Distcos in the regulated market will often end up purchasing a costlier mix of technologies because of the auction design. Because of this practice, the average cost of contracts in the regulated market (passed through to regulated consumers via electricity tariff) has been trending much higher than contracts in the deregulated market, as illustrated in Figure 3.

In addition, to facilitate the process of obtaining financing from financial institutions, the contracts offered for new supply in regulated auctions have long duration (typically 15 to 30 years). Because these long-term contracts are take-or-pay for the generators (the Distco assumes the consumption risk), Distcos are vulnerable to having excess contracts in their portfolio in case of a mass migration of consumers to the free market. Regulated consumers will thus tend to be saddled both with the higher costs of energy purchases and the costs of Distcos's excess contracts.

This situation is a major flaw in the market design that creates a free-riding behavior for consumers that migrate to the free market (if they are regulatorily able to) or that adopt DG. It is especially a moral and social concern as it disproportionally burdens residential consumers

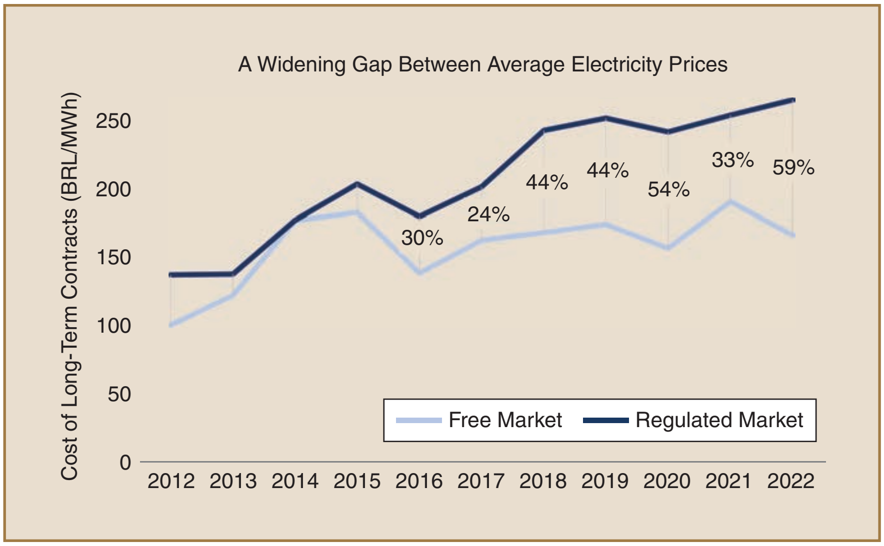


**figure 3.** Historical average electricity prices for contracts in Brazil's free market and energy purchase costs in the regulated markets: 1 USD = ~5 BRL.

and small businesses that are more likely to remain in the regulated market. More recently, last-resort contract auctions and capacity reserve auctions with costs borne by all consumers were introduced as a step in the right direction to start fixing this flaw, despite the still-standing legacy cost of reliability assigned only to the regulated market.

### Legacy Incentives and Tariff Distortions

This section will introduce Brazilian legacy energy policy mechanisms that effectively reduce certain consumer categories' cost of electricity. This type of policy can be justified in certain cases: in Brazil, these subsidies have been responsible for the dissemination of renewable sources (as incentivized energy), DG, and also for mitigating social issues via social tariff programs. Nonetheless, concerns exist that regulatory decisions made under different conjunctures may become misaligned with the current system reality.

Table 2 illustrates how specific business models can benefit from distortions and arbitrages in Brazil (each column of the table represents a business model that will be described next). The table summarizes the net effect of complex tariff interactions that relate to the following tariff components (paid to the Distco by both free and regulated consumers):

- ✔ The TUSD-D component represents the costs of remunerating the transmission and distribution (T&D) networks in Brazil and will be referred to in this article simply as *T&D costs*. This component tends to be substantially greater among low-voltage consumers (around two times greater on average). In addition, whereas low-voltage consumers always pay for these costs on a per volume basis ($/MWh), high-voltage consumers will tend to pay for most of these costs on a basis of peak demand ($/kW/month).
- ✔ The TUSD-E component is referred to as a *charges* component that includes various types of cost component that are typically charged on a per volume basis ($/MWh) and that also tends to be higher for low-voltage consumers. A major contributor to this component is the Energy Development Account, which is the country's fund to recover costs associated with various cross-subsidy programs. Another cost component relates to the Distcos' "efficient" loss levels (technical and nontechnical in nature).

In the case of DG, consumers only need to pay the Distco in proportion to their net consumption (i.e., the difference between energy imported from and exported to the grid), regardless of the hourly profile of these electricity flows. As a consequence, they can effectively avoid paying any costs that are charged on a R$/MWh basis by the Distco (which is why the charges component for both low-voltage and high-voltage consumers, in addition to the T&D costs for low-voltage consumers, are represented as a "high" subsidy in Table 2). Law No. 14300 from January 2022 brought changes to the net-metering mechanism aiming to reduce this tariff distortion over time (in particular for the T&D components); however, the phaseout of the incentive will be gradual over the next 10 years, with existing projects retaining the current level of benefits until 2045. It is worth noting that, starting in 2023, this subsidy to adopters of DG will be incorporated explicitly into the Energy Development Account (part of the charges component) as a cross-subsidy.

In the case of the green tariff self-supply route, a portion of the T&D cost component is translated into a premium (in R$/MWh) that is added to the cost of electricity at peak hours. As discussed earlier, this premium tends to be so high that many adopters end up maintaining a diesel generator "behind the meter." Furthermore, the premium is calculated by assuming a predefined capacity factor at peak hours. The net effect is that, by operating such a generator, consumers end up not paying for a portion of the associated costs of the transmission and distribution network (though this is a medium-low subsidy proportionally).

The incentivized energy subsidy is a legacy incentive to renewable generators established 25 years ago in the form of a 50% discount in the T&D tariff component of both the sellers and the buyers of electricity from incentivized sources. When the law was originally enacted, the economic viability of these sources was profoundly different from today, and

**table 2. Examples of tariff arbitrages and distortions in Brazil.**

| Expected Proportional Tariff Reduction | | Regulated Market: Distributed Generation | Regulated Market: "Green" Tariff Self-Supply | Free Market: Incentivized Energy | Free Market: Outside-the-Fence Self-Production |
|---|---|---|---|---|---|
| Low voltage | Transmission and distribution costs (TUSD-D) | High | N/A | Medium high* | None* |
| | Charges (TUSD-E) | High | N/A | None* | Medium high* |
| High voltage | Transmission and distribution costs (TUSD-D) | None | Medium low | Medium | None |
| | Charges (TUSD-E) | High | None | None | High |

*Currently inaccessible (until retail liberalization reaching low-voltage consumers).

the free market (eligible for this tariff discount) was constrained to a much smaller pool of consumers. Consumers connected to the low-voltage grid are not only much more numerous, but they also have much higher T&D tariff components in absolute terms. As a consequence, as the free market expands, this subsidy could grow significantly, with its costs incorporated into the charges tariff component.

Another opportunity that consumers can take advantage of to avoid certain electricity sector charges is the so-called *self-production* arrangement. In Brazil, it suffices for a consumer to be the shareholder of power plants that do not need to be located on the consumption site to be exempted from a significant portion of the charges component (including cross-subsidies relating to the costs of the incentivized energy and, starting in 2023, of the DG program). More recently, a special juridical structure has allowed consumers to profit from this benefit even without a capital commitment on the generation plant.

### *Consequences and Concerns of Existing Cross-Subsidies*

Concerns with the potential cost imbalances of the subsidies described earlier have been raised. They create regulatory risk-free arbitrages, backed by the coexistence of different incentives perceived by consumers that may stimulate migration to the free market for reasons other than simply the market price and better services by the supplier. Perhaps most importantly, increasing rates of adoption tend to create a positive feedback loop, in which a larger number of adopters to the free market leaves a smaller number of consumers to pay for the costs left behind, which in turn increases tariffs and incentivizes further migration. These feedback loops are especially concerning when considering that, even in the context of a full market liberalization, most likely it will be smaller- and lower-income low-voltage consumers that can be expected to have the greatest level of difficulty in making this migration, requiring them to absorb much of the resulting price shock.

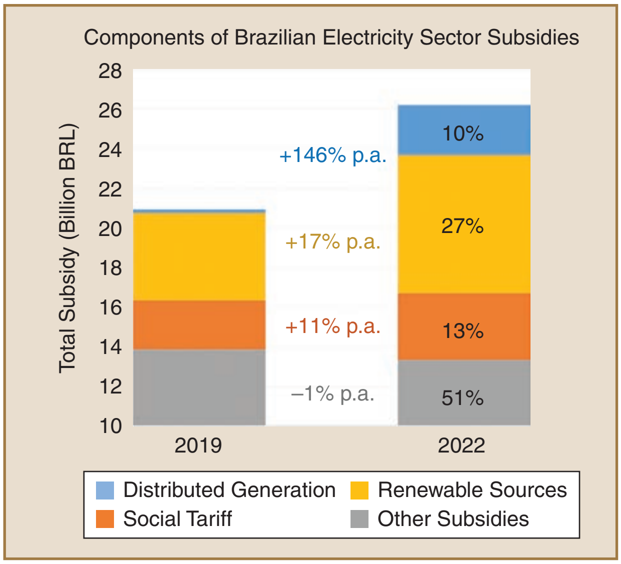


**figure 4.** Comparison of total subsidies in the Brazilian electricity sector in 2019 and 2022, highlighting key relevant components; 1 USD = ~5 BRL. p.a.: per annum, average year-on-year increase during the period.

Figure 4 illustrates how key subsidy components have been growing over the past few years. The increase in the DG component results from the exponential growth of DG, whereas the incentivized energy component is largely associated with the migration of consumers to the free market. With further retail liberalization, room exists for the incentivized energy subsidy to grow even more. The biggest issue here is not necessarily with the existence of these subsidies, but with facilitating access to existing arrangements to broader groups of consumers with higher tariff components, without concern for the effect on consumers that remain in the regulated market.

## Despite Challenges, the March to Retail Liberalization Moves on

The abovementioned distortions show a potential risk of mass migrations to the free market or DG in a disorganized way due to risk-free regulatory or tariff arbitrages. This situation has resulted in a consensus in the country that it is important to organize and move forward with an organized market liberalization. The issues that will need to be solved to enable a sustainable process are profound, with no clear-cut solution in sight. Despite this difficult context, Brazil has been able to accumulate several successes and steps in the right direction that are worth highlighting.

### *Robust Regulatory Agency and Institutions Matter*

Perhaps one of the most important assets, when dealing with a situation in which agents have competing interests and do not wish to part with legacy benefits they are (arguably) entitled to, is to have a robust mechanism of governance and trustworthy institutions to lead communications and discussions with society.

The current Brazilian regulatory framework originates from the 1988 Brazilian Federal Constitution, which highlights that public services are a responsibility of the state but can be granted to private companies, opening the way to privatizations in the 1990s. The Brazilian electricity regulatory authority ANEEL was created in this context in 1996, as a technically, administratively, and financially autonomous institution.

Even though, sporadically, there have been initiatives in Congress to challenge some of ANEEL's decisions, in more than 25 years of the Brazilian Power Sector Regulatory Framework, the net effect has been a strong regulatory governance driven by technical priorities rather than political ones. ANEEL is a regulatory agency that has gone through many cycles of (different) federal governments, maintaining its core characteristics, its respect for the sanctity of contracts, and has

> Despite these limitations, a free market that plays a more active role and that is comfortable with financing new capacity is an important step for further improvements in the market design.

contributed over the years to the security, robustness, and trustworthiness of the sector. While the Ministry tends to be more politically minded and more subject to transient energy policies, having a more technically minded regulator strengthens the institutional framework. Brazil also has other autonomous institutions that may be involved in the matter of the evolving electricity market framework, such as the National Electric System Operator (ONS), the market operator Chamber of Electric Energy Commercialization (CCEE), and a planning company Energy Research Office (EPE). In addition, there is a culture across Brazilian institutions of running public hearings with ample participation from interested parties and of sharing technical documents with analyses of potential impacts of various policy decisions. These efforts have contributed to ensuring that, most of the time, electricity market agents are well-informed and that their concerns are heard.

Despite the complexity of the matter of retail liberalization, a robust institutional framework like this one is virtually necessary to reach consensus or to make decisions on controversial topics, with the regulator playing the role of an independent arbiter when needed.

### *Regulatory "Backpacks" to Maintain a Balanced Cost Allocation to Final Consumers*

The need for a retail liberalization that does not cause tariff increases for consumers who remain in the regulated market is a concept explicitly provided for by Brazilian law. This concept constitutes an important framework for the regulatory design, although it has not always been observed, as shown in some of the examples mentioned previously.

In this sense, the notion of a regulatory *backpack* in the context of the electricity sector relates to a consumer, when migrating to the free market, taking with them a portion of the "surcosts" incurred by the Distco "on behalf of" this consumer, when it was part of the regulated market. The idea is that, even if the consumer is allowed to migrate, it must migrate taking its backpack with them. There are examples in which this core concept is applied in Brazil.

Brazil organized in 2020 a loan to cover Distcos' extraordinary expenses during the Covid-19 pandemic, to be repaid over the following years (the "Covid account"). Contrary to similar financial operations that had been carried out in 2014–2015, the Covid account mechanism anticipated that the costs of the loan would be paid by the regulated consumers plus any free consumers that ended up migrating after the loan was taken (ensuring they would still pay their fair share).

Another example refers to surcosts associated with legacy contracts in the Distcos' portfolio, an effort to avoid burdening only regulated consumers, as market liberalization expands. Bill 414/2021, currently under discussion in the Brazilian parliament, explicitly indicates that part of the excess contracting costs in Distcos' portfolios ought to be shared among all consumers (free and regulated), accounting for the fact that a large portion of this cost is due to consumers migrating to the free market. This same bill also establishes that migrating consumers will have to bear the level of sector charges in the regulated market at the time of migration. Thus, the concept of a *regulatory backpack* is effectively introduced and reflected in Brazilian system charges.

With regards to sharing system reliability costs among all consumers, it is worth mentioning the country's reserve auctions for procuring peak capacity, with associated costs to be shared among all consumers (except self-producers) through a specific sector charge. Brazil's first auction with this purpose took place in 2021. Similarly, the country's third nuclear power plant, considered a strategic project, if constructed, will have its costs also borne by free and regulated consumers, contrary to previous nuclear power plants that had been assigned to the regulated market exclusively.

Finally, it is worth mentioning that Bill 414 has provisions to reduce the risk that new and significant costs related to incentivized sources are transferred to regulated consumers. Indeed, the only hope of finding a healthy equilibrium between the free and regulated markets will be if costs are split fairly, especially in the case of projects that benefit the system as a whole.

### *Long-Term Power Purchase Agreements: Not Only for the Regulated Market*

Another success of the Brazilian market model has been the emergence of more robust financial instruments and the consolidation of free-market consumers and retailers as reliable and creditworthy off-takers. Even though this might seem like an obvious development, given that the free market currently represents almost 35% of the country's consumption, it is important to remember that, when the Brazilian energy contract auctions model was originally conceptualized, it was generally agreed upon that no new generation capacity would be built unless they could rely on long-term contracts financially backed by a Distco. For several years, this indeed seemed to be the case, which is why most of the system expansion in the 2000s and 2010s was from projects that were committed in the energy auctions, and why the

Distcos were saddled with a costly contract portfolio. Project developers were used to having access to these very long-term contracts with reliable off-takers and generous terms tailored to each technology.

Over time, however, free consumers started to show an increasing appetite for procuring mid- to long-term contracts, and project developers have similarly shown a greater willingness to make investments in new capacity backed by free-market contracts. Even financiers have joined in these innovations, accepting generators' demonstrations that, even if they do not have long-term contracts covering their entire operational period, they can follow a predictable contracting strategy that greatly reduces the volatility of their expected revenues (which, in turn, increases the maximum amount of financing they can procure). The success of these long-term contracting strategies is illustrated in Figure 5: approximately 40% of contracts have a duration of four years or more.

Current practices in the free market are not perfect, of course; after all, these long-term contracts are at least in part made viable by the legacy subsidies and regulatory arbitrages described earlier in this article. Furthermore, the expansion that is financed by the free market is almost fully based on the cheapest generation sources available, which have been wind and solar. This situation often launches a debate regarding to what extent these technologies—and hence free consumers—can contribute with necessary system services (such as flexibility and resilience) valued by the system operator and planner. Despite these limitations, a free market that plays a more active role and that is comfortable with financing new capacity is an important step for further improvements in the market design.

## *Modernization of the Distribution Business*

Perhaps one of the most glaring deficiencies of the Brazilian market framework in its path toward retail liberalization is how the Distcos are structured, as a combination of distribution network owner and operator and a monopolist retailer for the regulated market. The most important recommendations raised in this context that directly affect the Distcos' business model and that could play a role in enabling market liberalization are as follows:

- ✔ improve Distcos' tools (and incentives) to manage their contract portfolios, including facilitating the exchange of contracts among utilities and sales in the free market
- ✔ avoid new expensive and long-term contracts in the regulated market, focusing on more technology-neutral auctions, with shorter contracts offered to suppliers, and with the costs of valuable attributes shared between all consumers to avoid free-riding on reliability
- ✔ unbundling retail and grid activities of Distcos, with specific regulatory frameworks for each, including guidelines for "supplier of last resort" services.

Grid digitalization is also under discussion, as in Brazil it is still incipient compared to the country's potential. Smart meters, for example, are available to roughly 1 million consumers, a tiny fraction of Brazil's almost 90 million. Many regulatory factors that explain this timid rollout are known and being addressed, such as reviewing Distcos' revenue structure and reducing under-remuneration risks for grid services. A clear unbundling of the grid and retail businesses allows an identification of the risks these businesses are subject to and an indication of which "other services" could be provided by each of these two businesses. Altogether, they

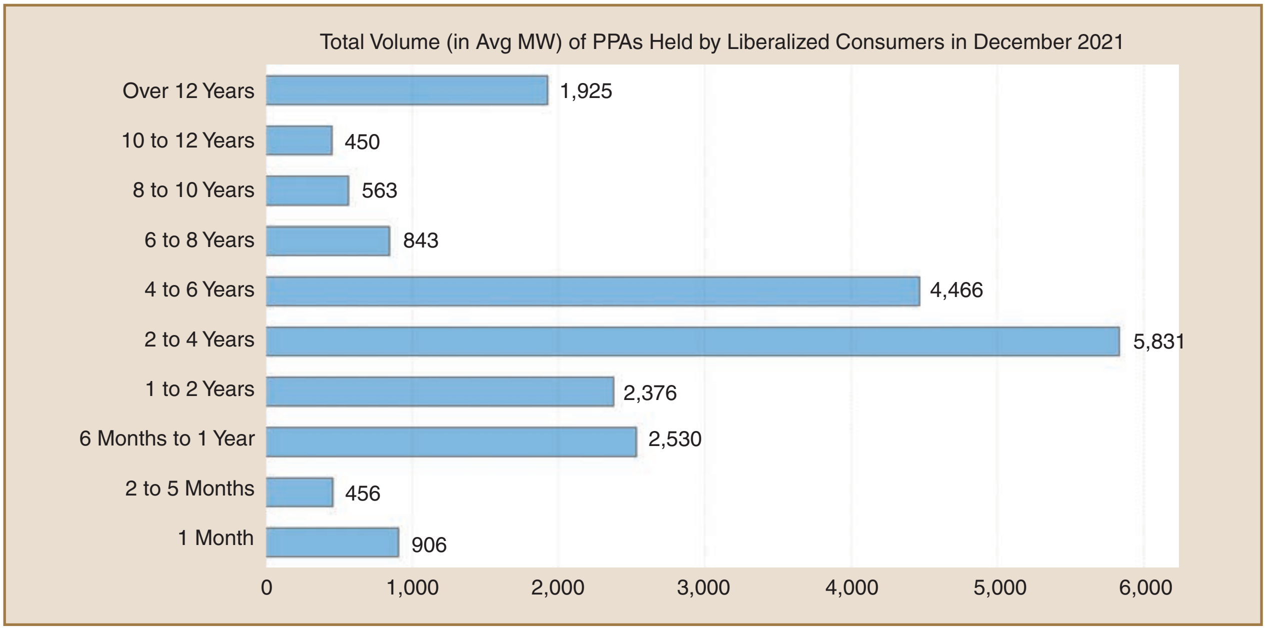


**figure 5.** Total volume (in average megawatts) of contracts held by consumers in the free market in December 2021, classified according to the contract term.

could not only enable a more-efficient market design but also a stronger diffusion of new technologies and innovative services, with ample synergies among these efforts.

## In Summary

In a context of increasing decarbonization, digitalization, and decentralization (with dissemination of distributed energy resources), there has been increasing pressure for retail liberalization across the world. Looking into how middle-income countries such as Brazil have been facing these challenges can be relevant for other countries with similar pressures. In addition to empowering consumers on their energy management, retail liberalization in Brazil gained momentum in the face of the growth of DG, which "liberalizes" the market to consumers that are still regulated. Hence, the authors perceive retail liberalization as a one-way road.

Without arguing the benefits of retail liberalization, to discuss it after almost 25 years of liberalization at the wholesale level is not an easy task anywhere. Contractual and regulatory legacies might compromise the overall efficiency of the liberalization process, as distorting price signals might overburden certain consumers and create self-reinforcing feedback loops without a well-conceptualized retail liberalization plan. This type of negative influence has been exemplified with the situation in Brazil, but it is a common consequence of legacy cross-subsidies in markets with partial retail liberalization.

The creation of free-riding opportunities for migration due to factors other than competition itself is also a risk, as costs not paid by one class of consumers must be paid by others. Lower-income classes might not be attractive to retailers, effectively remaining in the regulated market, which may deepen social divisions and create further concerns. In Brazil and elsewhere, it is not always feasible for the Treasury to simply absorb the cost of cross-subsidies, requiring a more complex solution.

In-depth knowledge of individual country contexts is important in order to find specific solutions for the conundrums involved in promoting full retail liberalization, which is why the Brazilian context was used to illustrate the broader issue. For Brazil and other countries facing a similar context, however, strategies tend to be based on similar core fundamentals:

- ✔ discussions with market agents, political actors, and society at large, hopefully backed by strong technically oriented institutions, as illustrated by the best practices that have been part of Brazilian institutions' core procedures from the beginning
- ✔ an element of regulatory backpack charges for fairly splitting costs between the free and regulated markets—while these have not been systematically applied in Brazil, there is increasing awareness to their importance, and explicit implementation on a case-by-case basis (e.g., Brazil's Covid-related program for electricity consumers)
- ✔ equitable contracting practices between the free and regulated markets, with any extra costs deemed necessary (such as "reliability-driven" contracting) made transparent and split by both groups—one aspect in which Brazil best serves as a cautionary tale to the potentially dire consequences of allowing imbalances and distortions between the free and regulated markets to persist (and the difficulty of handling legacy costs)
- ✔ a robust regulatory framework for Distcos, including, but not limited to, unbundling their retail and grid activities, with better designed incentive-based regulated contracts and tariff structures: Brazil has only taken its first steps on this front, although the need for a more modern framework for the distribution business model has been proving increasingly crucial.

## For Further Reading


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# Beyond Individual Active Customers

By Nicolò Rossetto

THE ENGAGEMENT OF ENERGY CUSTOMERS HAS been considered an important pillar of the European Union (EU) strategy to reach net-zero greenhouse gas emissions by 2050, while preserving a competitive and secure energy system. The legislative package Clean Energy for all Europeans (CEP), adopted by the EU in 2019, confirms the relevance of removing the existing barriers for end users not only to choose their energy supplier but also to invest in distributed generation and storage and participate in all energy markets. Interestingly, the new European legal framework goes beyond the recognition of the rights and duties of individual active customers, the so-called prosumers, and introduces for the first time an explicit reference to energy communities, which take two specific definitions: citizen energy communities (CECs) and renewable energy communities (RECs).

This article provides the reader with an introduction to the concept of energy community and the reasons why European policymakers decided to foster the emergence of this type of actor in the energy system (the section "Collective Actors to Support the Energy Transition"). It then presents the main elements of the new European legal


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framework, highlighting both the similarities and the differences that exist between CECs and RECs (the section "The European Legal Framework"). After that, the article illustrates some of the critical issues that have emerged and the opportunity that the current energy crisis in Europe may represent (the section "Critical Issues and Future Opportunities"). Finally, a summary of the article is provided (the "Conclusions" section).

# Citizen and Renewable Energy Communities in the European Union

## Collective Actors to Support the Energy Transition

### *A Change of Paradigm*

The European energy and climate targets imply that renewable and other low-carbon energy sources will have to replace fossil fuels in the next three decades. This transformation means not only huge investments in the capital stock but also a new organization of the energy system, capable of efficiently integrating energy sources that are characterized by a more dispersed geographical distribution and intermittency. The transformation also means the emergence of new business models able to recover those upfront investments and satisfy the needs and preferences of an increasingly differentiated customer base. Eventually, the transformation means the shift to a more decentralized paradigm in energy, where local solutions are trialed and adopted in response to specific conditions and where the active involvement of consumers is an essential factor.

Consumers, be they households, businesses, public bodies, or other organizations, must engage in the transformation of the energy system and support it. After all, climate neutrality will not be achieved in an efficient and effective manner by simply changing the supply of energy: the way that energy is consumed will have to adjust as well. Consumer engagement in energy can obviously take the form of individual actions—you may think of an industrial firm that produces the heat and electricity it needs on site via a gas turbine or a household that covers its rooftop with solar panels. However, consumer engagement can also take the form of collective action, where a plurality of consumers chooses to act together. This is the concept of energy community to which we now turn.

### *A Heterogeneous Phenomenon*

Energy communities represent a heterogeneous sociotechnical phenomenon, for which it is difficult to provide a precise definition. Broadly speaking, the expression "energy community" refers to energy-related initiatives led by a group of households, businesses (typically small and medium-sized), public authorities, and nongovernmental organizations. These initiatives are often, but not necessarily, local and typically focus on the distribution and supply of energy or on joint investment in energy production, frequently based on renewables. Energy communities may also target energy efficiency and, more rarely, the provision of other services, such as the recharging of electric vehicles or the management of distributed energy resources, including those on the demand side. Participation in an energy community is usually open and voluntary, while decision-making is based on democratic principles (e.g., one member, one vote).

Energy communities typically do not have a commercial nature, namely, they do not pursue primarily financial profits for their members. On the contrary, mutualistic purposes and/or social and environmental motivations play a key role. In the first case, energy communities aim to provide an economic service to their members, such as electricity supply, while in the second, they aim, for instance, at fostering local development, fighting energy poverty, or accelerating the decarbonization of the energy system. Although generalization is difficult, it is quite safe to say that most of the community-based initiatives try to combine both the mutualistic and the socioenvironmental goals as the majority of consumers are not ready to bear a significant extra cost for participation. On the contrary, the possibility to achieve some economic savings is an important driver to expand membership beyond relatively few environmental or social activists.

Energy communities are not an entirely new phenomenon in Europe. Between the end of the 19th century and the first half of the 20th century, several cooperatives were established in the Alps and elsewhere to ensure the production and distribution of electricity to their members. At that time, access to modern energy was often a challenge, and neither private nor publicly owned enterprises were much interested or able to address it in remote and sparsely populated areas. Therefore, in some cases, such as, for instance, in different locations in the Alps, local communities decided to take the lead and benefit from the availability of abundant local resources, such as hydropower. In Europe, this first wave of energy communities, mostly focused on electrification, lost momentum after the Second World War, when the creation of large public enterprises in charge of the electricity service at the regional or national level confined energy communities to small niches.

A second wave of energy communities started in the final years of the 20th century, especially in countries such as Denmark and Germany, and is in full swing today. Again, people and small businesses take the lead in the field of energy, sometimes with the support of local public authorities. Their focus is different, though. Rather than looking after access to modern energy, an issue solved basically everywhere in Europe, they mostly aim at the creation of a more sustainable energy system and a decreased reliance on the traditional, profit-driven, players of the sector. The use of energy as an opportunity for social innovation and local development is an important motivation behind some of these initiatives too.

The factors supporting this second wave of communities are multiple. Some of them are technological, such as the development of the technologies for distributed generation and storage or for the monitoring and control of loads. Others relate to the policy and regulatory framework, such as the liberalization of the energy sector and the promotion of renewables. Social factors are at play as well, such as the increasing environmental awareness of citizens and the appeal of the sharing economy principles.

## *Strengths and Weaknesses*

Energy communities are today a minor actor in the European energy system, but the statistics that we have available, although limited and often hard to compare, confirm their role is growing (see Table 1). This situation reflects

**table 1. Quantification of energy communities in a sample of European countries.**

| Country or Region | Year | Number of Energy Communities | Number of Individuals Involved | Source |
|---|---|---|---|---|
| Europe | 2022 | 1,900 energy cooperatives who are members of REScoop | 1.25 million citizens | REScoop (https://www.rescoop.eu/about-us) |
| France | 2021 | 41 collective self-consumption projects | 607 participants | Enedis (https://flux50.com/media/5757/05%20Enedis.pdf) |
| Germany | 2021 | 847 energy cooperatives | 220,000 members | DGRV (https://www.dgrv.de/wp-content/uploads/2020/07/20200708_State-of-the-sector-2020.pdf) |
| Great Britain | 2021 | 495 community energy organizations | 58,000 members | Community Energy England (https://www.communityenergyengland.org/pages/state-of-the-sector) |
| Greece | 2021 | 1,036 energy communities | Not available | The Green Tank (https://thegreentank.gr/en/2021/11/22/brief-encom-en/) |
| Ireland | 2022 | 677 sustainable energy communities | Not available | Sustainable Energy Authority of Ireland (https://www.seai.ie/community-energy/sustainable-energy-communities/) |
| Italy | 2021 | Three RECs and 73 historical energy cooperatives | 18 final customers who are members of RECs and 80,000 clients of historical cooperatives | GSE https://www.gse.it/documenti_site/Documenti%20GSE/Rapporti%20delle%20attivit%C3%A0/GSE_Rapporto_Attivit%C3%A0_2021.pdf and Confcooperative (https://www.consumo.confcooperative.it/I-SETTORI/Elettrico) |
| The Netherlands | 2021 | 676 energy cooperatives | 112,000 members | HIER opgewekt (https://www.hieropgewekt.nl/local-energy-monitor-2021) |

(Source: author's compilation of various sources.)

the strengths and weaknesses that characterize collective action in the energy sector. In terms of strengths, energy communities can take advantage of the larger scale at which they operate vis-à-vis individual consumers. While a single family or a small business can invest in a photovoltaic unit of a few (tens of) kW, a group of families or small businesses may easily install a plant of some hundred kW or more. Energy communities can also benefit from the possibility of investing in more than one project or combining multiple activities, such as generation and supply. They can also profit from the complementary needs of different members, thereby improving the capacity factor of their assets. In all these cases, average costs tend to diminish, increasing the competitiveness of collective action compared with the individual one.

However, the search for mere economic efficiency is not the only strong point of energy communities. Community-based initiatives can also deal better with the lack of social acceptability of new infrastructures. Today this issue represents a major obstacle to the construction of new power plants, including those running on renewables, and electricity grids. People located around a wind or a biomass project developed by some firm external to the local community are likely to oppose it, contributing to the lengthy permitting and authorization processes, which are currently important reasons for the slow uptake of renewables and the cost escalation of some projects. By building on the trust that exists among community members, by involving all the stakeholders in the decision-making process, and by actively pursuing a positive return for the local economy and society, an energy community may defeat the resistance to the construction of new infrastructures and reduce substantially the time required to obtain permits and authorizations.

Despite the advantages just mentioned, energy communities may still suffer from an enduring cost gap with the traditional actors of the sector. This gap can be the result of the intermediate scale at which communities operate. While a community can invest in larger assets than individuals, those assets are usually smaller than those operated by classical energy firms. In the cases of technologies that exhibit important economies of scale, such as offshore wind, community-driven initiatives will face a disadvantage and be less attractive for those consumers that attribute an important role to the economic benefits of participation. The expansion of existing energy communities and the establishment of new ones are likely to be affected.

The lack of specific skills and the technical expertise necessary to develop and manage complex projects or interact with the rest of the energy system and the various energy markets can equally hinder the development of energy communities and call for the support of professional partners. Similarly, limits in the financial resources that can be mobilized may imply a slower implementation of community projects or even the surrender of more ambitious initiatives. The same democratic and participatory governance that can promote members' engagement and the identification of consensus solutions may turn into a drawback when it slows down the decision-making process and the subsequent implementation phase. In this context, the presence of members or promoting actors endowed with specific competencies and a sense of initiative and leadership represents a fundamental ingredient of a successful energy community.

From this brief overview, it is apparent that energy communities have the potential to play an important role in facilitating the energy transition and making it more sustainable, also from a social point of view. However, there is no certainty that such potential will materialize, especially at the scale required for the EU to reach net-zero greenhouse gas emissions by 2050. To make that happen, it is necessary that the policy and regulatory framework properly considers the specific characteristics of energy communities, such as the intermediate working scale and the noncommercial nature. It is equally necessary that public authorities, in particular those responsible at the local level, put in place concrete support measures that address the most important weaknesses, such as insufficient funding and the limited ability to deal with complex procedures.

## The European Legal Framework

### *A New Deal for Consumers*

Until 2018, there was no specific reference to the concept of energy community in the European legal framework. The numerous directives and regulations issued since the 1990s were aimed at the liberalization, integration, and decarbonization of the energy sector within the EU. They mentioned energy undertakings, national regulatory authorities, and final customers but did not foresee a particular role for collective actions put in place by end users. Community-driven initiatives that were already developing, especially in the northern part of the continent, could then not benefit, at least at the European level, from dedicated norms that recognized their intrinsic difference from the traditional, profit-driven actors and their potentially positive impact on consumers, the environment, and society at large.

However, in 2015, the European Commission (EC) acknowledged the size of the challenges posed by the energy transition and the increase in energy costs borne by European citizens and firms. The EC then decided to offer a new deal for consumers. The deal, included in the broader political initiative on the Energy Union, committed the EU to reform its energy markets and policies on the promotion of renewable energy sources, while putting consumers at the center. According to this new deal, consumers, either individual or collective, had to have the necessary tools and rights to play an active role in energy and directly benefit from competition in energy markets and renewables' development. By means of such consumer empowerment, the EC sought to achieve three goals: 1) promoting a better use of energy resources, in particular those at the distribution level; 2) mobilizing private capital for investment in the long-lived physical assets required by the energy transition; and 3) addressing the growing problem of local opposition to the construction of new plants, in particular those based on renewable energy sources.

Building on the pledges contained in the new deal, the EC proposed a comprehensive legislative package in November 2016, the already-mentioned CEP. After a long and hard-fought legislative process, the CEP was eventually adopted between 2018 and early 2019. Among the several pieces of new legislation, two are particularly relevant in this context: Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources, also known as the renewable energy directive II (RED II), and Directive (EU) 2019/944 on common rules for the internal market for electricity, also known as the internal electricity market directive (IEMD). These two directives represent together a watershed in European energy policy as they formally recognize for the first time the right for consumers to play an active role in the electricity markets and the transition to a decarbonized energy system. Four new legal concepts are introduced: active customers, (jointly acting) renewables self-consumers, CECs, and RECs. For each of them, a set of rights and duties is specified (see Figure 1).

Without any intention to be comprehensive, it is sufficient to say that based on the new provisions, final customers have 1) the right to access all energy markets without being discriminated and subject to disproportionate treatment or to network charges that are not cost-reflective and transparent; 2) the right to consume, store, and sell the energy produced within their premises or within other premises and to participate, either individually or collectively, in flexibility or energy efficiency schemes; 3) the right to delegate to a third party the management of the installations required for their activities, including installation, operation, data handling, and maintenance; 4) the right to share, within a group of renewables self-consumers located in the same building or multiapartment block, the energy produced from renewable sources on their site or sites, without prejudice to the network charges and the other relevant charges and levies applicable to each renewables self-consumer; and 5) the right to become a member, under certain conditions, of a CEC or an REC.

CECs and RECs are new collective actors of the energy sector that enjoy a set of rights and must satisfy specific requisites. These requisites, which overlap each other to a significant extent, relate to 1) the type of subjects that can become members of the community (see Figure 2); 2) the participation and governance models that can be adopted; and 3) the nature of the community's primary purpose, which cannot be the production of financial profits but rather must be the provision of economic, environmental, and social benefits for the members and stakeholders or the areas where the community operates. Consistent with the different goals of the two directives that introduce them, CECs and RECs present some differences, though. These differences are the topic we now consider in more detail.

### *CECs*

A CEC is a legal entity introduced by the IEMD with the purpose of enabling individuals; local authorities, such as municipalities; and (small) firms to take the initiative in the electricity sector and directly benefit from it. Such initiative can be very broad as the directive states that CECs may engage with electricity generation, supply, storage, distribution, and consumption. They can share the energy they

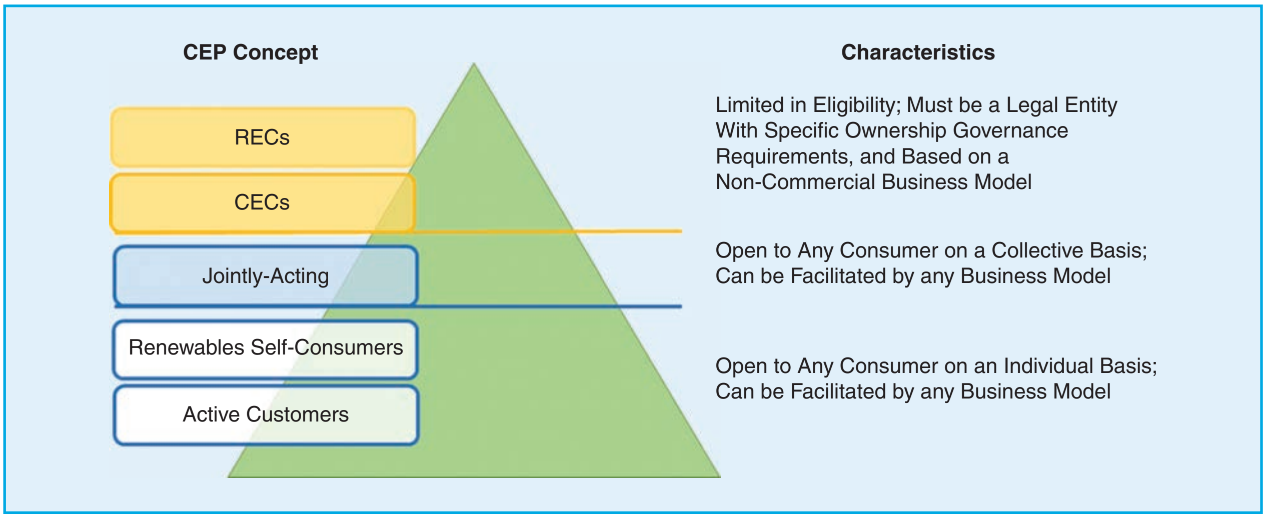


**figure 1.** Different levels of citizen and consumer empowerment in the CEP. (Source: REScoop and ClientEarth, 2020; used with permission.)

produce over the public network and be involved in aggregation or the supply of other services, such as energy efficiency and the recharging of electric vehicles, to their members and stakeholders.

CECs are not limited to a specific geographical area or to a specific type of energy source: they can indifferently use fossil fuels and renewables. However, participation must be open and voluntary, while control can be exerted only by individuals, local authorities, and small enterprises. Any large enterprise, including those involved in the energy business, that is part of a CEC cannot exercise such control. Members of a CEC preserve their rights as final customers (e.g., they retain the possibility to choose their own electricity supplier) and can leave the community if they wish.

The directive states that EU member states must adopt an enabling regulatory framework that ensures a level playing field for CECs in existing and new electricity markets. The cooperation by distribution system operators must be equally guaranteed. At the same time, however, CECs are responsible for their imbalances and must contribute their fair share of the electricity system costs.

### *RECs*

An REC is a legal entity introduced by the RED II with the purpose of enabling individuals, small and medium-sized enterprises, and local authorities to directly participate in the development of renewable energy sources and benefit from it. No explicit list of admissible activities is provided in the directive, and no exclusive reference to electricity applies (i.e., an REC can deal with heat or transport fuels as well).

On the other hand, the directive sets a series of requisites for RECs that are somehow stricter than those that apply to CECs (see Figures 1 and 2). Large enterprises and those that operate in the energy sector cannot be members of an REC, while effective control must be exercised by members that are located in the proximity of the renewable projects that belong to or are developed by the community. Additionally, an REC must be autonomous of its individual members. The satisfaction of these requirements is perceived as necessary to preserve the spontaneous and democratic nature of the community and its ability to fulfil the public goal assigned to it, which, as it was said earlier, is to accelerate the development of renewables by implementing distributed solutions, mobilizing private capital, and addressing social resistance to new infrastructures at the local level.

However, these eligibility criteria are matched by a series of rights. First, RECs have the possibility to produce, consume, store, and sell the renewable energy they produce, including through power purchase agreements. They can also share, within the community, the energy produced from plants owned by the community and access all suitable energy markets, both directly and through aggregation, in a nondiscriminatory manner. In addition to these rights, which are similar to those of CECs, RECs are entitled to an enabling framework that promotes and facilitates their development. This framework, among other things, has to ensure 1) the removal of all unjustified regulatory and administrative barriers; 2) the cooperation of distribution system operators to facilitate energy transfers within the communities; 3) the

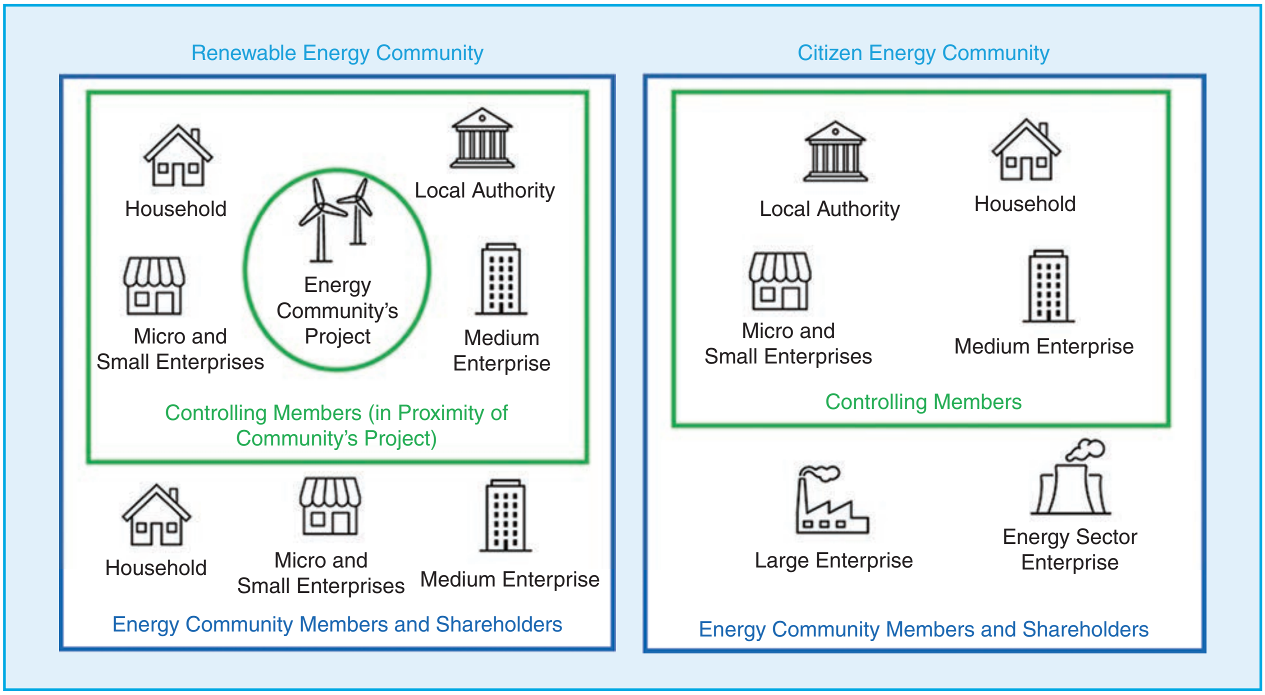


**figure 2.** Membership and effective control criteria of RECs and CECs. (Source: adapted from Alaton and Tounquet; used with permission.)

possibility for all consumers, including those in low-income and vulnerable households, to participate; 4) the availability of tools that facilitate access to finance and information; and 5) the provision of regulatory and capacity-building support to public authorities that want to participate in an REC or facilitate its establishment. Beyond this enabling framework, EU member states must consider the specificities of RECs when designing renewable support schemes to allow them to compete for support on an equal footing with other market actors.

## Critical Issues and Future Opportunities

### *The Devil Is in the Details*

With the CEP, the EU amended its legal framework in a way that is more favorable to consumer engagement. By addressing several of the weaknesses that characterize both individual and collective initiatives, the set of rights and duties introduced at the European level provides the basis for the empowerment of and a more active participation by consumers in the electricity sector and the energy transition. However, as is often the case in the EU, the current legislative framework only sets the direction that national laws and regulations must follow. Member states now have to transpose that framework to the national level, potentially adapting it to their particular conditions and policy preferences.

In the transposition process, member states benefit from a significant degree of freedom. First, they have the right (but also the duty) to specify the numerous elements of the two directives that were voluntarily left general or even vague. For instance, member states are called to clarify what legal forms a CEC and an REC can assume and what proximity to a renewable project means. Second, member states must concretely set charges and procedures that are transparent, nondiscriminatory, and cost-reflective in the context of their specific legal and regulatory framework. Third, member states can choose the level of effort they devote to enabling the uptake of energy communities. It is up to them, for example, to define the financial and human resources that are allocated to support public authorities willing to participate in community-driven initiatives or to simply facilitate their establishment by third parties. Finally, member states are free to preserve already existing forms of energy communities and to create additional types as well, as long as the minimum level of rights and duties prescribed for CECs and RECs in the two directives is observed. Alternative implementation scenarios are possible in this regard (see Figure 3).

Depending on the actual choices by member states, the development path of energy communities is likely to differ in the various countries, extending the heterogeneous situation that is currently visible in Europe (see Table 1). Nonetheless, this period of experimentation that follows the adoption of the CEP may allow, over time, the identification of best practices and most convenient solutions. In turn, this may lead in the future to more detailed and harmonized rules being adopted at the EU level. Convergence in the evolution of energy communities may then follow across the continent.

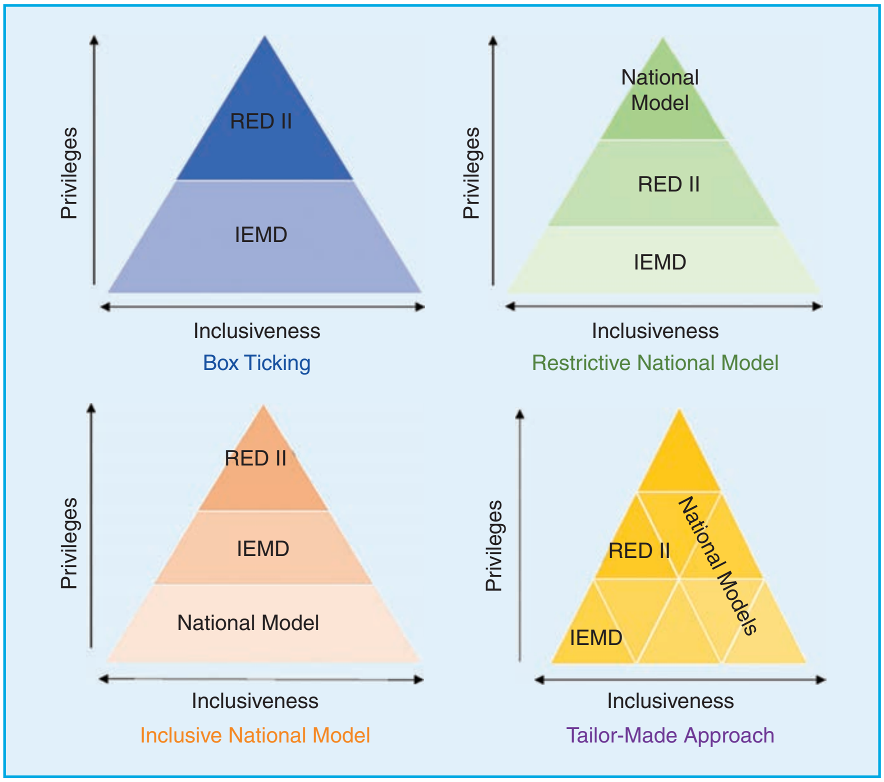


**figure 3.** Different implementation scenarios by member states. (Source: adapted from M. Jasiak, "Prosumers in the clean energy package—Way forward," presented at the 2019 EUSEW, Brussels, Belgium, Jun. 19, 2019; used with permission.)

### *How to Support the Uptake of Energy Communities?*

Energy communities can potentially provide several benefits to the energy system and to society in general. However, these benefits may not materialize due to the limits of collective action we saw earlier and the difficulties of operating in a sector, the energy one, whose rules were developed with large, profit-driven organizations in mind. Hence, it makes sense that governments put in place an enabling framework to support energy communities flourishing.

How to enable or support the uptake of energy communities is a debated topic, though. It is so for at least two reasons. First, energy communities are multifaceted; they can take several forms and be involved in many different activities. Depending on the form assumed or the activities they focus upon, energy communities are likely to face different barriers and generate different benefits to society. In turn, this characteristic calls for different support schemes. Second, introducing forms of dedicated support is likely to generate costs for other market parties and stakeholders or the society at large. A balanced approach that ensures efficiency and fairness must be then identified when developing any support measure.

An example that illustrates this tradeoff is provided by the case of network charges for energy communities involved in energy sharing at the local level, also known as collective self-consumption. By using electricity locally, a community can reduce energy losses and minimize the need for network expansion. In some cases, it may also reduce balancing costs. These savings undoubtedly represent a benefit for the system and may justify a discount on the standard network charges applied to the electricity shared, in particular for the part relating to transmission. However, the benefits of local energy sharing are usually far from justifying a complete rebate of those charges. First, the members of such a type of community normally continue to rely on the local grid to share the electricity they self-consume and on the main grid to receive electricity when community generation does not produce. Second, the reduction in network peak demand, the main cost driver for networks, may be much more limited than the reduction in the amount of the electricity consumed locally and coming from the main grid; the savings for the system associated with local energy sharing would then be rather small. Third, exempting community members from contributing to the recovery of network costs could simply shift those costs onto consumers that are not part of the community and may be unable to join one; an issue of equity is immediately visible in this regard.

For these and similar reasons, the emerging view among regulators and policymakers is that energy communities should be enabled by the introduction of explicit subsidies rather than by implicit subsidies hidden in noncost-reflective network tariffs. Subsidies should incentivize communities to decrease system costs and be potentially linked to the deployment of new renewable generation capacity. In addition, great attention should be paid to the removal of those regulatory barriers and elements of the electricity market design that are a legacy of the past and may not be justified anymore (e.g., certain constraints on the participation of small assets to wholesale electricity markets and balancing mechanisms). In general, public authorities should play a more important role in raising awareness and provide technical and financial assistance to those consumers that want to set up an energy community. This type of support is particularly important to activate specific categories of consumers, such as the vulnerable ones or those living in social housing.

## *The Energy Crisis as an Opportunity*

The EU is currently facing a severe energy crisis. On one hand, the skyrocketing prices caused by the Russian invasion of Ukraine are reducing the welfare of European citizens and firms. On the other hand, the need exists to deeply transform the energy system to mitigate climate change over the coming decades. This gloomy situation can turn into an opportunity, though.

As mentioned earlier, the wave of new energy communities observed in the last two or three decades in Europe was mostly related to the activism of a relatively small number of people and organizations that wanted a greener and more local supply of energy. Those people and organizations were ready to commit time and money to set up collective initiatives and contribute, by this way, to environmental sustainability and a reduced reliance on traditional energy companies.

The situation is very different today for at least three reasons. First, energy is a topic of significant interest for a large part of the population, because of either the increasing bills or the growing awareness of the threat posed by climate change. Second, community investments in renewable-based plants are now a source of energy with relatively stable and competitive costs. Communities that procure energy from those plants, either by directly owning them or via long-term power purchase agreements with independent producers, are shielded, at least partially, from the vagaries of wholesale prices and the increasing cost of fossil fuels. Third, digital technologies allow the active and coordinated management of distributed energy resources, including those on the demand side, and the exploitation of the benefits associated with the integration of different energy sectors at the local level (e.g., electricity and heating).

For all these reasons, today, the opportunity exists for energy communities to play a larger role than in the past and help the EU deal with the current energy crisis. However, to seize this opportunity, the right policy and regulatory choices must be implemented by policymakers and regulators. This means, first of all, the full transposition of the two European directives and the adoption of the related enabling frameworks for energy communities at the national level, something that not all EU member states have already done. Second, it means that the policy reaction to the explosion in energy prices should not "mute" the incentives for consumers to get engaged, either individually or collectively. Unfortunately, the opposite seems to be the case. In some countries, governments have frozen retail prices below costs for all consumers and not just for those in poverty or more vulnerable. Network and policy costs have been often moved to the state budget, while in some cases, new taxes targeting windfall profits or additional obligations on energy companies have been introduced.

Energy cooperatives were usually not spared from these penalizing measures.

This reaction of governments to the surge in energy prices is understandable, given the political pressure exerted by consumers. However, trying to protect consumers by isolating them from price dynamics may weaken the motivations for a growing number of them to become active and more directly engaged, individually or collectively, with electricity markets and the energy transition in general. If that is the case, the current crisis may turn into a missed opportunity for the EU and its energy communities.

## Conclusions

The decarbonization of the energy system requires a shift from a centralized paradigm that relies on the exploitation of fossil fuels to a more decentralized paradigm that relies on the development of local solutions to integrate and exploit renewable energy sources. The engagement of consumers is an important element of this shift. Consumers can engage in energy both individually and collectively. In the latter case, they can form an energy community, a collective actor that is typically characterized by a democratic governance and a noncommercial nature. Energy communities are not a new phenomenon, but their growth in size and number has been noticeable in recent years. By mobilizing the resources of multiple consumers and building on the trust existing among members, energy communities can achieve a certain level of economic efficiency and solve issues related to the social acceptance of new infrastructures. For this reason, they have the potential to be an important player in the energy transition. However, this potential can fail to become reality due to some weaknesses typical of collective action, such as the difficulty in dealing with complex and uncertain procedures.

Conscious of the challenges posed by the rapid transition to a low-carbon energy system and the need to have consumers on board, the EU has proposed a new deal, recognizing the right for consumers to actively participate in all electricity markets and contribute to the development of renewables. This right can be exercised as individual active customers and individual renewables self-consumers or collectively by joining a CEC or an REC. A CEC is a new actor of electricity markets that allows consumers to participate on a level playing field with traditional players. This actor is not bound to a specific place nor to the exclusive use of renewables. On the contrary, an REC is a social organization that allows consumers to deal with renewables, also beyond electricity generation, and directly benefit from it, without the need to rely on the support of traditional actors. Given their potential role in decarbonization, RECs are entitled to an enabling framework that promotes and facilitates their development.

The new European legal framework set the scene for the offtake of energy communities but is not sufficient by itself. Its actual transposition at the national level will be essential to the successful development of energy communities over the coming years. EU member states have significant leeway in how to implement the obligations imposed on them by the EU legislator, in particular with regard to the definition of the enabling framework for energy communities. Depending on their choices, the development of energy communities may follow different paths. However, to avoid inefficient and unfair results, member states should adopt a balanced approach and try to incentivize only those initiatives that will enhance social welfare and not just the welfare of community members, to the detriment of the rest of the energy system and society. The severe crisis that Europe is facing in energy can represent an opportunity for consumers to fruitfully raise their level of participation in the energy sector. Nevertheless, the delays in the transposition and proper implementation of the new legal framework, combined with some of the measures adopted by governments to shield consumers from the consequences of high and volatile energy prices, are deterring the creation and growth of energy communities. By doing that, the EU may miss an opportunity to advance toward a more sustainable, not only from an environmental point of view, energy system.

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# From "Fit and Forget" to "Flex or Regret" in Distribution Grids

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## Dealing With Congestion in European Distribution Grids

**By Ellen Beckstedde and Leonardo Meeus**

THE SUPPORT OF DECENTRALIZED ENERGY resources under the Fit for 55 package and the REPowerEU plan places distribution grid users and distribution system operators (DSOs) at the center of the future European energy system. Also, the interaction between both types of agents is gaining importance for two reasons. First, DSOs face challenges connecting these new grid users to their network, leading to an increased need for grid investments and congestion management measures. Second, engaging these new grid users can bring opportunities for DSOs to manage their network and its possible congestion more efficiently.

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## Introduction

In this article, we describe the need, organization, and open issues of congestion management in distribution grids. We focus on Europe, and we will address the following questions. Do we already have congestion in distribution grids, and how did that happen? Do we plan to have more congestion in distribution grids, or will we avoid congestion with investment planning? How do DSOs procure grid services to solve congestion, and what are the main differences? What are some of the open issues?

## Do We Have Congestion in Distribution Grids, and How Did That Happen?

In Europe, DSOs are increasingly faced with congestion in their grids. It started in countries like Germany with injection peaks caused by wind and solar farms that created


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situations with more generation than load in some areas, sometimes congesting the local lines or transformers. It then spread to countries like The Netherlands, where DSOs started to experience congestion due to generation peaks from renewables and load peaks from new data centers. The next wave of grid congestion is expected to come from electric vehicles (EVs). Leading countries in EV penetration, like Norway, already have distribution grid congestion caused by EV charging. The United Kingdom is also experiencing congestion in distribution grids, which is mainly driven by EVs or renewable generation, depending on the area.

As illustrated by Figures 1 and 2, heatmaps or hosting capacity maps are often used by DSOs to report congestion, but there are different practices.

Figure 1 is an image from The Netherlands for new grid connections of load [Figure 1(a)] and generation [Figure 1(b)]. Red means that all network capacity has been reserved for other grid users, and you cannot connect anymore in that area. Orange indicates that you cannot connect unless certain congestion management measures are taken. Depending on the case, these measures can be limited capacity contracts or market-based redispatch. The shaded areas indicate where congestion management measures are already in place. Yellow means that the connection is uncertain; there is an application procedure to follow that will tell if you can connect. Only in transparent zones can you connect without capacity limitations.

The ongoing debate in The Netherlands is to what extent the DSOs should continue connecting new grid users. The more they overbook the network, the more they will need to resort to congestion management in peak hours. If they do not overbook, the connection queues start to be awkwardly long. As a result, they have entered into discussions on who should get priority to connect. Should it be a local housing project or a data center of a multinational? Should it be first come, first served, or should there be auctions for distribution grid connection capacities?

Figure 2 is an illustration from the DSO Schleswig-Holstein Netz in Germany. The colors represent the number of hours renewable generators have been curtailed in a selected period. Red means that you can still connect new renewable generation projects, but you have a higher risk of being curtailed if you do. For example, renewable generators located in the dark red zones of Figure 2 were curtailed for

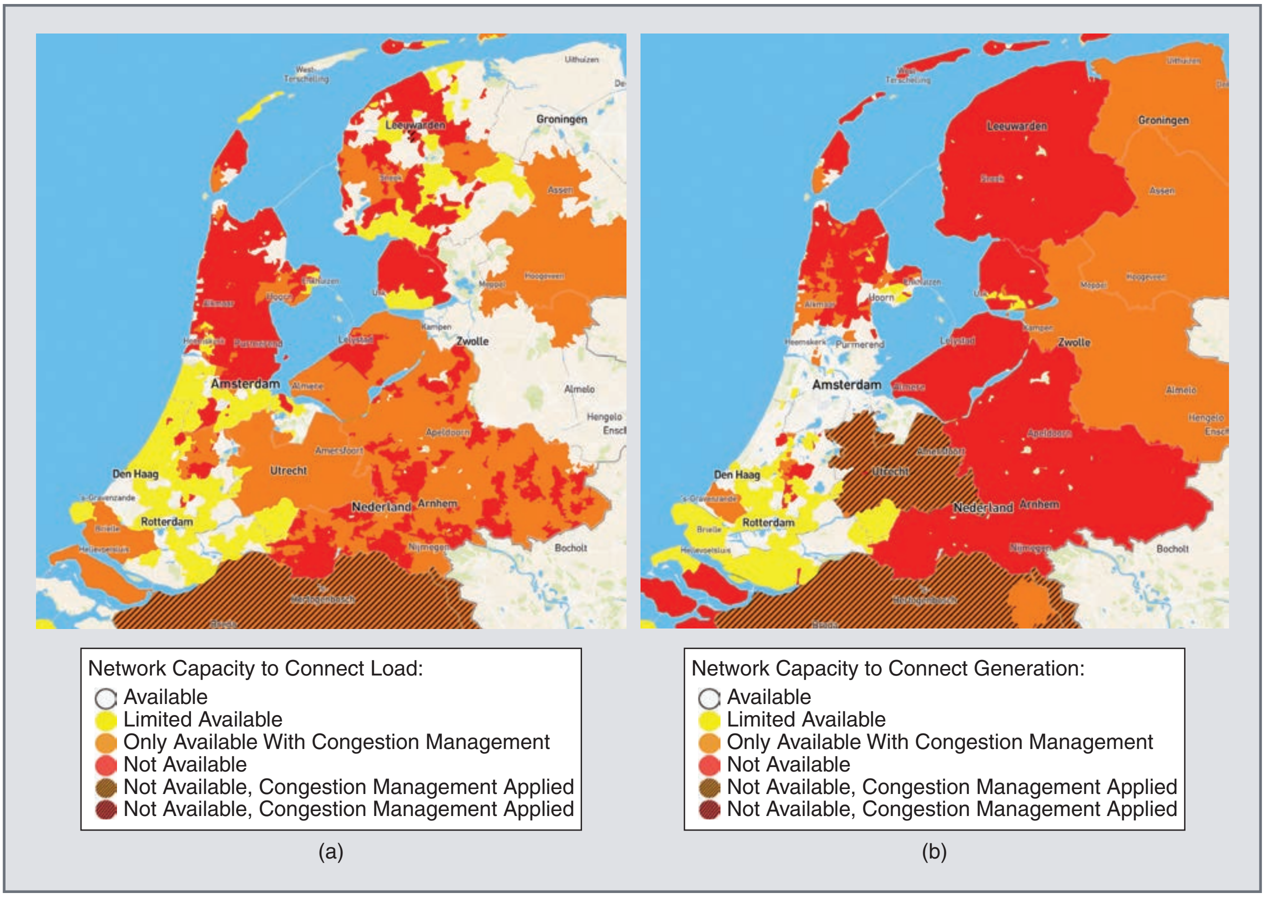


**figure 1.** Network congestion heatmap of The Netherlands. (Source: Netbeheer Nederland; https://capaciteitskaart.netbeheernederland.nl/.)

more than 16,000 h in 2022. Green means that no curtailment was necessary for that area.

German DSOs used to curtail renewables in real time at the cost of the lost revenues of these generators under the so-called *feed-in management regime*. In October 2021, this regime was replaced by Redispatch 2.0. In more detail, congestion is now managed by a schedule-based process that contains several validation loops between DSOs and transmission system operators (TSOs) and ends 15 min before real time. All generators, such as renewable energy, combined heat and power plants, conventional units, and storage facilities, with an installed capacity above 100 kW must provide congestion management services. To ensure cost efficiency, system operators select generators based on their imputed costs, which consider the technical impact of the generator on the congestion issue and the feed-in priority for renewables. A final difference is that system operators have to compensate for the lost revenues of the generators and the imbalance costs of its balancing responsible party.

In many other European countries, congestion in distribution grids is still far from being a concern for stakeholders. However, the lessons learned from countries like the ones mentioned reveal that congestion can rapidly become an issue in certain zones, catching DSOs unprepared. The decisions for grid users to invest in renewable generation, build a new data center, or switch to an EV are quicker than the typical grid expansion planning and execution processes. This issue is already well known in transmission grids, and the same is now happening at the distribution level. The main difference is that including network constraints in market pricing algorithms is more challenging for distribution than transmission. For instance, the IEEE community has already worked on theoretical models for distribution locational marginal pricing. However, these approaches are not yet considered an actual solution to manage congestion in distribution grids.

## Do We Plan to Have More Congestion in Distribution Grids, or Do We Need Better Planning to Avoid Congestion?

For more than a decade, European transmission investment plans have been publicly discussed. These national plans are developed with standardized methodologies and coordinated by a pan-European strategy. This exercise, led by the European Network of TSOs for Electricity (ENTSO-E), is referred to as the Ten-Year Network Development Plan. The plan, which is updated and improved every other year, has been an impressive achievement of harmonization and collaboration across many countries.

In the first two decades of electricity market reforms, congestion in distribution grids has not been an issue. But recently, it became evident that distribution grids can turn into a bottleneck for the functioning of the European electricity market and the transition toward a more sustainable energy system. Article 32 of Electricity Directive 2019/944 of the European Union (EU) Clean Energy Package introduced several new regulations for distribution network planning. The legislation uses the terminology "network investment plans for distribution systems," but some are already talking about Ten-Year Network Development Plans for distribution. DSOs have promoted the EU DSO Entity, aimed at replicating the role of ENTSO-E, to develop a new methodology for the future investment

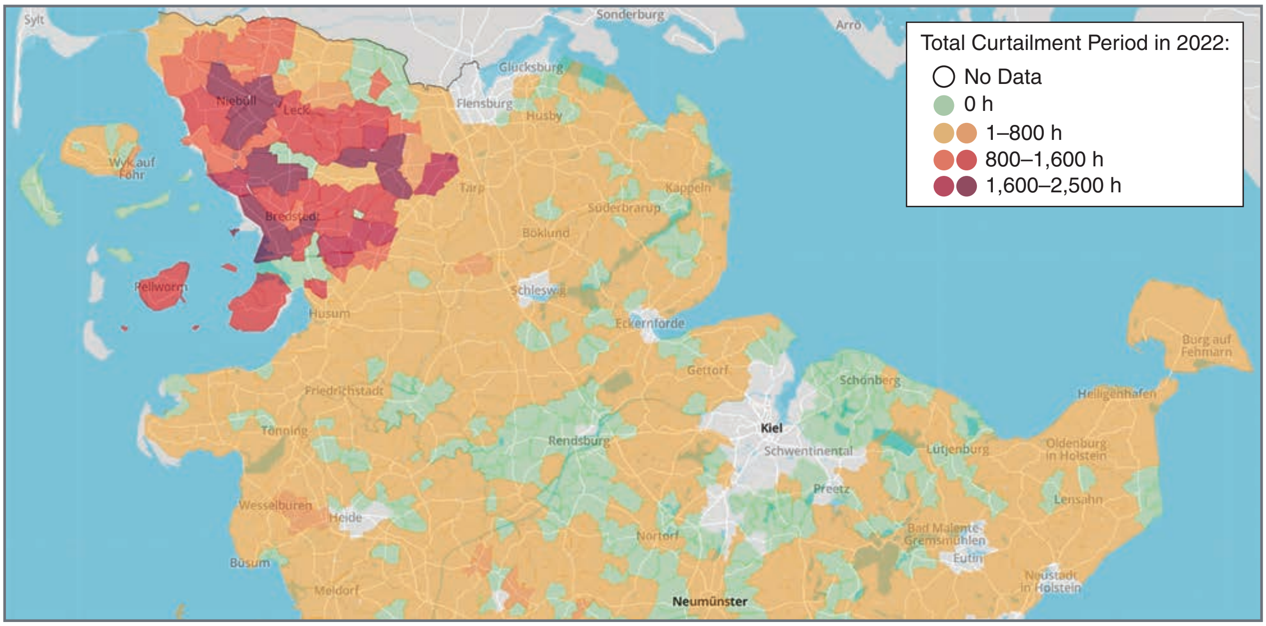


**figure 2.** Network congestion heatmap of Germany. (Source: Schleswig-Holstein Netz https://www.netzampel.energy/shnetz/historical.)

> The legislation uses the terminology "network investment plans for distribution systems," but some are already talking about Ten-Year Network Development Plans for distribution.

plans of distribution grids that all DSOs will apply. In the meantime, different approaches to designing these network investment plans are emerging.

On the one hand, DSOs gathered via their industry associations and asked consultants to produce a first European plan as a dry run. On the other hand, DSOs have already published the first version of their local plans to comply with the new regulations of the Clean Energy Package. We now introduce both approaches.

- ✔ The first European plan was developed by Eurelectric, Monitor Deloitte, and E.DSO. The study argues that evening peaks of households will drive congestion and investments in distribution grids and illustrates this with the European version of the duck curve, reflecting the impact of solar production mainly around noon. Figure 3, taken from this study, argues that investments in the next 10 years will need to increase annually between 50% and 70% (from an average of €23 billion per year to between €34 and €39 billion per year). Important assumptions for such a plan are the renewable energy objectives and the ambition to electrify transport and heating. Even though most European countries have clear national targets, inferring the future impact on local distribution grids is not always obvious. Another key assumption is the level of flexibility that will be available, which will depend on the incentives in place to manage peaks and the resulting response from end users. The first European plan treats flexibility as an assumption, while European legislation asks DSOs to consider the tradeoff between flexibility and expansion of the network in their upcoming network development plans.
- ✔ An example of DSOs that have published their first version of a multiannual network investment plan following the new regulations of the Clean Energy Package is Fluvius, the DSO active in the north of Belgium. Figure 4 is a picture of this study that shows the level of congestion the DSO expects in each municipality of the region by 2030 if it does not expand the network. Fluvius also qualitatively discusses alternative solutions to manage congestion, such as dynamic network operation, distribution network tariffs, mandatory flexibility services, and market-based flexibility procurement. Although an extensive tradeoff mechanism between flexibility and network investment has yet to be included, Fluvius describes the first building blocks of how this mechanism will look. To further develop its strategy, it will focus on flexibility products for congestion management in its high voltage network with a minimum investment cost of 100 k€ (50 potential projects per year).

There is not yet a consensus on the actual potential of flexibility as an alternative to distribution grid investments. Some argue that cost-reflective distribution network tariffs would bring enough incentives for grid users to reduce their peaks. We believe there is a potential for DSOs to do more than provide cost-reflective signals via their network tariffs. One reason to defend the need to explicitly procure flexibility is that tariffs will always depend on the grid users' voluntary response and be imperfect as they compromise between cost-reflectiveness and other principles, such as fairness and simplicity. Another reason is that investment planning under uncertainty can result in unexpected congestion.

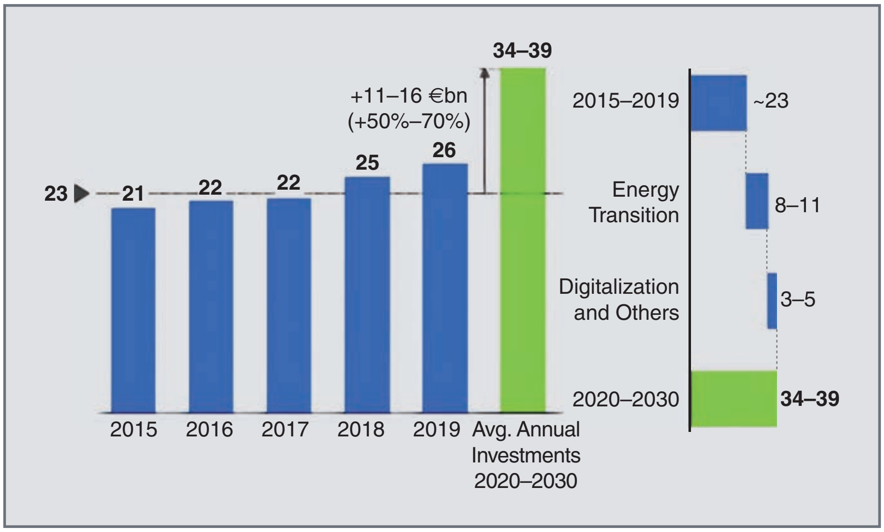


**figure 3.** Expected increase in annual distribution network investments in Europe and its main drivers. Avg.: average. (Source: Eurelectric, Eurostat, the IEA, DSOs and national associations, and Monitor Deloitte, 2021.)

The European countries that currently experience congestion in distribution grids indeed did not plan for it, but they still have to deal with it. The experience has shown that DSOs cannot simply stop all requests to connect to distribution grids; they are subject to significant pressure to overbook and manage the congestion resulting from this overbooking. An additional concern is that grid users could start to create congestion, anticipating that they can get paid to solve it (i.e., inc-dec gaming). Gaming is a valid concern limiting the potential of market-based flexibility, but we believe it will not apply equally in all situations. When and how DSOs will contract flexibility also plays a role, which is what is discussed next.

## How Do DSOs Procure Grid Services to Solve Congestion, and What Are the Main Differences?

Many DSOs in Europe have set up demonstration projects to test flexibility services to manage (potential) congestion in their grids. Figure 5 illustrates some of the biggest projects financed by the EU's Horizon 2020 research and innovation program and the countries that have hosted the demonstrations.

DSOs with a lot of congestion in their networks evolved from demonstration projects to full-scale flexibility markets. Some DSOs, such as Enedis and Enel, have developed their own platforms to tender flexibility services, but market platforms owned and operated by third-party companies also entered this space. In what follows, we will discuss three of these third-party platforms that are currently the most relevant ones in Europe in terms of procured volumes or capacities: NODES, Piclo Flex, and GOPACS. All initiatives started in countries that were among the first to experience congestion in distribution grids: Norway (and Germany) for NODES, the United Kingdom for Piclo Flex, and The Netherlands for GOPACS.

- ✔ NODES is an independent market platform founded as a joint venture between the Norwegian utility company Agder Energi and one of the leading power exchanges

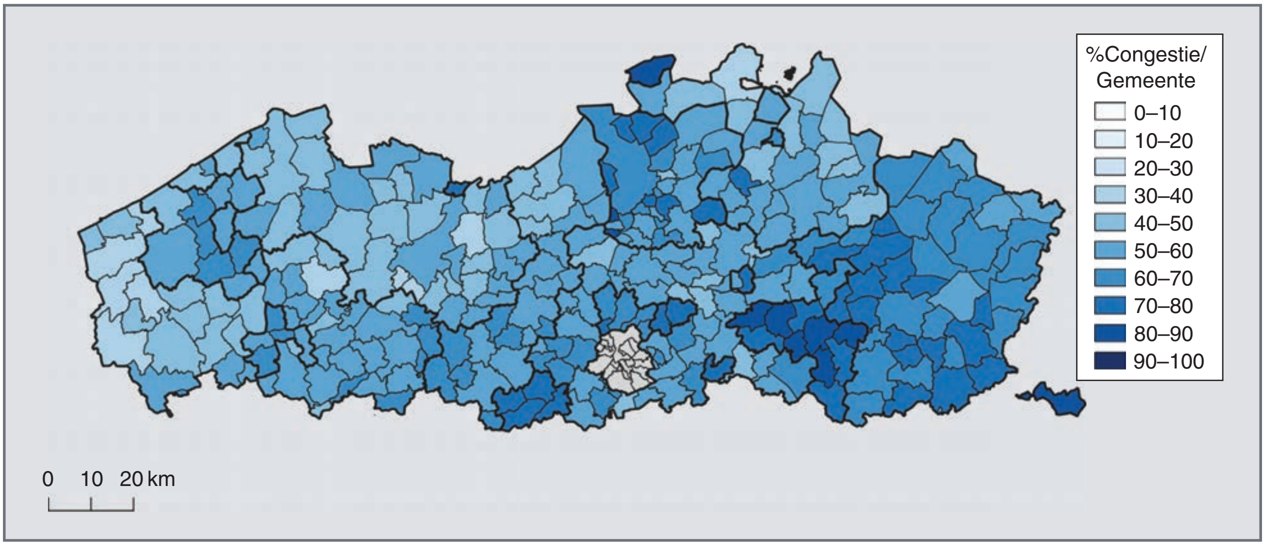


**figure 4.** Expected share of congestion per municipality by 2035 if the network is no longer expanded. (Source: Fluvius, 2022.)


**figure 5.** Projects funded by the EU's Horizon 2020 research and innovation program focused on developing new flexibility services.

in Europe, Nord Pool. Today, all shares of NODES are owned by Agder Energi. NODES is an open-market platform that acts as an intermediary between stakeholders for all market-related tasks. The products are adapted to the local characteristics and needs of the involved market parties. Two types of products can be traded on NODES among different time horizons. ShortFlex products are exchanged close to real time in a continuous market. LongFlex products are reserved by the grid operator for a certain time and awarded via a tendering process. NODES has already proven its market concept in countries such as Norway, Germany, Sweden, and the United Kingdom. Table 1 shows the traded ShortFlex volumes and reserved LongFlex capacities over the years in their biggest demonstrator, NorFlex, a shared flexibility market between the Norwegian TSO Statnett and the DSO Adger Energi. Typical flexibility providers in NorFlex are aggregators offering flexibility from industrial buildings, commercial buildings, and households.

- ✔ Piclo Flex, a privately owned start-up mostly active in the United Kingdom, is a market platform designed for DSOs to procure flexibility services and operates separately from existing energy markets. Four types of contracts are typically traded on the Piclo Flex platform and are defined by the Energy Networks Association (ENA) in the United Kingdom and Ireland: 1) *sustain products* set predefined schedules for flexible resources to manage predictable, low-risk network constraints; 2) *secure products* require flexibility providers to be available at peak times to react to real-time network conditions; 3) *dynamic products* support DSOs during specific events, such as maintenance; and 4) *restore products* help system operators activate flexibility services in real time during unplanned network events. DSOs in the United Kingdom use Piclo Flex to tender these products for contracts with different lengths, from one-year contracts up to seven-year contracts. Table 1 gives an overview of the procured capacities (MW) over the years for UK Power Networks (UKPN) and SP Energy Networks (SPEN), which currently have organized most competitions on the Piclo Flex platform. Contracts were typically awarded to technologies such as EVs, gas engines, batteries, biomass, and commercial demand side response. Besides that, it must be noted that no flexibility tenders were coordinated by SPEN in 2022 because of successfully tendered multiyear contracts in 2021, which reduced the need for congestion management services and the availability of flexible service providers in the 2022 tenders.
- ✔ GOPACS was founded in 2019 by the Dutch transmission and distribution system operators. Rather than being an additional market platform, GOPACS acts as an intermediary between the network operators and existing energy markets, such as the Amsterdam Energy Trading Platform and the European Power Exchange. Bids submitted to these intraday market platforms become available on GOPACS if a locational tag is added. In this way, these bids can be activated by system operators to relieve congestion in their network or by other market parties for other purposes. Flexibility providers that are not acting in existing electricity markets can also bid on the GOPACS platform using a specific client portal. Another typical feature of GOPACS is that system operators must counterbalance their activated flexibility with bids outside the congested zone to maintain the balance in the network. Table 1 shows the procured volumes (MWh) by the largest DSO buyer, Liander, which are traded as part of their pilot in Neerijnen. The table also contains the traded volumes of the TSO TenneT to show that the volumes of Liander are still relatively small in comparison. However, the traded volumes by DSOs are expected to grow with the rollout of a new congestion management product for DSOs that was introduced in the Dutch Electricity Network Code at the end of 2022. This new product has three changes compared to the current redispatch products traded on GOPACS: there is no minimum amount of market participants, there are no counterbalancing measures required, and there is the possibility to close long-term contracts.

**table 1. Contracted capacity or traded flexibility volumes on third-party market platforms.**

| | 2019 | 2020 | 2021 | 2022 | Unit |
|---|---|---|---|---|---|
| NODES (NorFlex) | — | — | 225.2 | 734.6 | Traded volume [MWh] |
| NODES (NorFlex) | — | — | — | 3.38 | Contracted capacity [MW] |
| Piclo Flex (UKPN) | 19.3 | 123 | 350 | 367.6 | Contracted capacity [MW] |
| Piclo Flex (SPEN) | 53.3 | 139.6 | 555 | — | Contracted capacity [MW] |
| GOPACS (Liander) | — | 69.2 | 111.3 | 7.6 | Traded volume [MWh] |
| GOPACS (TenneT) | 36,552.1 | 53,887.8 | 142,997.6 | 181,933.1 | Traded volume [MWh] |

UKPN: UK Power Networks; SPEN: SP Energy Networks. (Sources: NODES, https://nodesmarket.com/market-data; UKPN, https://smartgrid.ukpowernetworks.co.uk/flexibility-hub/; SPEN, https://smartgrid.ukpowernetworks.co.uk/flexibility-hub/; and GOPACS, https://smartgrid.ukpowernetworks.co.uk/flexibility-hub/.

A fundamental difference in the approaches of the United Kingdom, The Netherlands, and Germany exists. In the United Kingdom, the DSOs really plan for flexibility. They make the tradeoff between distribution grid expansions and procuring flexibility. UKPN, for example, recently committed in their RIIO-ED2 Business Plan 2023–2028 to 410 million £ of deferred load-related investments through the use of low-voltage flexibility. They estimated the cost of the flexibility services based on their experience with flexibility tenders. The DSOs in The Netherlands did not plan to use flexibility. They are forced to overbook the grids as they cannot follow the demand for grid connections and then have to procure flexibility to solve the resulting congestion in their grids. This situation is not the result of a cost-benefit analysis.

The DSOs in Germany are also in a different situation. They have also been overbooking their grids because there was a bigger demand for grid connection than they could offer, leading to high curtailment rates in certain areas. However, after controlling the most severe capacity issues with network investments, German DSOs can do a cost-benefit analysis to compare the cost of curtailment with the investment cost to expand their grids. In more detail, they can consider a curtailment of 3% of the annual output of each connection point in their network planning. In this context, buying flexibility services can be an alternative to compensating grid users for curtailing them. In other words, the German situation nicely illustrates how we can avoid DSOs being at the mercy of flexible service providers to solve congestion in distribution grids (the biggest worry of some skeptics).

## What Are Some of the Open Issues?

There are many open issues. In what follows, we illustrate a few.

### *Does Incentive Regulation Need to Be Enhanced to Make Sure DSOs Consider Flexibility as an Alternative to Investments?*

Flexibility services are operating expenditures (OPEX), and DSOs typically have efficiency benchmarks for OPEX with rewards if they outperform their OPEX baseline and penalties if they underperform. Distribution grid investments, however, are treated differently as capital expenditures (CAPEX). Once approved, CAPEX enter into the regulated asset base, on which the DSO receives a regulated rate of return. When DSOs use flexibility as an alternative to distribution grid investments, OPEX (cost of flexibility services) increase and CAPEX (cost of investments) decrease, negatively impacting their efficiency benchmarks and return on investments.

The regulatory authority in the United Kingdom, Ofgem, has been one of the first to address this financial disincentive by introducing what it refers to as the total expenditures (TOTEX) approach. It implies that a fixed share of the TOTEX (OPEX and CAPEX) can enter into the regulated asset base, which gives DSOs incentives to consider flexibility as an alternative to grid investments. Today, there is an ongoing discussion on whether to address this disincentive with regulatory measures. The most advanced incentive regulation schemes developed to address this issue have reached an inadvisable level of complexity. Considering that DSOs are under pressure anyway to keep their network tariffs under control, maybe the current push for more transparent network investment plans can be sufficient to compensate for the financial disincentive.

### *In What Situation Will We Use Which Approach to Source Flexibility?*

While the main focus of this article is on flexibility markets, there are also other ways to source flexibility. Generally, the provision of flexibility can be mandatory or voluntary, and flexibility contracts can be short or long termed. Table 2 illustrates both approaches by mapping different flexibility tools on these two dimensions. While each approach has its opportunities and disadvantages, the magnitude of these effects still needs to be determined. As a result, DSOs are examining different ways to contract flexibility in their networks. For example, the Dutch DSO Liander currently considers four congestion management alternatives to connect new grid users in congested network areas. Two types of short-term flexibility markets are tested using the GOPACS platform characterized by voluntary or mandatory participation of this new grid user in the market. Besides that, new grid users can also enter two kinds of long-term connection agreements, with and without day-ahead curtailment announcements by the system operator.

It will be interesting to learn more from theory and practice about the optimal approach to source flexibility and the interdependence of this choice on local network characteristics, such as the number of available flexible resources, grid topology (rural, urban, etc.), voltage level (low voltage, medium voltage, etc.), and congestion cause (renewables, EVs, data centers, etc.). Also, it will be important to better understand the pros and cons of combining different flexibility tools. While incompatibilities among the different approaches might exist, we also see opportunities for combining them, for instance, long-term flexibility contracts (voluntary or mandatory) with shorter term flexibility markets.

### *How Do We Ensure Coordination Between TSOs and DSOs?*

We have discussed the challenges and opportunities of procuring flexibility from a DSO perspective. However,

**table 2. Illustration of the two approaches to source flexibility using existing flexibility tools.**

| | Mandatory | Voluntary |
|---|---|---|
| Short term | | • Flexibility markets |
| Long term | • Default nonfirm connection contract<br>• Grid connection requirements | • Flexibility markets<br>• Choosing between firm and nonfirm connection agreement |

the DSO's activation of flexibility might also impact other energy stakeholders, such as the TSO. There are at least two interactions between TSOs and DSOs to consider. First, TSOs and DSOs might want to access the same flexible resources for different grid services, such as congestion management and balancing. This competitive interaction among system operators might create a need for cooperation or sequence in selecting flexible units. Second, TSOs and DSOs might impact each other's networks when activating flexible resources for their own purposes. When the activation of flexibility moves closer to real time, there might be a need for coordination or validation mechanisms between the system operators to avoid network issues.

Many stakeholders and academics have already recognized the importance of TSO–DSO coordination, which led to the development of different coordination schemes for the TSO's balancing and the TSO's and DSO's congestion management services. However, translating these coordination schemes into practice is often difficult because of the complexity of the problem and the required information sharing among the stakeholders. Therefore, new regulations to manage the described interactions among system operators might arise in the meantime. An example is the European System Operation Guideline, which allows DSOs to refuse the participation of flexible resources to the TSO balancing market based on technical reasons. It is only remains to see how these rules and coordination schemes will evolve in the coming years.

## In Summary

This article has four key takeaways, each relating to one of the discussed questions on congestion management in distribution grids.

1) DSOs in European countries, such as Germany and The Netherlands, increasingly face congestion in their distribution networks because of the connection of renewables, EVs, and new loads, like data centers. Heatmaps or hosting capacity maps are typically used by DSOs to report their congestion issues to grid users, and different practices exist.
2) Current practices on distribution network plans show the need for increased grid investments in the coming year to control congestion levels and recognize the opportunity for flexibility to contain these investment costs. However, there is not yet a consensus on the actual potential of flexibility as an alternative to distribution grid investments.
3) Third-party market platforms, such as Piclo Flex, GOPACS, and NODES, are tapping into this opportunity for flexibility and quickly growing over the years. These flexibility markets are used by DSOs for different reasons (e.g., to trade flexibility proactively or out of necessity) and have developed diverse types of products, time frames, and interactions with existing markets and system operators.
4) Open issues regarding congestion management in distribution grids include the financial incentives for DSOs to consider flexibility as an alternative to grid investments, the best approach for DSOs to contract flexibility regarding local network characteristics, and the coordination between the DSO and other stakeholders, such as the TSO.

In other words, when "fit and forget" is not an option anymore, we will have DSOs that proactively engage in flexibility and DSOs that might regret they did not; hence the title.

## For Further Reading


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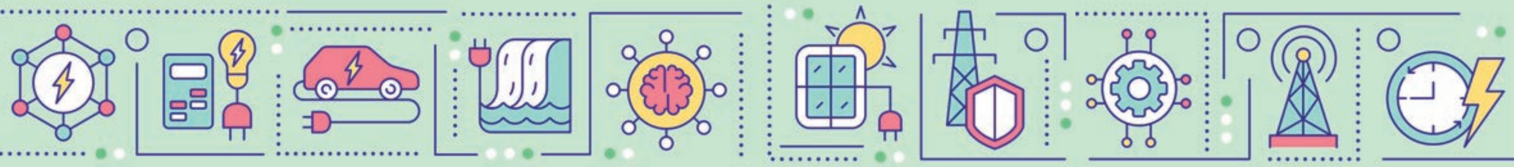

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# From the Humble Building to the Smart Sustainable Grid

## Empowering Consumers, Nurturing Bottom-Up Electricity Markets, and Building Collaborative Power Systems

RECENT GEOPOLITICAL DEVELOPMENTS HAVE PLACED GLOBAL DECARbonization at the top of the global agenda. However, moving toward a low-carbon energy system is challenging. The exponential growth of renewable technologies introduces unprecedented uncertainty in the operators' decision-making process, while the increasing electrification leads to drastic increases in demand, further straining the power grid. The behavior of electricity customers is no longer a passive parameter of system operation

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but an active part of it. Demand-side flexibility has been identified as a critical piece of the puzzle, i.e., stimulating customers to modify their consumption patterns and contribute to the energy supply through local production. Residential, office, and commercial buildings contribute roughly 30%–40% of the total energy consumption, hence holding massive potential to offer flexibility services.

To unlock this potential, individuals need to be provided with the necessary technological means [e.g., building energy management systems (EMSs)] plus efficient local electricity markets for trading their flexibility. However, these enablers are still nascent, currently lacking widespread engagement and sufficient fertile ground to fully unlock their bottom-up flexibility potential. This article discusses the challenges and potential solutions from consumers actively contributing toward low-carbon energy systems. It centers on the chain of increasing sustainability (see Figure 1): pure consumers, passive prosumers, smart and sustainable buildings (SSBs), local energy communities (LECs), and finally smart sustainable distribution grids underpinning a clean energy transition.

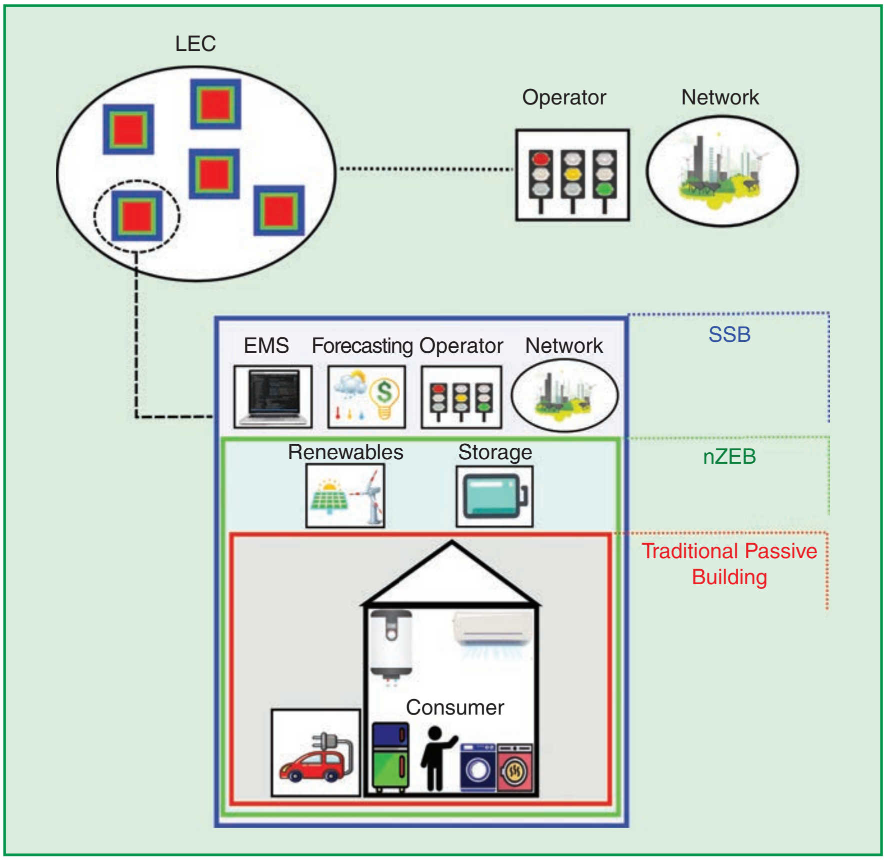


**figure 1.** From passive buildings to local energy communities: overview of main concepts. LEC: local energy community; SSB: smart sustainable building; nZEB: nearly zero energy building.

## The State of Buildings in 2022 and the Prospect of Demand-Side Flexibility

### *Where Are We?*

Global events have resulted in skyrocketing energy prices and increasing energy poverty. The European response has been a reinvigorated push for integrating renewable and low-carbon resources into the energy system, with net-zero energy independence becoming a priority across European governments. A key piece of the puzzle is the demand, specifically of residential and commercial consumers. In most developed countries, buildings account for 30%–40% of the total energy consumption, stemming from heating/cooling applications, lighting, and traditional everyday appliances. In the future, many anticipate an increase in electrical heating/cooling in individual households and common district systems. The rapid growth of electric vehicles will further add to the high demand. Traditionally, these developments would require massive reinforcements in the electricity grid infrastructure and lead to prohibitive electricity prices, unless a more intelligent, consumer-centric way of designing and operating buildings is employed.

A key aspect of the new status quo will be the strong presence of demand-side flexibility. By changing their energy profiles for some financial benefit, consumers can be empowered to actively support the energy grid operation. Examples include matching their consumption to

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the variable renewable energy production and lowering their demand at times of high system stress. Both electricity and thermal demand can be altered, e.g., by delaying or shifting the charging of electric vehicles or the operation of devices like space heating/cooling or washing machines. For instance, the United Kingdom's National Grid Winter 2022 Demand Flexibility Service asked consumers to reduce their aggregate demand at prespecified timeslots. After 10 hourly testing events, more than 1 GW of demand turn-down was provided, at £3,000/MWh.

### *What Could We Be Doing?*

How much flexibility could buildings really provide? While this depends on the type of building, early indications show heating loads as major contributors. A 2012 Danish study on the potential of residential heat pumps noted a 20% increased utilization of excess wind generation and reduced use of fuels utilizing thermal storage. Even for poorly equipped buildings, the most cost-effective solution was to utilize their thermal mass as heat storage (store heat in the construction). This solution allows for postponing or extending the heating/cooling without affecting the occupants' thermal comfort. Many buildings may also contain some type of thermal storage (e.g., domestic hot water tanks), which can use excess heat for space heating or for white goods, which in turn decreases electricity needs. Similar approaches could be used with district heating or cooling, where the thermal mass of buildings could be utilized similarly to buildings with heat pumps.

Despite the positive outcomes of such trials, large-scale nonindustrial demonstrations of demand-side flexibility have been limited. Efforts have mainly focused on uncoordinated calls for load reduction rather than on optimizing the aggregated building-level flexibility with respect to the energy system. Most buildings are equipped with simple energy meters without communication-enabled sensors and smart devices, hindering the efficient exploitation of demand response. While these are available in the market, consumer habits and conventional solutions in the residential sector are still dominant. The lack of system integration and synergies (sharing of devices and data) leads to technical redundancy, higher overall cost, and loss of customer value—a major barrier to implementing large-scale demand-side flexibility. Harnessing the increasing amounts of data is also a crucial impetus for fostering value in these new opportunities for customers, communities, and society at large. It is paramount to encourage data sharing and collaboration among the involved parties as this will unlock new opportunities to provide more integrated demand response services efficiently and cost-effectively.

## How Are Electricity Markets Supporting Bottom-Up Opportunities?

### *Where Do the Markets Stand Today?*

The reader must have pondered if there is any framework in place to entice more bottom-up support. Up to now, electricity markets have been mainly organized at the wholesale level, dominated by central (large) generation units. While this design was a perfect fit for fossil-fuel-dominated systems, it is now considered largely outdated for the transition to a low-carbon energy supply. Even today, no coordinated efforts have been made to formally integrate the flexibility made available from smaller, decentralized units, like renewable resources, battery storage, and demand-side flexibility. But what can be done to nurture these bottom-up opportunities for grid integration and flexible support? Let us discuss the current market and do a deep dive into the current (underused) opportunities.

Two types of electricity markets exist: *energy* and *ancillary services*. In energy markets, electricity is traded on different timescales (months ahead up to intraday); this typically translates into agreements or auctions to generate and consume certain amounts of energy at given timeslots. In ancillary services markets, a variety of support products helps system operators maintain the power grid stability. These services include reactive power to maintain acceptable voltage levels and frequency support to maintain the grid frequency at its nominal value or to restore balance after some failure (line trip, bad forecasting, etc.). Most services value ramping up or down power production/consumption (from seconds to 15-min periods) and, especially, maintaining this response for a sufficient duration. Traditionally, it has been large (fossil-fuel or nuclear) power plants trading across both types of markets. However, a low-carbon system with a heavy emphasis on decentralized smaller units increases the risk of insufficient cross-market liquidity. On the other hand, this situation also provides opportunities for new players to enter these markets and contribute to their growth. Examples include the following:

- ✔ *Virtual power plants* bring together smaller generation units (e.g., wind or solar, potentially supported by batteries and smart loads), the collective entity being treated as a single unit in the market. Thanks to the progress in digitization and communication, virtual power plants can be highly dispersed and need not be localized in a single area.
  - *Distributed energy resources* (connected to the distribution grid) can be *aggregated* at the power level (from kilowatts to megawatts) to provide ancillary services and at the energy level (from kilowatt hours to megawatt hours) to trade on energy markets. Across Europe, system operators are lowering the various thresholds for market participation, such that a handful of medium-sized distribution-connected resources can already participate competitively in wholesale markets. This push for leveling the playing field is often driven by emerging players like aggregators or prospective flexibility service providers.
- ✔ *Demand-side response* has enormous potential to contribute to maintaining grid balance or tempering electricity prices. As discussed, instead of being discarded, the excess renewable electricity generation could be consumed by increasing flexible electricity consumption. Including the demand side in the equation offers an entirely new perspective on how consumers could support power system management. The evolution of smart grids will allow tapping into demand response across all voltage levels, down to residential customers, small companies, and all manners of buildings in general; see Figure 2.

### How Could Markets Adapt to Accommodate More Demand Response?

Once again, demand-side flexibility pops up as a crucial aspect of the future energy system. The ability of smarter and more sustainable buildings to shift their electricity profile without impacting end-user comfort should be extended to full market participation. For more than a decade, it has been clear that residential appliances can in fact provide flexibility services. A 2015 Belgian study measured the flexibility potential of more than 400 residential appliances over a three-year period. Wet appliances alone could provide a 2-GW power increase (or a 300-MW decrease), sustainable for more than 30 min, for the whole of Belgium [peak demand is between 8 GW (summer) and 15 GW (winter)]. This outcome was made without accounting for the flexibility potential of electric vehicles, which have since

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**figure 2.** The Pinsent Masons building in London provides demand response services.

increased manifold. Indeed, the further decarbonization of the built environment and the electrification of end demand will multiply this potential. Additionally, the ongoing evolutions in information and communication technology will unlock this potential at lower costs, from individual SSBs to sophisticated energy communities. Smart control algorithms will maintain the integrity of end-user comfort, for instance by monitoring indoor temperatures or by charging electric vehicles before use.

SSBs have already started contributing to emerging distribution-level flexibility markets by providing services like congestion mitigation. For instance, some distribution system operators in the United Kingdom are procuring flexibility services from residential consumers at the low-voltage level, where enduring profile alteration or demand reduction is sought through smart or energy-efficient solutions. These services are far cheaper than reinforcing distribution grids in paving the way for the energy transition. Furthermore, they serve as tangible proof that the building sector can actively serve the grid's needs and leave behind something of lasting value. The reader should be made fully aware of the implications: this is not some far-fetched future scenario. These changes are steadily developing, and as long as they maintain traction, their positive impact will grow wider by the day.

With the rapid changes in the building sector, and some field-trial experience, it seems everything is in place, and it is time to establish local flexibility markets that incentivize and enable consumers to participate in the energy transition toward a more renewable supply.

## Coming Together Is the Beginning: The Story of the gENESiS Project

### *Defining the SSB*

Buildings and end users are clearly at the core of the energy transition. It is thus no secret that most research efforts and industrial developments are focused on the evolution of buildings into more sustainable and flexible entities and their optimal integration into electricity systems. In response to the growing need for a more holistic, sustainability-driven mindset, we should no longer approach buildings with a narrow perspective of "*what can the building do for me?*" Whole-system sustainability is a fundamental building block in the pursuit of climate change mitigation. The European objective has shifted to unearthing new ways for buildings and end users to contribute to the energy transition, as we move toward the net-zero system in an efficient and cost-effective manner. To get a clear indication of the previous claims, the reader needs only to go through the recent European initiative concerning new buildings, which stipulates that from 2020 onward they must all be nearly zero energy (nZE).

Inspired by the previous initiative, a 2019 international research project (a collaboration among Luxembourg, Belgium, and Denmark) sought to capitalize on the recently expedited shift toward buildings. Based on the concepts of the nearly zero energy building (nZEB) and the smart building (SB), the project proposed the SSB archetype (see Figure 3). Its salient features can be described as follows:

- ✔ A building is an nZEB if, over a year, its renewable energy production nearly matches its consumption.

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**figure 3.** Elie Radu is an nZE, smart, and sustainable school in Romania.

**table 1. Conventional Danish building versus SB performance over a 10-day period.**

| Case | Energy Consumption (kWh) | Operational Expenses Bill (€) |
|---|---|---|
| Conventional (winter) | 209.3 | 40.5 |
| Smart (winter) | 164.6 | 26.6 |
| Conventional (summer) | –156.3 | –22.4 |
| Smart (summer) | –236.8 | –41.7 |

- ✔ A building is smart if equipped with an EMS. Following a customer-defined objective, it optimally manages the building's assets (storage, load, generation, etc.) without compromising indoor comfort. Note that, while an EMS is a prerequisite for smartness, gauging the actual level of sophistication is a different discussion.
- ✔ A building is sustainable if, on top of being an nZEB, its material stock (construction and electric-thermal assets) has an overall low environmental impact based on its lifecycle assessment. This distinction is important: an nZEB is not necessarily sustainable if its environmental footprint (from construction to demolition) exceeds its nZE benefits. Sustainability is fundamentally tied to the initial design and continued operation phases.

## The Prospects of SSBs

SSBs and their integration into smart grids are of major value in building a more sustainable society. To provide the desired benefits, an SSB must be carefully designed, relying on advanced optimization models and centered on customer benefits and bottom-up empowerment across three phases:

- ✔ *Building design*: Prioritizing investment profitability by deciding on the optimal size and type of assets while meeting environmental and operational constraints. At this stage, factoring in future EMS actions and the potential flexibility interactions is desirable but often difficult to model with sufficient accuracy.
- ✔ *Energy planning and management*: Designing an efficient EMS that offers customers free reign over the benefit they wish to maximize. This benefit could range from economic (electricity bill minimization) to tradeoffs between monetary and environmental goals.
- ✔ *Grid integration and provision of flexibility services*: The paradigm shift from passive buildings to active SSBs revolves around the optimal integration of buildings in smart grids, i.e., examining and exploiting their win–win interaction modes. Sustainable consumers are decisively empowered to enter electricity markets through various products, such as shifting their consumption or arbitrating between production and consumption through battery storage.

With customers unlocking previously unknown revenue streams and grid operators being able to defer costly grid reinforcement and release additional capacity headroom, the result is a clear win–win situation. The inclusivity of this empowerment is its strongest asset: social benefits can be achieved both by opportunistic profit pursuit as well as by customers with genuine environmental concerns, ready to sacrifice some monetary gains in favor of a more sustainable goal. Some preliminary evidence is presented hereafter.

The validity of our hypothesis was tested on real residential buildings in Denmark (Table 1) and in Luxembourg (Figure 4 and Table 2). The building construction is different per country, but the main asset composition was the same: solar panel, electric vehicle, energy storage, heating, ventilation, and air-conditioning (HVAC), water heater, washing machine, and tumble dryer. For the specific experiments, the buildings were equipped (at no cost) with an EMS that independently scheduled and controlled the operation of the preceding devices. The buildings were directly exposed to wholesale energy prices, with the electricity bought and sold at market price, rather than at retail or a with fixed feed-in tariff. End users could override the default settings and program their own preferences into the optimization, such as when the car charging should be completed or during what time the washing machine should be operating. The Danish buildings were examined in two similar 10-day

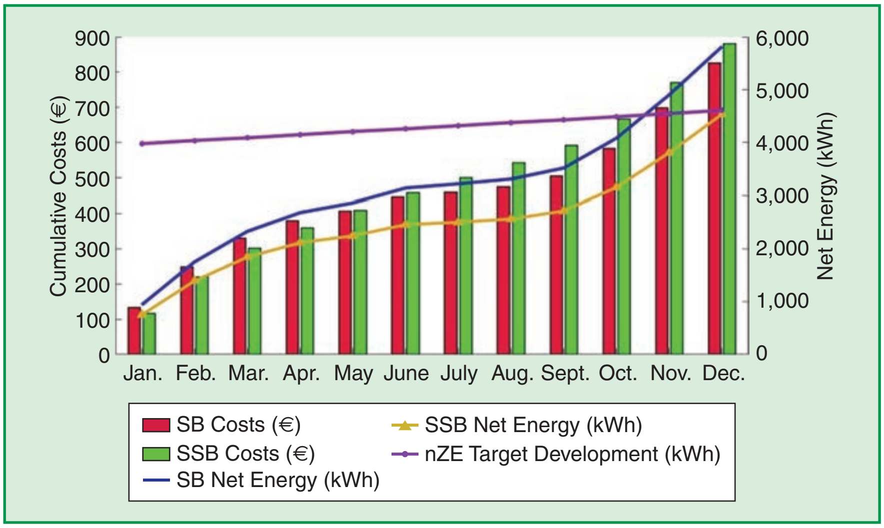


**figure 4.** SB versus SSB in a year with low solar production (buildings in Luxembourgian).

> The Danish buildings were examined in two similar 10-day periods over summer months and winter months, both with and without the EMS controlling the assets.

periods over summer months and winter months, both with and without the EMS controlling the assets. On average, the SBs achieved a 45-kWh energy reduction during the winter (a 40% cost savings) and managed to export an additional 70 kWh during the summer (90% additional benefits from selling power into the grid). The Luxembourgian buildings were examined during a year when the local solar production was much lower than expected. We compared SBs that did exclusively cost minimization with SSBs that simultaneously kept track of their environmental profile. The SBs did close the year with lower electricity costs (about 60 €), but the SSBs had a much lower net consumption (about 1,400–1,500 kWh). Under a carefully calibrated management strategy, the second type of building had a massively positive environmental impact at only 4 extra cents per saved kilowatt hour (this cost could be kept low due to the direct wholesale market access).

Table 2 presents the yearly flexibility provision of SSBs governed by different flexibility remuneration schemes and extra cost tolerances. Undoubtedly, the most important observation was that buildings can support grid operation at no additional cost even when flexibility is treated as a free service. Naturally, when flexibility remuneration is competitive to wholesale market prices, the system operator's collection of year-round requests is met at an excess of 90%. Though the customer's willingness to sacrifice some profits to support the grid is an important parameter to consider, the primary driver is clearly the financial value of flexibility provision—when the minimum financial value is set at reasonable levels, the SSB exhibits practically identical behavior regardless of the value of $\varepsilon$ (see the following paragraph). What is crucial to mention is that even though flexibility provision increases the yearly net consumption, imposing strict environmental constraints (e.g., nZE mandate and daily energy neutrality) can help in containing the resulting increase. Simply put, environmental goals can still be met assuming the flexibility requests are reasonable in terms of size.

The SSB concept proved unique in targeting the fundamental agents of the green energy transition: making the building desirable for consumers, grid operators, and the environment. However, the marriage between these agents was not always organic; it requires a variety of mathematically rigorous methodologies in support. Everyone will naturally prioritize their own objective, some focusing on designing green buildings and monitoring environmental impact, and others being more concerned with participating in local flexibility markets. Naturally, there is no end to the prospective complexity and diversity. For example, highly sophisticated customers may want to track the national low-carbon energy production and appropriately steer their building profile or try to gain more independence from the grid. While accommodating everyone's aspirations will be challenging, the win–win effect is inevitable. If anything, the Luxembourg-based project demonstrated that a collaborative approach, where the requirements of individual agents are sufficiently met, is a viable proposition. Coming together requires no more proof, simply action.

**table 2. Yearly flexibility requests and delivery for the different scenarios examined.**

| Scenario | Flexibility Request (kWh) | Flexibility Provision (kWh) |
|---|---|---|
| FP = 0 €/kWh, $\varepsilon$ = 0% | 246 | 168 (68%) |
| FP = 0.15 €/kWh, $\varepsilon$ = 0% | 273 | 263 (96%) |
| FP = 0 €/kWh, $\varepsilon$ = 15% | 390 | 313 (80%) |
| FP = 0.15 €/kWh, $\varepsilon$ = 15% | 257 | 257 (99%) |
| FP = 0 €/kWh, $\varepsilon$ = 25% | 323 | 297 (92%) |
| FP = 0.15 €/kWh, $\varepsilon$ = 25% | 277 | 270 (97%) |

FP: reimbursement offered for flexibility provision; $\varepsilon$: maximum extra cost to maintain nZE status.

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**figure 5.** An LEC in the continental United States.

## Staying Together Is Progress: Creating Smart Sustainable Energy Communities

### Defining Local Energy Communities

No matter how sophisticated an individual consumer or building is, the lone path is rarely efficient. A single unit rarely has a big enough piece of the pie to instigate change. However, the story is quite different when you band together; this is where collective energy initiatives come into play. From energy cooperatives to ecovillages and large-scale communities—aggregated energy entities are currently popping up all over Europe. Built with the fundamental objective of serving the participants' collective welfare, LECs strike a balance between being innovatively disrupting, socially beneficial, and reasonably complex. They are viewed as a highly promising option to achieve collective energy representation in a sustainable way.

The legislation put forth in the European Clean Energy Package formally acknowledged the term *energy community*, defining the legislative framework for "citizen-energy communities" and "renewable energy communities." Broadly, an LEC (see Figure 5) is a legal entity with open and voluntary participation to organize its members' collective energy actions to provide economic, environmental, or social benefits. The LEC members can engage in various activities, including generation, distribution, supply, storage, consumption, aggregation, sharing, and energy-services provision. Customer empowerment and social innovations are at the heart of the LEC concept. End users with co-ownership of renewable energy resources become responsible for their collective energy actions, thus assuming an active role in the energy transition. LECs can promote the implementation of local energy projects that would be challenging for single individuals to launch, facilitate increased autonomy and grid independence, and provide easy, cost-effective, and fair access to local renewable energy, especially to energy-poor and vulnerable customers. Furthermore, by enabling end users to assume various roles, LECs can give birth to innovative solutions and new business models and opportunities.

### LECs in Service of People, Sustainability, and the Grid

The simplest way for an LEC to enjoy economic benefits is to export its locally produced renewable energy surplus to the local grid. Its members can further agree to steer their collective behavior toward maximizing their self-sufficiency and/or self-consumption, further boosting grid independence and shielding them from events like price spikes. This local optimization is also beneficial for distribution grids as it leads to reduced network losses and increased efficiency. Cases exist where an LEC has led to the reduction or even full deferral of network reinforcement. LECs may also provide a variety of services to grid operators, such as demand response of aggregated energy patterns or provisional energy storage through an aggregator.

The SSB-focused project also examined the optimal management of diverse LECs (with different types of end users) to simultaneously achieve economic objectives and support the local distribution grid. The examined LEC was unique in that every agent involved played a distinct role in forming its operation—from the LEC's shared energy storage down to the individual electric vehicle or washing machine. First, each customer optimized its behavior, and then the shared battery asset further coordinated the collective profile to maximize self-sufficiency or self-consumption. The community battery could also provide extensive support to the grid, either in the form of direct energy requests or by the grid operator reserving part of the

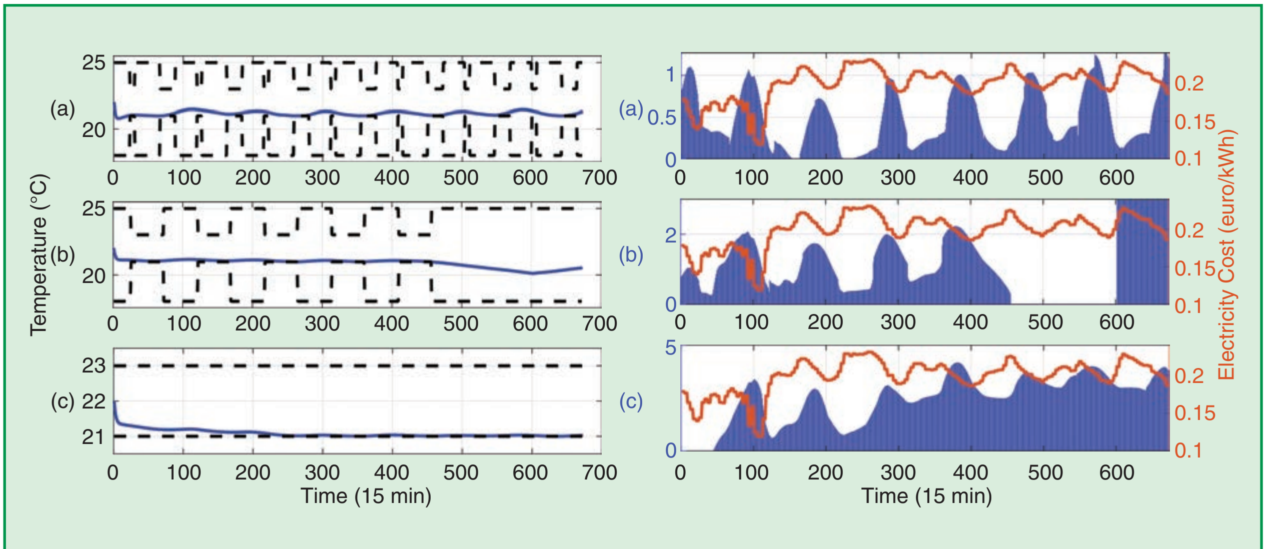


**figure 6.** Indoor air temperature and HVAC power consumption over a week for: (a) residential building, (b) office building, and (c) health-care facility.

battery capacity to be on standby. Preliminary results were positive, with the proposed control structure proving computationally efficient, less prone to cyberattacks and data leaks, and financially beneficial for all participants. Aside from the LEC reaching self-sufficiency levels of more than 97% (during summer), individual buildings could indirectly receive up to €3 within a 2-h period due to the communal battery providing flexibility services (the number in the U.K. trials was close to £2.8).

It is also worth observing whether the aforementioned financial benefits lead to any negative consequences in terms of comfort for the LEC members. Figure 6 presents the weekly indoor air temperature evolution, accompanied by the power consumption levels of HVAC devices (managing the internal temperature), for the three examined building types: residential, office, and health-care facility. As expected, the EMS of each building maintains the desired comfort range with no issue and does so optimally to maximize monetary returns. The temperature dynamics are clearly different between the different building types, but this is simply an academic observation; all that the end users need to know is that the temperature is consistently within acceptable levels. With respect to how the electricity price affects the internal temperature profile, each HVAC system reserves its intense operation for low-price periods. Naturally, the consumption pattern also implicitly reflects the occupancy and thermal needs per building type: residential buildings demonstrate a repeating up-and-down pattern (people going to and returning from work), office buildings operate at high demand during the work week and shut down during the weekend, and health-care facilities maintain a cost-optimal yet consistently active operation.

At the same time, these setups are still under trial, and it is important to remain vigilant of still necessary improvements. Despite the immoderate advantages, there is still vagueness surrounding the specific legal standing of LECs. Because of this situation, member states can make unilateral decisions, which may hinder the harmonic development of a common framework. The necessary level of technical sophistication is no secret; significant investment in information and communications technology (ICT) infrastructure is required to optimally set up LECs. Finally, the interests of LECs and system

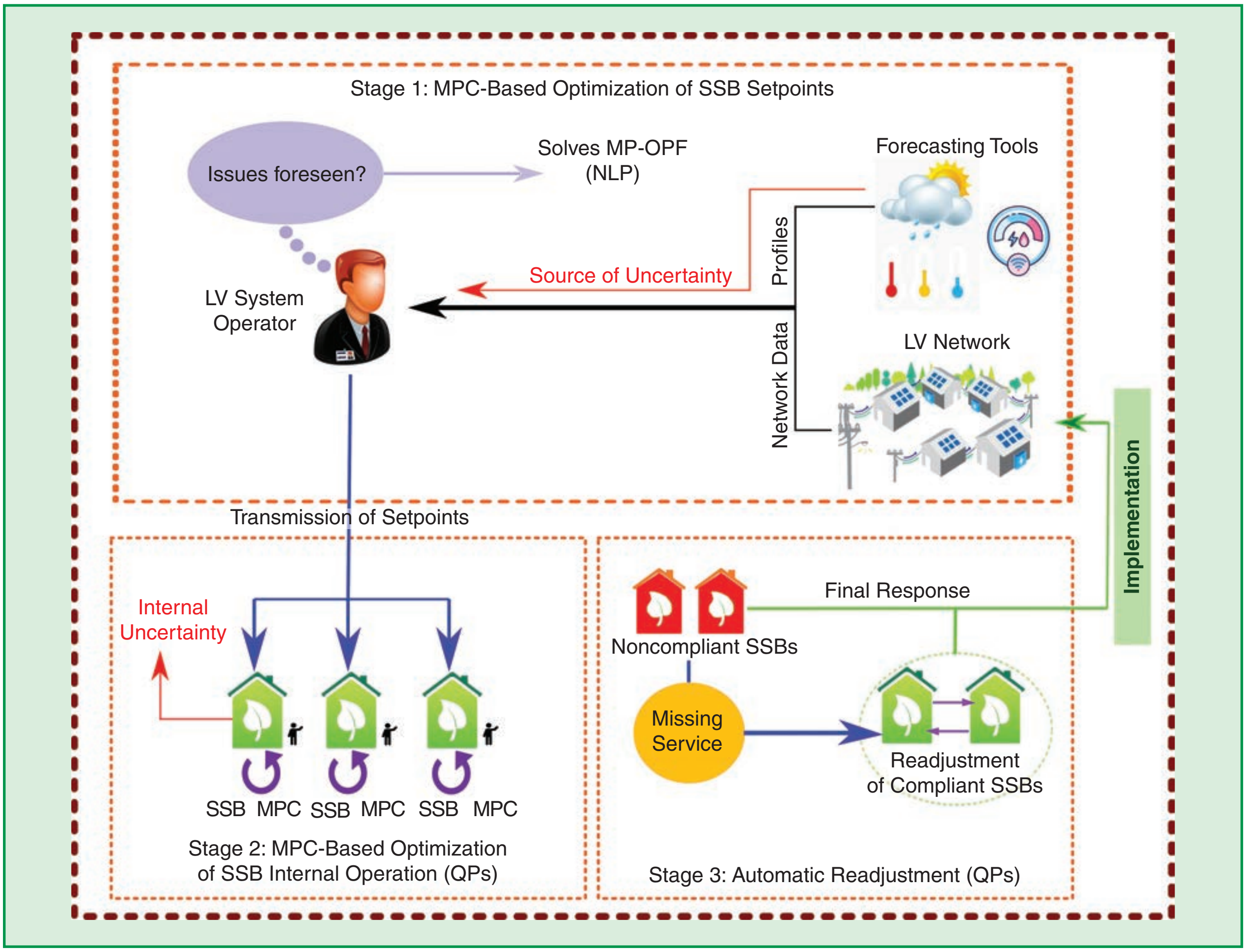


**figure 7.** Bringing it all together: a collaborative approach to build smart sustainable power grids. MPC: model predictive control; MP-OPF: multiperiod optimal power flow; NLP: nonlinear programming; LV: low voltage; QP: quadratic program.

operators can lie at vastly opposing ends, which can lead to the activation of conflicting services and lead to further grid stress and a collective loss of social welfare. Regulatory frameworks enforcing suitable tradeoffs are yet to be found.

## Working Together Is a Success: Toward the Smart Sustainable Power Grid

### *Defining a Rigid Customer–Grid Collaboration Framework*

This article has focused on supporting end users and fostering bottom-up developments. Still, one should not discount the merits of top-down approaches, i.e., grid operators dictating development according to network needs. It is true that bottom-up approaches lead to customizable, nonintrusive approaches that allow for significant leeway in designing one's strategy for interacting with the grid. This approach is a great way to stimulate interest and large-scale investment in sustainable development. However, removing all restrictions from end users would likely result in an unpredictable setting for grid operators with little room for collaboration, which is not sustainable in the long term. Now, giving the same freedom to grid operators is also unreasonable, but there are positive elements to be adopted. The high degrees of network optimality and compliance, alongside the superior observability, monitoring, and control, are not prospects to be easily discarded. In the end, the idea is to merge the positive aspects of the two viewpoints, contain any fallout from their caveats, and ultimately devise a collaborative approach, depicted conceptually in Figure 7, for optimal network management and increased social welfare.

Such an approach was shown to be viable. Starting with some more academic assumptions (e.g., a knowledge of network topology and building composition) and evolving into a more industry-friendly version, the project demonstrated that serving the objectives of all parties is feasible. The proposed first-of-its-kind three-stage design borrowed elements from all viewpoints: top-down network optimization and the creation of unique requests, partially voluntary bottom-up optimization from individual customers, and an ad hoc local flexibility market for whenever the voluntary support fell short. This approach produced very positive results, even with significant leeway for end users and limited communication. When compared to utopian, purely bottom-up or top-down alternatives, the collaborative approach resulted in no more than a 14% reduction in the recorded benefits for either party—a small inconvenience indeed for setting up a viable framework for smart collaboration.

### *Extracting Industrial Value for the Smart Sustainable Power Grid*

Going from theory to practice always requires stretching our assumptions and pushing closer to realism. Is there really much value to extract as we challenge ourselves with increasingly tight margins? The proposed approach challenged itself across six axes, noting the following:

- ✔ *Granularity*: Moving closer to real-time network management was possible, even when pushing the limits of practicality. One could go down to 15-min time steps, accompanied by long optimization horizons, up to 24 h long.
- ✔ *Scalability*: The complexity of similar (academic) approaches usually precludes scaling up. In this case, targeted approximations reduced solution times by up to 95% without compromising the quality of the results beyond an accuracy deterioration of 1.4%.
- ✔ *Data availability*: Limiting the amount of available information to a minimum would theoretically preclude any meaningful result. However, the use of only basic network models and black box building models did not hinder the effectiveness of the collaborative approach, demonstrating its viability even under the usual real-life challenges that we would normally face.
- ✔ *Communication*: Communication often breaks down, and information will not always be perfectly exchanged among parties. Still, a collaborative approach with high levels of participation and coordination proved resilient against communication failures. Even under extreme scenarios, the overall objective was admirably served, its deterioration not crossing the 1% threshold. This outcome was evidence of true industrial relevance.
- ✔ *Customer diversity*: Collaborative approaches should be inclusive and functioning with every type of end user since uniform customer compositions are rare. This inclusiveness was a fundamental prerequisite that resulted in an approach that was readily applicable to any building setting.
- ✔ *Exploiting overabundant flexibility*: Very rarely do we observe instances of too much flexibility being available; discarding residual capabilities would be a clear loss of opportunity. Tapping into the prospective financial and grid benefits was first proposed in this collaborative approach: after meeting local requirements, we expand these services to the upstream system and higher voltage levels. Besides the additional revenues for consumers, the contribution to whole-system security results in a drastic drop in market and network costs. Grid operators can engage with

previously inaccessible flexibility and ultimately focus on higher level objectives, like sophisticated coordination with the national power system.

## In Summary

While the overarching topic of this article is fostering the bottom-up empowerment of end users and buildings, we covered many different topics with the following key messages:

- ✔ *Buildings today and prospects*: Buildings are a significant contributor to global energy demand, making them an excellent candidate to undergo sustainable transformation. They can passively achieve high energy efficiency and customer benefits and ideally support grid operators with flexibility services. Though not widespread, these opportunities paint a hopeful picture.
- ✔ *Market support for buildings*: Despite the vast untapped potential, the few available local market structures are nascent and not broadly inclusive (with high barriers to entry, complex participation requirements, etc.). The added whole-system value is massive, as seen in several large-scale applications. Most tangible attempts to incorporate demand response have been crowned with success, paving the way for establishing proper frameworks at the global level.
- ✔ *The SSB*: The SSB is the meeting point between long-term environmental friendliness, smartness in service of unearthing customer benefits, and ability to support the grid's operation with flexibility. Recent research efforts have identified significant added value for society through this brand-new resource with high potential.
- ✔ *The smart sustainable community*: Collective energy representation can eliminate some techno-economic barriers that individual consumers would face by themselves. It makes achieving sustainability and economic goals easier and significantly expands the range of flexible options that can be offered to support the grid, thus unlocking new revenue streams.
- ✔ *The smart sustainable power grid*: Neither end users nor grid operators can pursue their objectives independently, mandating some form of collaboration. By reconciling bottom-up and top-down viewpoints, one can satisfy multiple objectives, even in the presence of practical restrictions like ICT failures or customer diversity. Positive effects are not limited to the local level and can have far-ranging implications, reducing network costs through the provision of multilevel flexibility services and seeding the ground for new electricity markets.

Significant potential exists for SSB applications. Their development fulfills the energy requirements of cost-effectiveness and sustainability. The concept is bound to dominate future developments as we move closer to the low-carbon 2050 vision. However, it is key to avoid one-sided developments and establish a fair and transparent collaboration framework. The best way to do so remains open, but agreeing on some basic common goals is the first action. Technological developments in smart sensors and meters are vital as these new sources of information will enable optimal energy management. On the other hand, stimulating consumers is not only a matter of technical and financial benefits; it requires a multidisciplinary approach, including the involvement of experts from social sciences to understand what people may best react to, depending on social, economic, and geographical context. From planning to implementation, success starts and ends with a common strategy and by being proactive rather than reactive. In the words of Albert Einstein: "A clever person solves a problem. A wise person avoids it."

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## For Further Reading

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# The Challenge of Integrating Demand Response

CAPACITY REMUNERATION MECHANISMS (CRMS) have become a pillar of the design of decarbonizing electricity markets. By complementing the economic signals conveyed by the energy market, they aim at enhancing resource adequacy, particularly in the current context in which power systems transition toward low-carbon technologies. CRMs are also being mentioned as a key piece to prevent, in the future, scenarios such as the energy crisis that started in 2021 in the European Union.

Although CRMs have been frequently criticized and identified as a tool for subsidizing conventional generation driven by fossil fuels, they have shown their potential in fostering new technologies and business models. International experiences have shown how demand response (DR) can compete with generation technologies and play a relevant role in capacity mechanisms. For instance, demand resources covered 10% of the capacity market in the Pennsylvania, New Jersey, and Maryland power system (PJM), one of the largest interconnections in the United States, in recent years. Figure 1 shows how dependent demand-side response has been upon the revenues coming from the capacity market of this power system. DR participation in European CRMs is also growing, but it accounts for only 3% of the demand for firm capacity in the region.

Integrating demand resources in CRMs is beneficial for the system since it reduces overall costs and promotes resources whose contributions in terms of flexibility will be much needed in future power systems. However, this participation adds a layer of complexity to the design of capacity mechanisms. Two key elements in the design of the CRM are particularly relevant when it comes to integrating DR: 1) the way the demand to be covered by the capacity mechanism is defined by the regulator and 2) the methodology to allocate the costs of the CRM among consumers who benefit from that coverage. There is currently a gap in the academic literature on resource adequacy and CRMs, which has often missed delving into these two aspects.

**By Pablo Rodilla, Paolo Mastropietro, and Paulo Brito-Pereira**

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## Providing a Comprehensive Theoretical Framework

The goal of this article is to define a comprehensive framework for the participation of demand resources in capacity mechanisms, identifying all potential participation modes and highlighting the inefficiencies that could arise from certain designs. The article first assesses the aforementioned two central design elements of CRMs for the efficient participation of demand resources, i.e., the methodologies to set the demand for firm supply and to allocate the costs of the CRM. Then, it defines a classification of all potential participation modes, listing the benefits and the potential inefficiencies of each of them but also highlighting which are being used in real CRMs. Finally, the article draws on regulatory recommendations.

## Demand for Firm Supply and Cost-Allocation Strategy

Most of the literature on demand participation in capacity mechanisms focuses on how the demand can sell some sort of DR service in the CRM as a capacity provider and some associated features of this participation (baselining and derating of DR agents). However, the potential role of DR conditions the process earlier on since it should be considered from the very start, i.e., when the regulator or the system operator estimates the expected need for firm supply during the delivery period.

*Firm supply*, a concept that encompasses both firm capacity and firm energy, is the expected contribution of a resource during scarcity conditions in the system. In capacity-constrained systems, such as power systems on the East Coast of the United States or in Europe, firm supply is usually computed through a derating factor (or capacity credit) to be applied to the installed capacity of the resource.

In most capacity markets, the demand for firm supply is set administratively, without any active role from consumers. In centralized capacity markets, this exercise results in a demand curve that is used in an auction, which tries to reflect some degree of elasticity. This elasticity is defined administratively, too. In decentralized capacity markets, the demand for firm supply is computed for each load-serving entity through an administrative methodology.

The most efficient way for demand to participate would be the involvement of end users in this initial phase, letting consumers define their own demand for firm supply without administrative interventions; this demand for firm supply would become the upper limit of their consumption during scarcity conditions in the system. Alternatively, the regulator could estimate an initial requirement for each consumer or consumer group and then allow them to increase or decrease such value. These approaches would also simplify and improve the efficiency of the cost allocation since such a self-declared demand for firm supply is the best cost driver on which to apply CRM charges. This process would be symmetric to the derating process for generation resources. Each consumer (or consumer group/category) would pay the costs of the capacity mechanism according to the consumer's expected "negative" contribution to the reliability of the system (since procuring 1 MW of firm capacity entails contributing "negatively" for that amount).

Nevertheless, in most CRMs, the demand for firm supply is estimated in a very aggregated way. For instance, the demand curve in capacity auctions is defined through an estimation of the whole-system demand and its evolution in the future, potentially applying a least-worst regret approach (e.g., in the United Kingdom). This approach significantly constrains the kind of participation that can be expected by demand resources, as analyzed in the next section.

As already mentioned, another design element of CRMs that affects demand participation is the methodology for the recovery of the costs of the mechanism. The latter arises from the signature of capacity contracts with reliability providers, selected either through a centralized auction or through bilateral contracts. It must be noted that, once these contracts are signed, their cost is a sunk cost. Therefore, a reduction of demand during scarcity conditions with respect to the estimation made to set the demand for firm supply does not reduce these costs, which must be paid even if the service is not activated. This condition equates CRM costs to other residual costs in the power sector, such as residual network costs or policy costs. According to economic theory, residual costs should be allocated, minimizing distortions to the economically efficient signals defined to recover other costs.

In the case of capacity mechanisms, this least distortion could be achieved, in principle, through the application of a fixed charge per customer. This charge should reflect the contribution of each consumer to the demand for firm supply. If this information cannot be extracted from the process of setting this demand, then the charge could be proportional to the historical consumption of each consumer during scarcity conditions. A moving average over a certain number of years or delivery periods could be applied to historical consumptions. Other cost-allocation methodologies are possible, such as the application of capacity charges on withdrawals made during actual scarcity conditions. As already mentioned, these withdrawals are not the real cost driver (reducing demand in real time would not reduce the CRM costs once they have been incurred). However, such a cost-allocation methodology may foster efficient behavior from consumers that could reduce future needs for further firm capacity, although it would also result in the under-recovery of CRM costs.

International practices, however, favor simple volumetric charges applied over a very large number of hours. For instance, Ireland applies a CRM charge to electricity suppliers according to the demand they serve during day hours (from 7:00 a.m. to 11:00 p.m.) during the entire year. Italy recovers 70% of CRM costs through charges applied to energy withdrawals during the 500 "peak

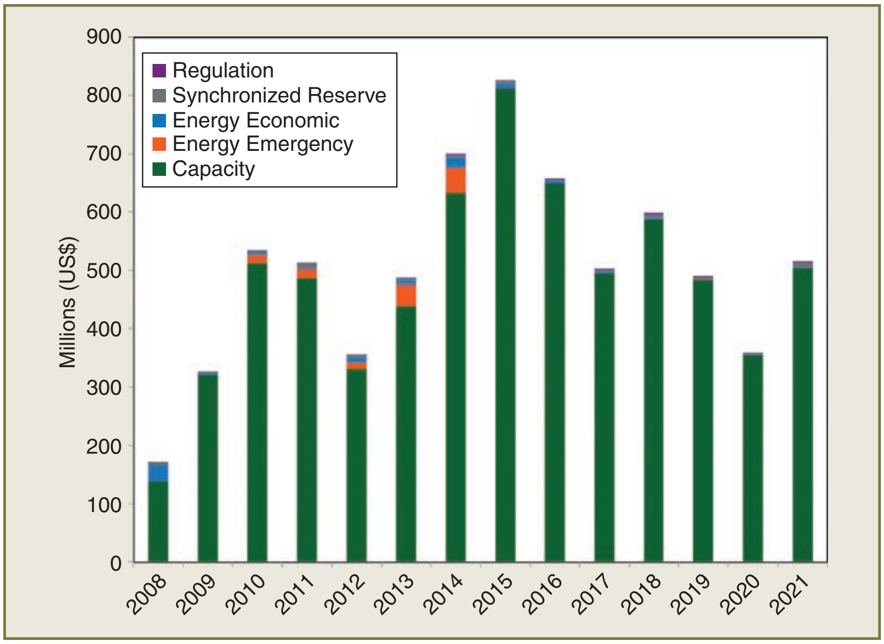


**figure 1.** The evolution of demand resources income in PJM; chart from Monitoring Analytics' State of the Market Report.

hours," defined as those hours in which the system is more likely to suffer a stress event; the remaining part of CRM costs is recovered through a much lower charge applied during the rest of the hours of the year. These cost-allocation strategies are equivalent to socializing the sunk CRM costs without providing any efficient signal to consumers but without guaranteeing cost recovery either. This approach affects the different modes of demand participation, as analyzed in the next section.

## Different Modes of Demand Participation in CRMs

After defining the necessary background on the methodologies for estimating the demand for firm supply and the strategies for CRM cost allocation, it is possible to classify the participation for demand resources in capacity markets into different participation modes. Using the standard terminology of DR, two broad categories are identified as follows:

- ✔ *Explicit participation:* Consumers explicitly take part in some phase of the capacity market and assume binding commitments. They can do that 1) in the demand side of the capacity market, by defining their demand for firm supply or 2) in the supply side, by selling DR services that are equated to the reliability services offered by generators. This participation mode is addressed in the "Implicit Participation" section.
- ✔ *Implicit participation:* Consumers do not explicitly participate in the capacity market, and they do not assume any binding commitment to reduce their load. However, they react to CRM charges during its operation, modifying their demand to reduce their contribution to the coverage of CRM costs (and, if charges are designed properly, their contribution to scarcity conditions). This participation mode is addressed in the "Implicit Participation" section.

### *Explicit Participation*

#### Demand Side (Opt-In or Opt-Out)

Although very infrequently used in practice, the most obvious way to involve consumers in capacity mechanisms would be to conceive an active role for them in the calculation of the demand for firm supply (according to some authors, PJM may be moving in this direction). Ideally, consumers could be asked to define beforehand the capacity they expect to need and withdraw from the power system during future scarcity conditions. The selection of this demand for firm supply could be informed by some brief report from the system operator with estimations on the number of stress events expected in the system and on the range of the charges to which this capacity demand would be subject. This value would limit actual withdrawals in real time during stress events since consumers would commit not to exceed that capacity demand. In power systems where smart meters have already been deployed, this approach could encompass the entire demand, including residential or regulated demand. In a few countries (e.g., Spain), consumers are already asked to specify different contracted capacities, e.g., for peak or valley hours, which are subject to different charges. Widening this approach to include resource adequacy would only require asking consumers to specify an additional contracted capacity that would be used to limit consumption during scarcity conditions (or to impose sanctions on the withdrawals exceeding it).

This theoretical approach would move the responsibility of defining the demand for firm supply fully onto consumers' shoulders. Although technically feasible, this shift may be challenging from a regulatory and political point of view. However, there are other approaches that mimic this first alternative and partially achieve its benefits. For instance, the regulator or the system operator could estimate an aggregated demand for firm supply but compute a disaggregated estimation for certain consumer categories (e.g., large commercial or industrial end users). The latter would then be given the chance of opting out, i.e., of reducing or directly setting to zero the demand for firm supply assigned to them. The opt-out would generate a commitment that allows the system operator to limit withdrawals during scarcity conditions, but it would also exempt the consumer from paying CRM charges for the opted-out capacity. This approach is represented graphically in Figure 2 for a centralized capacity auction whose demand and supply curves and the corresponding market clearing are depicted in a price-quantity chart. The same reasoning could be applied, however, to decentralized capacity markets in which the obligation for each load-serving entity could be reduced through an opt-out of some of its end users.

A similar approach would consist of estimating the demand for firm supply only for certain consumer categories (e.g., residential or regulated demand). The rest of the consumers would be required to define their own demand through an explicit opt-in in the capacity market, which would generate the same commitments that have already been mentioned previously. This opted-in capacity could be used to simply shift the demand curve [chart in Figure 3(b)], or these consumers could be asked to present price-quantity demand bids, also specifying the value that they assign to the firm supply [chart in Figure 3(c)].

It must be noted that these approaches would also simplify the allocation of CRM costs. The demand for firm supply is the real driver of these costs. Therefore, if some or all consumers have a certain demand for firm supply earmarked to them, either estimated by the regulator/system operator or self-defined by the end user, CRM charges could be easily applied to this capacity during each delivery period.

#### Supply Side (DR)

The disaggregation of the demand for firm supply is a complex task that, as mentioned in the "Different Modes of

Demand Participation in CRMs" section, is hardly found in real CRMs. Especially in centralized capacity markets, the demand is commonly defined for the entire system, and no opt-in or opt-out is allowed. In this context, consumers can still participate in the capacity market by offering DR services. These services are offered through price-quantity supply bids that go into the supply curve of the market, as shown in Figure 4. However, it must be highlighted that the consumers involved in such DR are represented twice in the auction, both in the demand curve (since they are part of the whole-system demand for firm supply) and in the supply curve. This feature is prone to arbitrages and other inefficiencies, as analyzed next.

For consumers to offer DR services in the CRM, the regulator must design a reliability product that these resources will be allowed to trade in the capacity market. In principle, the reliability product should be the same for all the resources competing in this market segment and should reflect the ability of each agent to contribute to the reliability target in force in the power system. However, many regulators, both in Europe and the United States, have defined specific reliability products that are tailored to the characteristics of demand resources and are meant to foster their participation. This is the case, for instance, of the reliability-option CRMs introduced in Belgium and Italy and of the decentralized capacity obligations traded in France. For instance, in Belgium, demand resources are allowed to bid their own strike price, a key element for the settlement of the reliability option.

### *Baselining*

Another element required to allow this kind of demand participation and the assessment of its performance is a methodology to identify a demand baseline. The latter may be used to define the firm supply of these demand resources in conjunction with a derating factor. Derating of demand resources usually depends on the self-declared or tested duration of the service that the demand aggregator can provide. Usually, the lower the duration, the lower the expected contribution to scarcity conditions and, consequently, the

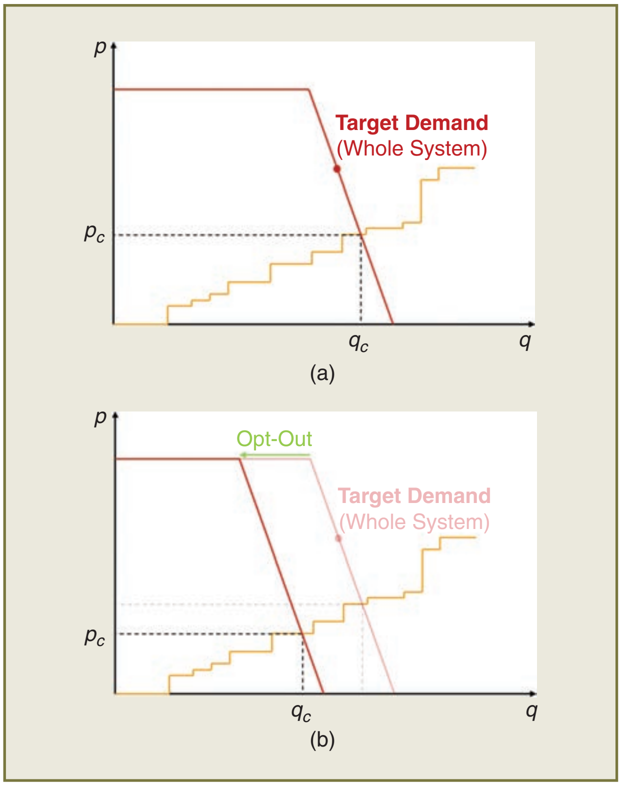


**figure 2.** (a) and (b) The explicit participation of demand resources in the demand side of the CRM through an opt-out (the demand curve mimics curves used in real CRMs, which represent demand elasticity).

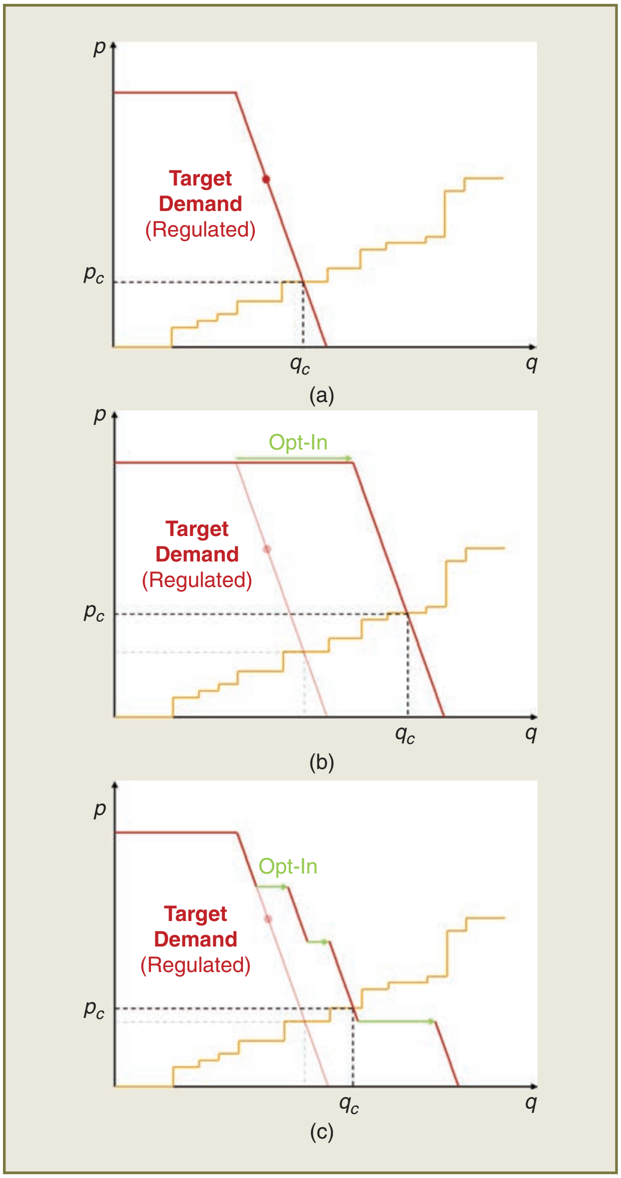


**figure 3.** (a)–(c) The explicit participation of demand resources in the demand side of the CRM through an opt-in.

derating assigned to the resource. The demand baseline is also essential to verify and quantify the compliance of these resources to their capacity commitments by comparing the actual withdrawal with the one that would have been registered if the service had not been activated.

As for any other DR program, several baselining approaches are possible. Some recent studies, such as the ones developed by Elia, the Belgian transmission system operator, found that the most widely adopted methods for capacity mechanisms are historical and control-group baselining. The former uses historical data to estimate the expected demand in the activation period by applying exclusion rules and rankings. For instance, high-X-of-Y methodologies focus on the last Y days of the same kind of activation day (e.g., working days) and, within this group, select the X days with the higher load. For each settlement period, the baseline is defined by averaging the load during these X days. Historical baselines may also rely on some sort of same-day adjustment, i.e., a methodology that modifies the baseline according to the load registered during the day of activation (with expedients to avoid gaming from the demand resource to overestimate its contribution). A typical example of a historical baseline methodology with same-day adjustment used in the California Independent System Operator (CAISO) is shown in Figure 5.

Control-group baselining does not rely on historical data but estimates the load that the demand resource would have withdrawn if it was not activated based on the withdrawals of a control group of consumers. These consumers may be selected from among those who are providing DR (randomized controlled trial over a small number of active consumers), or they may be consumers with similar characteristics to those in the DR program but who do not provide DR services. In particular, this type of demand baselining is used in the United States.

Other baseline methodologies, which are rarely used in the framework of capacity mechanisms, are Meter Before/Meter After, which defines the baseline based simply on the load registered before the DR service is activated; declarative baselining (in which the baseline is estimated directly by the DR service provider, who communicates it to the operator); and regression-based baselining (in which the baseline is computed through a complex formula with several parameters, such as temperature and daylight, whose coefficients are defined based on historical data).

### *The Double-Remuneration (or Double-Benefit) Problem*

The supply-side explicit participation of demand resources in CRMs has a significant disadvantage that stems from the presence of a certain group of consumers both in the demand and in the supply curve of the capacity market. A demand

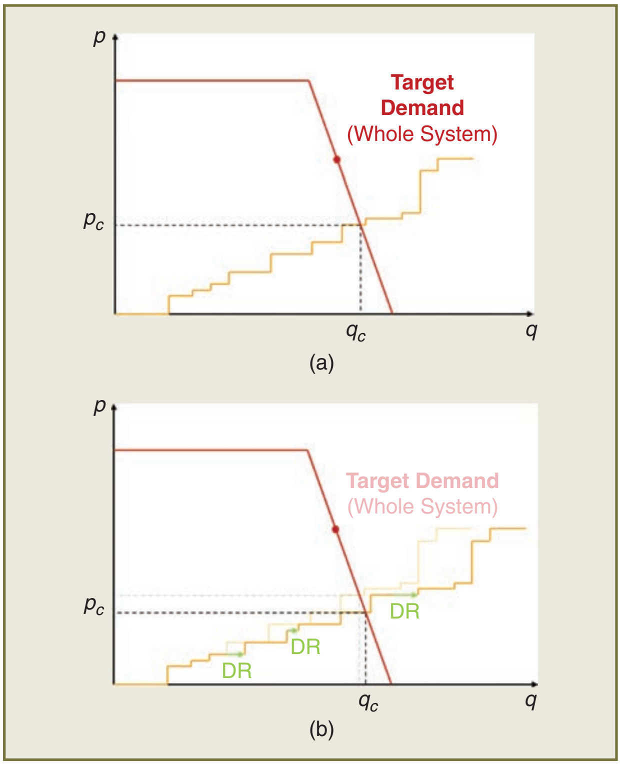


**figure 4.** (a) and (b) The explicit participation of demand resources in the supply side of the CRM through DR services.

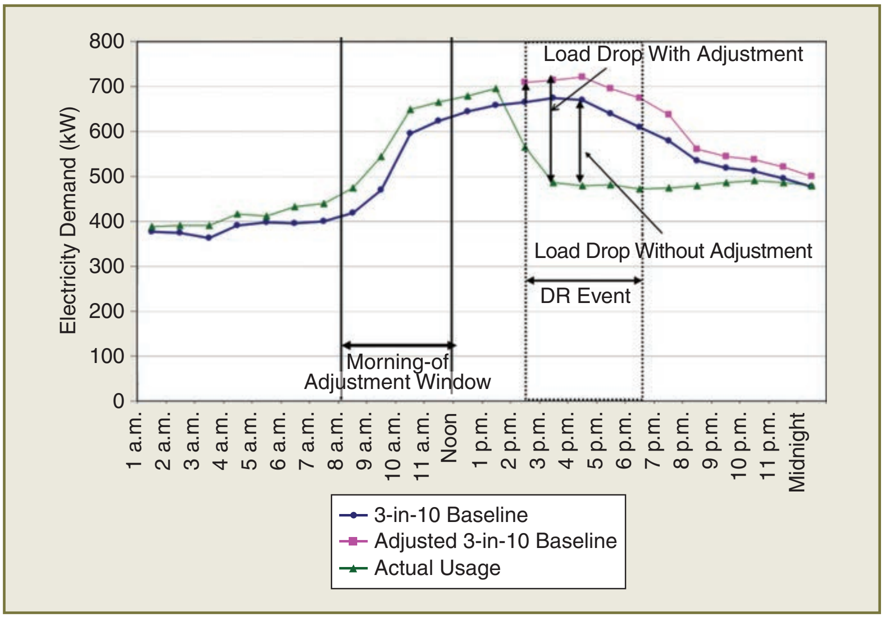


**figure 5.** Historical baselining with morning-of adjustment used in CAISO.

resource taking part in the capacity mechanism is remunerated for reducing its load during scarcity conditions. However, by doing so, it can also reduce its contribution to the recovery of CRM costs if the charges are designed to allocate these costs to the withdrawals during scarcity conditions. This way, the demand resource is remunerated twice, and more importantly, its net position in the CRM could be larger than zero, i.e., it could have a net revenue from its participation.

However, what the demand resource is actually doing is just reducing or setting to zero its load during scarcity conditions with the final goal of avoiding the payment of CRM charges (and without benefitting from the coverage of the mechanism). Therefore, its net position in the CRM should be, at maximum, null. This point of view was clearly stated by the Italian regulator ARERA during the design of its capacity mechanism. According to its criteria, a demand resource involved in a capacity market provides a service that can be used only by itself (through the consumers by which it is formed, who are also represented in the demand curve). However, the service from a demand resource cannot be provided to a third party, unlike the service provided by a generator, whose position in the CRM is, of course, expected to be larger than zero.

The risk of a double remuneration for demand resources depends on the design of CRM charges. Paradoxically, the double-remuneration problem has been avoided so far thanks to the inefficient cost-allocation strategies adopted in most capacity mechanisms. Volumetric charges covering a very large number of hours reduce the benefit that can be achieved by demand resources reacting during scarcity conditions. However, cost-allocation strategies based on capacity charges during scarcity conditions could increase the risk of double remuneration for demand resources. The most efficient way to deal with this problem would be, once again, to introduce fixed CRM charges (based, for instance, on historical consumption during scarcity conditions). With this approach, the demand providing DR services would pay a fixed amount of CRM costs and would offset this quantity by the revenues it receives from the capacity market. If all the elements of the CRM are properly harmonized, this combination should result in a net position close to zero, although deviations are possible.

### *Implicit Participation*

Once the capacity market is cleared and commitments assigned, there is still some space for implicit demand participation. The potential for this kind of participation mode clearly depends on the design of the charges introduced to recover the costs of the mechanism and on the signals they convey. Demand resources can basically shift their load to minimize payments derived from these charges, moving their consumption out of potential scarcity conditions.

As mentioned in the "Different Modes of Demand Participation in CRMs" section, the real driver of CRM costs is the contribution of each consumer to the demand for firm supply, and a good proxy parameter to estimate this contribution is the historical load during scarcity conditions, with a moving average. Using historical data with a moving window certainly dilutes but does not eliminate the signal for consumers to reduce their load. If data from the last five years are used, an end user who manages to eliminate the load during all scarcity conditions registered in the system would stop paying any CRM charge after five years. The signal could be further strengthened if charges are applied on consumption during scarcity conditions in the delivery period, although this strategy may affect cost recovery.

In real CRMs, however, the implicit participation of demand resources has always been almost nonexistent since, in the majority of cases, CRM costs are recovered through volumetric charges applied over a large number of hours, impeding an efficient reaction by the load. The United Kingdom offers a paradigmatic example. Since the introduction of the capacity market, CRM costs were recovered through a charge on electricity suppliers that was applied to the net demand (gross demand minus embedded generation) they served from 4:00 p.m. to 7:00 p.m. in the working days from November to February. This approach prompted suppliers to sign agreements with embedded generation (mainly diesel gensets) to produce in those hours, thus reducing the net demand. This kind of DR was not efficient from an adequacy point of view since the load reduction was taking place in hours where no scarcity was registered, and it was having a harmful environmental impact. For this reason, the cost-allocation strategy was modified in 2018, and CRM charges are now applied to the gross demand of each supplier to avoid this inefficient implicit participation of demand resources. However, the inefficiency stemmed from an inefficient cost-allocation strategy, which was only partially amended by the 2018 reform.

## Conclusion and Regulatory Recommendations

Demand resources and the flexibility they may provide to the power system are extremely valuable in achieving resource adequacy. Most capacity mechanisms in place today allow the participation of demand resources, although with different rules and different outcomes. While DR covers a larger share of the demand for firm supply in some power systems in the United States, Europe is lagging behind, and DR accounts only for under 3% of capacity markets in the region.

This article presents a comprehensive theoretical framework for the participation of demand resources in capacity mechanisms. Its first finding is that the efficient participation of these resources depends on the definition of the demand for firm supply and the cost-allocation methodology. Regulators should define accurate methodologies that allow computing the demand for firm supply as disaggregated as possible. The most significant advantage of this approach is that it facilitates the participation of consumers in the side of the CRM where they belong, i.e., the demand side. The regulator would define the demand for firm supply for each end user or broader categories of them. Consumers would then be allowed to modify this value, defining the capacity they would like to be covered by the capacity mechanism and at which they would be allowed to withdraw during scarcity conditions.

A disaggregated definition of the demand for firm supply also allows a more efficient cost allocation. In fact, this demand is the real driver of CRM costs; these costs, once the capacity market is cleared, should be considered as sunk costs, and they will not vary if consumers reduce their demand during the delivery period below the value that was procured for them. If the demand for firm supply is disaggregated, CRM charges could be easily applied to the demand for firm supply allocated to each consumer (or broader categories) through fixed charges. Fixed charges could also be applied on a proxy basis, for instance, using historical consumption during scarcity conditions. Other approaches for cost allocation could try to foster some sort of implicit participation of demand in the capacity market by reacting to the economic signals conveyed by charges. This goal could be achieved, for instance, by applying capacity charges during scarcity conditions, although such an approach may endanger cost recovery. CRM costs can also be recovered through simple volumetric charges applied over a large number of hours, as is done today in many CRMs. However, these charges do not send any efficient signal to consumers and can be equated to a de facto socialization of these costs.

If consumers are not allowed to take part in the definition of the demand for firm supply, then they can be allowed to participate only in the supply side of the capacity market, where they could sell DR services. This approach is actually the most widely adopted in capacity mechanisms. However, it presents several complexities, stemming from the fact that the same demand is represented twice in the capacity market, both in the supply side and in the demand side. This situation could result in the so-called double-remuneration problem, when a demand resource is remunerated for reducing its load during scarcity conditions, but by doing so, it also reduces its contribution to the coverage of CRM costs.

The participation on the supply side also requires methodologies for the definition of a baseline. As mentioned in the article, the most widespread methodologies are historical (e.g., high-X-of-Y) and control-group baselining. In theory, demand resources should be required to provide exactly the same reliability product as other resources since they compete in the same market. However, several regulators have defined specific products that are tailored to DR services and are meant to reduce the risk perceived by these agents and to incentivize their participation.

All these complexities for the participation of demand resources in the supply side of the capacity market, if not properly addressed, may result in significant inefficiencies in the operation of the CRM. Regulators should strike the right balance between supporting DR and ensuring the performance of the capacity mechanism.

## Acknowledgment

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# Assuring a Sustainable Decarbonization

By Tim Schittekatte and Carlos Batlle

EUROPE STARTED TO GO THROUGH AN EXTREMELY severe energy crisis in the summer of 2021. The Brussels-based think tank Bruegel reported that governments spent billions of euros, representing several percentage points of their gross domestic product, to shield consumers and industry from high prices (Figure 1). Even when considering that substantial public support, many end users were (at the time of writing, in February 2023) still facing energy affordability issues. At that time, it was not possible to foresee the end and whether an unprecedented scenario of a period of sustained high prices could repeat itself. However, what the energy crisis showed was that although it was a gas crisis, the current regulatory power market compound proved to be fragile to political interference. In this article, we elaborate upon a proactive regulatory-driven solution with the aim to protect (certain tranches of) end users from periods of sustained high electricity prices. Thereby, political turmoil leading to potential negative consequences for the ongoing decarbonization process can be avoided. We call our proposal *affordability options*.

At the time of writing, political interference manifested itself in costly interventions in the functioning of power markets (e.g., revenue caps and fuel subsidies for thermal generators as the so-called Iberian exception) and in more radical calls to overthrow the regulatory compound gradually built up over the past two decades and more. It is worth starting out by pointing at the actual reason behind the current urgency to change the regulatory compound in the European Union (EU): (marginal) energy prices have reached sustained and never expected high levels, and there are reasons to think that this is not necessarily going to be an exceptional situation. Adding to this, also much earlier than expected, investment costs of renewable energy sources (RES) have been significantly reduced. RES appear now not only to be by far the cheaper alternative power generation resources but also to be capable of collecting significant income when participating in the spot market. These two factors have led to a political desire to allow end users (in some cases, specific categories of customers) to benefit from these reduced costs, even if this might imply reconsidering the rules governing power markets that have been undisputable so far.

In a theoretical market context with strictly zero entry barriers, the current crisis would be nothing less than a great opportunity. From today to tomorrow, thousands of renewable megawatts could connect. Since there would be a severe risk to new entrants of what now has been called *cannibalization*, they would necessarily have to rely on some sort of long-term commitments with end users. The massively entering renewables would quickly bring overall price levels down by selling their currently below-market-price energy, considering not only their operating costs but also capital

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## Affordability Options

expenditures and a reasonable rate of return. But the fact that the power market is far from this theoretical ideal needs little explanation, for entry barriers (technical and economical) are very significant. It is in this context that the open (and like any other marginal) market framework is severely questioned. However, the market framework is a compound of many interrelated mechanisms, and the fact that the current market outcomes might deviate from what politicians would desire does not mean that all its building blocks are malfunctioning. In this article, we discuss two of these important building blocks: spot markets and long-term markets.

Spot power markets—even though often seen as the core issue by politicians and the wider public—have been working as they were supposed to do. Spot price signals lead to the dispatch of the least-cost resources, the efficient organization of cross-border trade, and, if end-user tariffs are properly designed, the possibility for end users to optimize their consumption patterns. Importantly, due to the successful coupling of the day-ahead (and intraday) market, billions of euros are saved each year across the EU. Any change to the spot market's price setting rules, as some radical proposals for "market reforms" apparently aim to do, risks fragmenting the European market. As discussed, for instance, in Hogan 2022, in a future with a more heavily decarbonized power mix, marginal spot pricing becomes even more important than it already is today; it is the only suitable way to coordinate increasingly volatile supply and increasingly controllable demand, storage, and grid flows. Obviously, the European spot power market design can and should be gradually improved over time. Examples are fully locational prices, less complex and more convex bidding formats, the removal of utility portfolio-based balance-responsible parties, and scarcity pricing.

What has never worked are long-term markets. More precisely, there is a total lack of sufficient electricity price hedging opportunities beyond two years in organized forward markets; i.e., long-term markets are "incomplete." The conclusions of the EU Agency for the Cooperation of Energy Regulators' final assessment of the EU wholesale electricity market design were also largely aligned in this respect. It is not the objective of this article to delve into the reasons behind this market flaw (e.g., vertical integration generation/retail and a lack of demand-side participation in long-term markets, partly due to transaction costs but mainly due to the trust in governmental intervention in times of stress). However, it is undisputed that long-term market incompleteness has been an issue of concern for years and that there has not been any advance along these lines. Hence, any proposal for the improvement of the existing regulatory compound should be focused on completing the long-term market rather than making any change to the short-term market.

How to complete the long-term power market is the topic of this article, particularly to provide those more sensitive end users with some sort of hedge and also to prevent politicians from panicking. We divide the article into three main parts. First, we explain the rationale behind the need for a regulatory-driven complement to the long-term market, aiming at the mitigation of affordability concerns. Second, we describe the affordability option product design. Third, we discuss the procurement of affordability options, splitting the discussion up between new and existing generators. We end with a summary.

## Completing the Long-Term Market to Mitigate Affordability Concerns

The issue that power markets have significant entry barriers and are far from being complete has been recognized for a long time, which has led to complements to the energy-only market idea developed decades ago. Since the implementation of electricity markets worldwide, first via the design of stranded cost mechanisms and then through different sorts of subsidization tools (mainly) for nonemitting technologies as well as via capacity remuneration mechanisms (CRMs) in some contexts, policy makers have intervened with the expectation to guarantee at least a "reasonable" floor on the income of the generation capacity deemed necessary. These complements are variants of (mostly) centrally organized auctions awarding long-term contracts.

The main objective of CRMs is to complete the market by reducing uncertainty in future revenue streams of resources that are deemed necessary to continuously guarantee a sufficient level of resource adequacy. None of the existing CRMs lead to a (significant) transfer of income from the generators to consumers during periods of sustained high spot prices. In the current European context, capacity is not the problem: no blackouts and rolling brownouts are witnessed. There is still a lot of work to do to improve the design of these mechanisms. Although this discussion is of utmost importance, we deem it out of the scope of this article.

The aim of support schemes for RES is to provide revenue certainty for new investments in carbon-free generation technologies. RES support schemes are also not designed to protect against affordability issues, but some types of RES support do, rather by coincidence than by design. For example, under contracts for differences (CFDs), RES generators sell their production in the spot market and receive/pay the difference between the preagreed strike price and the reference price. Currently, strike price levels are typically under the average spot prices witnessed in the past year. Consequently, significant income is transferred from CFD holders to their counterparties, which indirectly (depending on the tariff regulation) transfer (or should transfer) this income to end users.

However, apart from a few cases in South America (e.g., Peru and Brazil), these regulatory mechanisms are mainly focused on promoting adequate investment on the generation side, and thus, they do not necessarily hedge future electricity bills. In the current context, the difficulty for politicians and, in general, the wider population is to understand how it is possible that some sort of hedge for demand in case prices could skyrocket was not equally envisaged. Implicitly trusting in governmental protection in case of need (as the EU energy crisis has confirmed), end users have evidenced their relentless insufficient participation in forward markets. The crisis also shows that the same is true for several retailers. In any case, there is no doubt that the direct impact of the current price levels on the financial health of certain tranches of consumers is a major issue that needs to be tackled. Beyond that consideration, this scenario of electricity prices reminds us of a higher-order threat: the potential loss of trust (and patience) in the political class (and the mass media) in the whole market compound. The probability of overreaction after a price shock

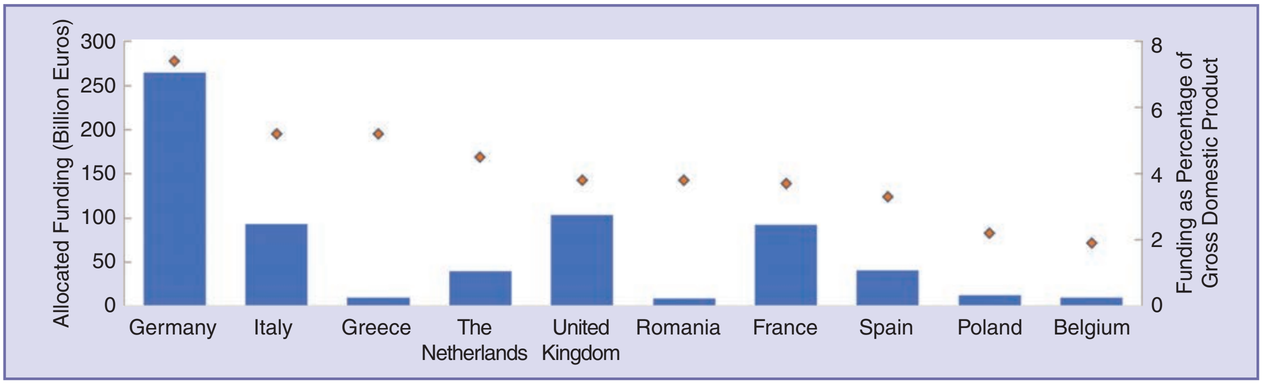


**figure 1.** The government funding to shield households and industry from high energy prices in the 10 most populous countries in the European Union and the United Kingdom, from September 2021 to January 2023 (and updated on 13 February 2023). (Data source: Breugel.)

Governments spent billions of euros, representing several percentage points of their gross domestic product, to shield consumers and industry from high prices.

of this nature, potentially leading to a major step back in the decarbonization process, can no longer be seen as a risk: it is a fact. The Australian market suspension that took place in summer 2022 can be taken as another illustrative example.

Risk-averse governments cannot directly hedge themselves against that risk unless they have a stake in the electricity generation companies and redistribute their inframarginal rents. However, doing so would, in some countries, imply the (forced) divestment of privately owned companies. Also, in the EU, the direct redistribution of any rents to electricity consumers would have been a violation of State aid rules in force until the crisis took place. The only reasonable way to hedge that risk, at least in that context, is to introduce a hedge on behalf of the consumers that are deemed in need of bill protection. The introduction of such a hedge would be welfare enhancing. The risk for sustained high prices would be transferred from risk-averse consumers (and, indirectly, the risk-averse government) to less risk-averse market parties that can better manage this risk. The transferred risk would create an incentive for those market parties to hedge themselves by investing in generation assets (e.g., RES plus storage) and/or the purchase of long-term gas contracts. A chain of long-term hedging contracts would possibly be "ignited," which would lead to a more efficiently functioning power system. So far, the need for generators to hedge themselves against very high gas prices, at least in the middle to longer term, is limited, as they can directly pass through the costs of high gas prices via high electricity prices.

An important question is whether each of these desirable policy goals that the so-called energy-only markets have very rarely shown to deliver in their current shape (resource adequacy, decarbonization, affordability, and others that we do not discuss) requires its own procurement mechanism and long-term product. Even though politically harder to pursue due to additional complexity, the stance we take is that it seems more appropriate to tackle each goal separately. However, it is hard to deny that there are spillovers. These spillovers can be positive or negative; e.g., RES support aimed at decarbonization potentially mitigates affordability issues but can worsen adequacy concerns (especially when RES support schemes are ill designed). In this article, we focus on the affordability concern.

## Product Design of Affordability Options

The aim of the regulatory-driven long-term complement is to protect at least some categories of consumers (e.g., those consumers considered particularly vulnerable) during periods of sustained high energy prices. At the same time, the product must not distort incentives provided by spot markets for both generation and load. In short, what an affordability option does is introduce a preagreed transfer of the gains of generators that are profiting from periods of sustained high prices to consumers suffering affordability issues. This protection does not come for free; consumers pay a fee for this "insurance" (such as a regulated RES levy in the bill), while generators exchange part of their uncertain future revenues for a regular payment. In what follows, we discuss in more detail how three key design choices of affordability options are determined to comply with the original aim: the choice for an option product and not an obligation, the settlement frequency, and the level of the strike price. We also provide a brief discussion on the difference with reliability options and a numerical example.

First, the introduction of a financial option is more suitable than an obligation (i.e., a two-sided CFD), as the objective is to protect end users from periods of sustained high prices, rather than to entirely fix the price paid for electricity under any scenario. It can be argued that a CFD would also hedge end users in the long run, without necessarily minimizing their incentive to respond to short-term signals; this is partially true, but we consider that an option would be a less intrusive solution. More precisely, when covered by an option, the electricity bill would remain unaltered during periods of "normal electricity" prices, while a CFD would have an impact under any price scenario.

Second, the objective of the hedge provided by the affordability options is not to protect consumers from sporadic price spikes. Instead, the objective of the hedge is to prevent sustained high prices from threatening the financial health of certain categories of end users. What eventually matters for end users are not a few hours of very high prices (which can have a moderate impact on the monthly bill) but months with very high bills. In this regard, an Asian option for which the payoff depends on the average of all prices over a specific period seems to be a suitable product design, as opposed to vanilla European and American options, where the payoff is determined at a single expiration date. We propose that affordability options have a monthly fixing to be aligned with typical bill cycles. A "strip" of affordability options should last sufficiently long; we propose a duration of five to 10 years (respectively, 60 to 120 "bill cycles").

Third, the level of the strike price can be interpreted as the maximum average electricity price (arithmetic or load weighted) that is deemed sustainable over the given settlement period. What that exact price level will be is at the discretion of the regulator (e.g., an average day-ahead electricity price of €100/MWh over a month). Obviously, the lower the strike price, the higher the option premium and vice versa.

Affordability options are not to be confused with reliability options that have been introduced to mitigate adequacy concerns in, for example, Colombia, Ireland, and Italy. The idea of reliability options is to induce investment (and retain installed capacity) that is flexible enough to support the power system when it is very tight. Moments of high stress are reflected by scarcity prices. This reasoning behind the design of reliability options leads to different design choices: an hourly settlement and a relatively high strike price. Table 1 shows the interactions between the choices for the settlement frequency and strike prices.

Figure 2 provides an illustration of the functioning of affordability options. Figure 2(a) shows the hourly prices in the Spanish day-ahead market in 2020 and 2021. Two different abnormal price scenarios are highlighted in different colors. In cyan, January 2021: in the second week of that month, a persistent blizzard affected half of the country and led to the occurrence of some hours with high prices. In red is December 2021, a month in the middle of the ongoing energy crisis. Figure 2(b) and (c) provides greater detail of the prices resulting in these two months.

If the regulatory decision would have been to hedge, for instance, vulnerable customers with an affordability option at a strike price of, for example, €100/MWh and a flat load profile, the impact in both cases would have been radically different. In January, even though spot prices were above €100/MWh 51 times during the month, the average price was €60/MWh. Therefore, the affordability option would not have been exercised ("out of the money"). Conversely, the average price in December was €239/MWh, and the electricity bills of vulnerable customers would have been beyond the acceptable range. The affordability option would have been exercised, resulting in a payout of €139/MWh. Imagine that, on behalf of each vulnerable consumer, 300 kWh were contracted per month. In that case, each vulnerable consumer would receive €41.70 per month to compensate for the high electricity costs. However, the same customers would still be incentivized to consume more when prices were low and vice versa.

## Engaging With Newly Connecting and Existing Generators

In this section, we go into more detail on how we see the completion of the long-term market to avoid affordability concerns. We divide the discussion between new entrants and existing generators.

### *Newly Connecting Generators: Auctions, Bundling Access, and Long-Term Contracts?*

The crisis has woken the demand side. In contrast to the situation before the crisis began, there is currently an increased eagerness to sign long-term contracts with new entrants. The developers that were recently granted access to the network on a first come, first served basis can benefit from their application. At current spot price levels, these developers of renewable power plants can go merchant or sign lucrative long-term contracts, in most cases collecting a higher income than the levelized cost of energy of their investments. It might take some time for spot price levels to go down. Also, the pace of connecting renewables seems to have slowed down in several countries, mostly due to administrative issues (permitting and the like), a lack of or limited availability of physical grid connections, and, more recently, supply chain bottlenecks. Two questions arise when thinking about new entrants, as summarized in Table 2: how to deal with the network connection and how to deal with exposure to price risk.

### *Auctions to Enhance Competition for Accessing the Network and End Users*

Regarding the network connection, the lesson learned should be: no more granting network access for free, not for any resource, renewable, or other (at least not at the transmission level). A more adequate mechanism to allocate scarce connection opportunities is the introduction of auctions for granting network access. Auctions for granting network access are not a new idea, but it has not been generalized, so far. Examples are auctions of offshore wind sites in North

**table 1. The tradeoffs and opportunities for the design parameters of the auctioned-off call options and the impact on the cost of the option premium.**

| | High Strike Price (e.g., €1,000/MWh) | Low Strike Price (e.g., €100/MWh) |
|---|---|---|
| High-frequency settlement (e.g., hourly) | Reliability options in Colombia, Ireland, and Italy: protection from scarcity prices, exposure to short-term signal for consumers | Constant protection from high prices, limited exposure of short-term signal for consumers |
| | Ambiguous impact on cost option premium | High option premium |
| Low-frequency settlement (e.g., monthly) | No protection from scarcity price and sustained high prices, full exposure to short-term price signals for consumers | Affordability options: protection from sustained high prices, exposure to short-term signal for consumers |
| | Very low option premium, as option is (almost) never exercised | Ambiguous impact on cost option premium |

Sea countries and the United States. The ability to auction the right to connect not only allows leveraging the benefits of competition for access to the system but also makes more efficient coordination of generation and transmission capacity expansion possible, which is a major challenge today.

Regarding the exposure to price risk, the question becomes how to auction scarce network capacity. As in current Portuguese auctions, there are two extreme alternatives: auctioning an annual fee for access and auctioning network access bundled with a long-term contract. In the case of an annual access fee, the choice between selling electricity in the spot market and signing long-term contracts with private entities is up to developers. Shortly before the crisis began, incumbents claimed that there was no longer a need for governments to grant RES support in the form of any sort of long-term contracts. The main argument was that the levelized cost of renewables was reaching market value levels. The counterargument for keeping auctions awarding long-term contracts for RES in place was that new entrants could not easily find counterparties for power purchase agreements (PPAs). New entrants are in a significantly worst position than vertically integrated incumbents, which already have direct access to counterparties thanks to their historically inherited portfolio of customers. To that extent, RES auctions for mature technologies gradually became nothing more than a sort of CRM, of which the objective was "to complete" the long-term market and thus level the playing field between incumbents and often nonvertically integrated new entrants.

Following that reasoning, auctioning network access bundled with long-term contracts could lead to higher competitive pressure. Competition would push the price levels awarded in the long-term contracts closer to the levelized cost of new entrants and thus further from the market value of the generated electricity. At the same time, the feasibility of massively deploying RES generation to reach decarbonization targets would not be impacted. Another important advantage, in this context of auctioning long-term contracts jointly with network

**table 2. A stylized summary of key choices to make about new entry.**

| | Choices | |
|---|---|---|
| Network connection | First come, first served | Auction for access |
| Exposure to price risk | Merchant | Auction for long-term contract |

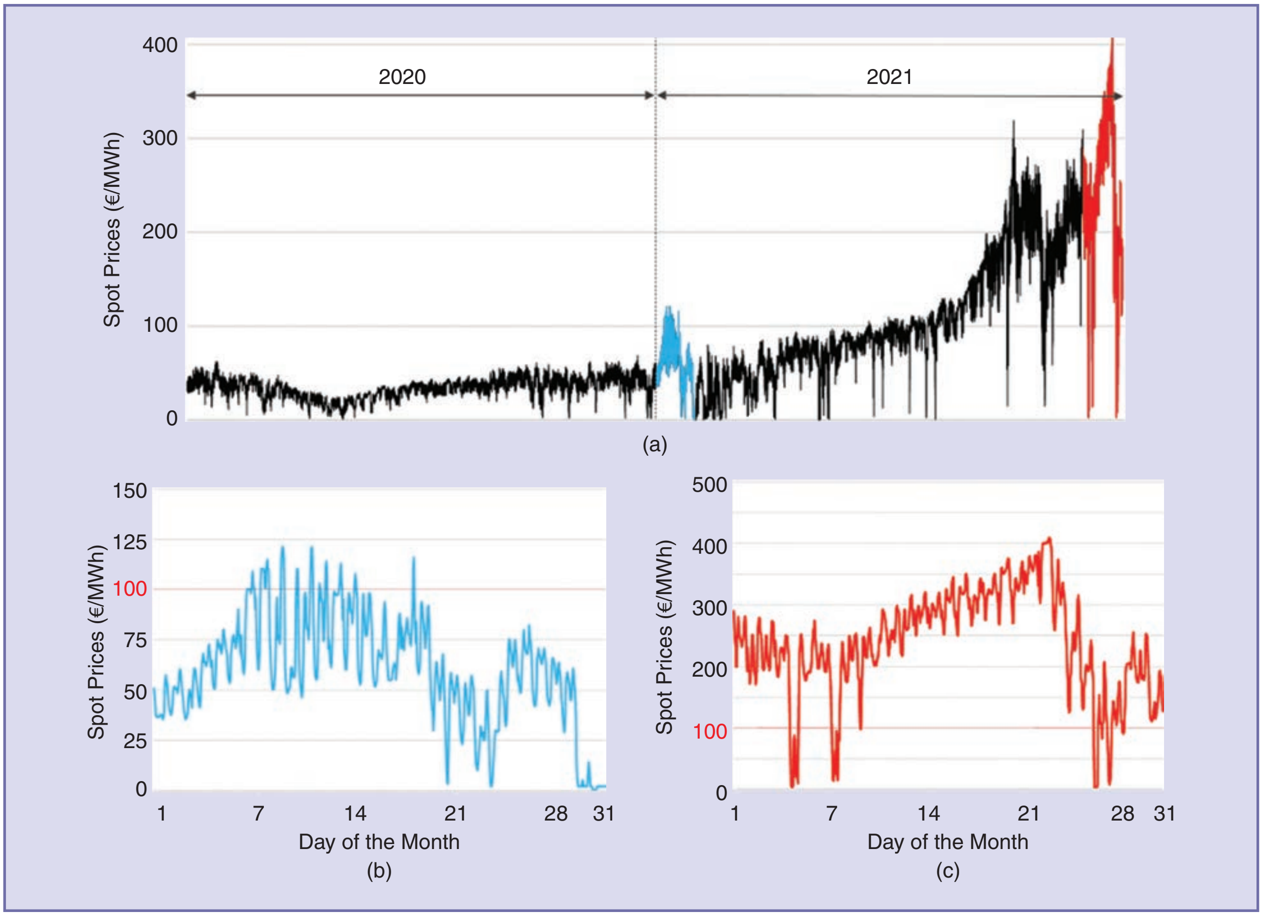


**figure 2.** (a) The hourly day-ahead market prices in Spain in 2020–2021. (b) The hourly day-ahead market prices in Spain in January 2021. (c) The hourly day-ahead market prices in Spain in December 2022.

RES entrants via centralized auctions for government-backed CFDs can slowly soften the medium- to long-term volatility of certain categories of end user prices.

access, is that counterparties could be protected against periods of sustained high prices. So far, counterparties in these centralized auctions have always been (directly or indirectly) the government, at least in the EU. In addition to having the possibility to sign bilateral PPAs, there might be good reasons to allow suppliers and large consumers, such as industrials, to voluntarily participate on the buyer side. Such an arrangement would basically imply a sort of centralization of the procurement of standardized PPAs. However, in periods of sustained high prices, only those who are on the buyer side would be hedged. In case the government is the counterparty, the decision of who should enjoy the value of the hedge in times of sustained high prices is in the hands of the government. In case the counterparties are mostly third parties, depending on who those third parties are, residential and small consumers might be less protected against affordability concerns.

### *Long-Term Hedge Format for Newly Connected Generators*

We focus on intermittent RES as new entrants, as they represent the bulk of expected newly entering capacity. The prime consideration of long-term contracts is that they reduce risks for project developers while keeping short-term incentives for efficient operation by exposure to the spot market (at least) on the margin. Risk mitigation is key to lower financing costs, which are crucial, as these assets are capital intensive. In that regard, the best contract design would likely be a CFD (obligation) since it provides more revenue certainty for the developer over (one-sided) call options.

CFDs are not new; they have been auctioned for many years for RES projects in Europe. What is important is that the exact contract design evolves as more RES enter the power system. We advocate for a contract format that resembles a standard CFD but keeps dispatch incentives intact without significantly increasing investment risk. More precisely, we recommend a capacity-based support mechanism complemented with ex-post compensations and penalties resulting from a plant's performance compared to a reference plant. Such a mechanism was implemented in Spain via royal decree 413/2014. A detailed discussion of the exact design of well-functioning CFDs, of which the appropriate format could depend on technology characteristics, while incredibly important, is beyond the scope of this article.

What is key for the discussion in this article is that new RES entrants via centralized auctions for government-backed CFDs can slowly soften the medium- to long-term volatility of certain categories of end user prices. However, this solution can be only partial. In the short to medium term, we cannot expect that new RES alone can solve the affordability concern. For at least a decade, the total volume of new RES electricity production is going to have a relatively limited impact on final bills. Moreover, unfortunately, in the absence of abundant storage, not just short-term but also seasonal, the market price that consumers pay will increasingly diverge from the price that new renewables receive in the market. This divergence happens due to the mismatching of end users' consumption and RES production profiles and is especially an acute problem for solar. As discussed in the following section, in this context, only large, and maybe even more important, fully diversified, generation portfolios provide the opportunities to truly address the affordability issue.

## Existing Generators: A Regulatory-Driven Auction for Affordability Options

In case the crisis continues longer than expected, the current affordability issue will remain active, while in case the crisis winds down, an affordability issue will resurface when a period of sustained high prices returns.

A very tempting option for governments to lower prices in the short run would be to hurry and negotiate some sort of long-term contracting with specific generators (e.g., nuclear plants) and incumbents. The current context of abnormally and sustained high market prices would be the worst moment to enter into such a commitment, particularly if there were no way (time and manner) to fully open the negotiation to every potential (existing, i.e., already installed or future) counterparty to maximize competition. A bilaterally negotiated price, absent competitive pressures, would necessarily end up being a bad deal for consumers in the medium to long run. Governments could be relieved by seeing a decrease of prices in the short run, but consumers would pay higher bills in the middle to long term when prices normalized again.

A preferred alternative approach is to levy a nondistortive windfall profit tax on generators, as long as there is the political urge to do so, and use these revenues to mitigate affordability concerns. When the crisis calms down, we propose the organization of regulatory-driven auctions for affordability options. The regulator must decide about the volume of affordability options it will procure. This decision will be based on which end users are deemed to need (or want) protection from sustained high prices and the total volume of production already under CFDs (existing and new entrants).

> The risk of an overreaction after a price shock of this nature, potentially leading to a major step back in the decarbonization process, is not irrelevant.

Such an assessment is not very different than, for example, resource adequacy forecasts that regulators perform.

To limit regulatory interference in the market and increase competitive pressure, we recommend minimizing the volume of affordability options and opening auctions to all generation technologies. Also, a reserve (maximum) price should be considered. Protected end users might be only "standard" vulnerable consumers, i.e., consumers facing energy poverty in normal price scenarios, or a larger share of residential and commercial consumers that would suffer significantly from periods of sustained high prices. End users that are not, by default, covered by affordability options (e.g., industrial consumers) should have the right to opt in and participate in auctions, with the same rights and future obligations. Besides all existing generation, new generation should be able to participate to add competitive pressure. In that regard, the auction lead time needs to be sufficiently long. New generators can be generators that do not enter via centralized auctions, for example, wind colocated with sufficient storage capacity. Maximizing competitive pressure is much needed, considering that large diversified electricity generation portfolios are often concentrated.

To ensure that generators have a natural hedge, they are required to prove that they can honor option contracts. Thus, having only sufficient generation capacity (in megawatts) is not enough. Also, proof of being able to deliver the energy is needed (e.g., a long-term gas contract for a gas-fired power plant and historical production time series for RES with storage). The exact implementation of these requirements and possible penalty schemes need to find a balance between minimizing financial risk for option buyers and minimum entry barriers for option sellers.

## In Summary

The ongoing scenario of sustained high electricity prices in Europe exposes a higher-order threat: the potential loss of trust (and patience) in the political class (and the mass media) in the whole power market compound. The risk of an overreaction after a price shock of this nature, potentially leading to a major step back in the decarbonization process, is not irrelevant. It is currently not possible to foresee when this crisis will end and whether this unprecedented scenario of a period of sustained high prices could repeat itself.

Even though spot power markets are blamed, what Europe has been facing is a natural gas crisis. Marginal spot pricing of electricity will become even more vital in the future. The current affordability issues stem from power market incompleteness, i.e., a lack/insufficient availability of long-term hedges. The solution, thus, must also be sought in that direction. We discussed the rationale behind complementing the long-term market, with the aim to proactively mitigate affordability concerns. We described our proposal to complete the long-term market: affordability options. Affordability options are a financial product that works as market-based "bill insurance" and is procured by the regulator/government on behalf of (tranches of) consumers, while not distorting spot prices signals. We explained how affordability options can be procured within the current regulatory framework.

## For Further Reading


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# power flow control

## *solutions for a modern smart grid*

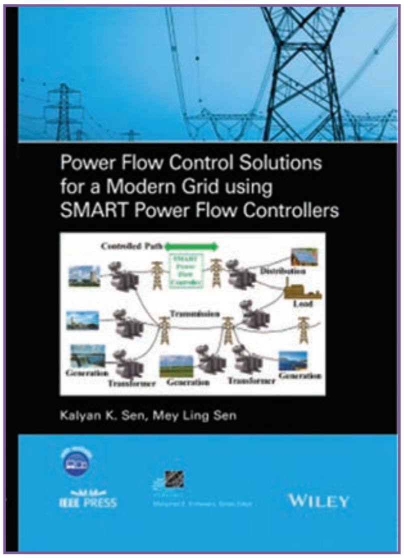
**Power Flow Control Solutions for a Modern Grid using SMART Power Flow Controllers**

*—By Kaylan K. Sen and Mey Ling Sen*

*POWER FLOW CONTROL SOLUTIONS for a Modern Grid Using SMART Power Flow Controllers* provides students and practicing engineers with the foundation required to perform studies of power system networks and mitigate unique power flow problems.

This book is a clear and accessible introduction to power flow control in complex transmission systems. Starting with basic electrical engineering concepts and theory, the authors provide step-by-step explanations of the modeling techniques of various power flow controllers (PFCs), such as the voltage-regulating transformer, the phase angle regulator, and the unified PFC. The textbook covers the most up-to-date advancements in the Sen transformer (ST), including various forms of two-core designs and hybrid architectures for a wide variety of applications.

Beginning with an overview of the origin and development of modern




PFCs, the authors explain each topic in straightforward engineering terms, corroborating theory with relevant mathematics. Throughout the text, easy-to-understand chapters present characteristic equations of various PFCs, explain modeling in the electromagnetic transients program (EMTP), compare transformer-based and mechanically switched PFCs, discuss grid congestion and power flow limitations, and more. This comprehensive textbook:

- ✔ describes why effective PFCs should be viewed as impedance regulators

This book is a clear and accessible introduction to power flow control in complex transmission systems.

- ✔ provides computer simulation codes of the various PFCs in the EMTP programming language
- ✔ contains numerous worked examples and data cases to clarify complex issues
- ✔ includes results from the simulation study of an actual network
- ✔ features models based on the real-world experiences of the authors, coinventors of the first-generation flexible ac transmission system (FACTS) controllers.

*—Shayan Behzadirafi*

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Joseph J. Cunningham

# city of innovation

## *New York City at the birth of electrical systems*

For this issue's "History" article, Joseph J. Cunningham returns for the 12th time to our pages. In this article, Joseph shares the history of New York City at the infancy of electric lighting and power systems. During the treatment of this period of electric history, Joseph shares stories of the early pioneers of success, lawsuits, suicide, failures, knighthood, and a sidewalk gunfight.

Joseph has contributed to our "History" pages on topics including industrial electrification, electric utility power systems, and electric rail transportation. Joseph's book, *New York Power,* was published in 2013 by IEEE History Center Press. We welcome back Joseph as our history author for this issue of *IEEE Power & Energy Magazine*.

John Paserba
Associate Editor, "History"

OVER TIME, CERTAIN CITIES became associated with a primary industry: Detroit with automobiles, Pittsburgh with steel, and Chicago with railroads. In the history of electrical manufacturing, the two primary cities that come to mind are Schenectady, NY, for General Electric and Pittsburgh, PA, for Westinghouse. Indeed, Schenectady was so linked to General Electric that a line in the 1956 movie *Earth Versus the Flying Saucers* referred to "the largest generator Schenectady makes," as it was assumed that audiences would understand the reference. However, at the birth and early infancy of the industry, it was New York City—specifically, lower Manhattan—that was a center not only of pioneer installations but of the business and component manufacturing as well.

While pioneer electric light installations were occurring across the country and around the world, the dense business and commercial center of lower Manhattan offered the best opportunity for new electric light and power systems (Figure 1). As for lighting, the business center of the city was an attractive potential market. A ready market for power in the form of electric motors was provided by the numerous small businesses that were crammed into a few city blocks: jewelers, printers, publishers, woodworkers, ship chandlers, and more. All of them used machines to perform their tasks, and machines required power. Steam was the standard, but it was complex and left much to be desired. While electrical equipment innovators focused initially on lighting, expansion into motors followed, often within a few months.

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Transportation of heavy machinery was expensive; thus, it was desirable to have manufacturing, or at least assembly, near the users. Thomas Edison's Pearl Street power station is the most famous of the pioneer systems; three distinct manufacturing operations were developed to support it. Electric motor pioneer Leo Daft constructed both component manufacturing and power generation systems in the area. Frank Sprague, an innovator of electric motors and railways, also began with facilities in the city. The Crocker-Wheeler Company, a major factor in the development of ac (such is usually attributed only to George Westinghouse), began with a factory in Manhattan. The Westinghouse Electric and Manufacturing Company also established a factory in New York City. Before exploring the efforts of those major firms, a look at some of the forgotten minor players is in order. While it is impossible to know just how many small independent companies existed, some made a mark before disappearing into history.

## The Early Pioneers: Success, Lawsuits, Suicide, Failures, Knighthood, and a Sidewalk Gunfight

### *The Electro-Dynamic Lamp Company*

The first recorded pioneer on the New York City scene was the inventor

William Sawyer, born in Brunswick, ME, in 1850. As a telegraph operator, he developed an interest in electric power and explored practical applications for it. In July 1878, Sawyer and financier Albon Man established the Electro-Dynamic Lamp Company. A complete system was demonstrated in a building at Elm and Walker Streets on 29 October of that year. Their plan was a system to supply power to buildings throughout the area for lighting, electroplating, motors, or heating. His engineering office at 21 Cortlandt Street hosted the development of a variety of technical components related to lighting that included a mechanical meter to record power consumption and an automatic cutoff (circuit breaker) for protection against damage from the failure of components. The Electro-Dynamic Company claimed to be the first to manufacture incandescent lamps on a regular basis. However, his lamps required a regulating device to prevent burnout, while Edison avoided that issue by the use of lamp filaments of adequate resistance.

As for lighting, the business center of the city was an attractive potential market.

### *The Sawyer-Man Electric Company*

In 1882, the Electro-Dynamic Company was supplanted by the Sawyer-Man Company, which engaged in successful litigation with Edison over the details of lamp patents (Figure 2). The primary success of his company was not enjoyed by Sawyer, however. He was troubled by alcoholism and a bad temper, and an ongoing dispute with a neighbor led to Sawyer shooting that


**figure 1.** The City of Innovation map. 1: Demonstration of the Electro-Dynamic Company in the building at Elm and Walker Streets. 2: The Sawyer-Man factory at 510–534 West 23rd Street. 3: Daft Electric Light Company at 115 Broadway. 4: United States Electric Lighting Co. at 59–61 Liberty Street. 5: The Equitable Building (Hiram Maxim claimed it was the first New York building with electric lights) at 120 Broadway. 6: Arnoux & Hochhausen Co. at 227 East 20th Street. 7: Excelsior Electric Co. at 66–68 Duane Street. 8: Edison Machine Works at 104 Goerick Street. 9: Edison Tube Works at 65 Fifth Avenue (presumably, South Fifth Avenue, now West Broadway). 10: Edison Shafting Company on Wooster Street (possibly in the same building as Bergmann, 104–108). 11: Bergmann Company at 292–298 Avenue B on East 17th Street. 12: Sprague Motor Company in the Union Lead Company Building on West 30th Street. 13: Crocker-Wheeler Company at 39 Cortlandt Street. 14: Ball Electric Light Co. of Canada, New York office and factory, on Ninth Avenue and West 27th Street.

neighbor, who lost an eye as a result. Sawyer was tried and convicted despite a claim of self-defense in which he alleged that the neighbor (a doctor) had displayed a gun. He was sentenced to four years but expected a pardon for his importance to the electric business. While awaiting a response to that plea, he died of internal hemorrhage in 1883 at the age of 33. Litigation with Edison was resolved the following year, when the patent examiner decided the issue in favor of the Sawyer-Man patent.

The best years of the Sawyer-Man Company were ahead; after success in the disputes with Edison, the company developed a line of lighting products (Figure 3). Sawyer-Man was then acquired by the United States Electric Lighting Co., which was then acquired in 1888 by Westinghouse. The Sawyer-Man patents became the basis of the "Stopper" lamp that illuminated the 1893 Columbian Exposition in Chicago. The extensive Westinghouse exhibit at that fair established the company as one of the two leaders of the industry. The Sawyer-Man factory was located in midtown at 510–534 West 23rd Street (Figure 4), a property that later became a motor component factory of the Westinghouse Electric & Manufacturing Company.

### *New York Electric Light Co./ Electric Power Co. of NY*

Leo Daft established the New York Electric Light Co. on Centre Street in 1879. An Englishman of varied talents and wide experience, he focused initially on lighting but later changed the direction of his effort to motive power for industry. He developed an extensive distribution system of power for industrial motors in dozens of industries in the area (Figure 5). At the start of 1884, the initial installations of his equipment by the Electric Power Co. of NY were located in two buildings at 13 and at 32–34 Spruce Street. Their success was such that his Daft Electric Light Company "Distributory" electric power system was installed in two stations operated by the Excelsior Power Company to supply power to numerous factories in lower Manhattan. The primary Excelsior Power Company power station was located at 33–43 Gold Street; the company was a successor to the Excelsior Steam Power Company (see "Forgotten Pioneer Leo Daft and the Excelsior Power Company" in the "For Further Reading" section). Daft located additional manufacturing facilities at 115 Broadway near Wall Street, but success came so rapidly that he was forced to move his manufacturing operations to New Jersey.

### *United States Electric Lighting Co.*

The United States Electric Lighting Co. was established in 1878 soon after the Electro-Dynamic Company was founded. It was formed to market the

**figure 2.** The Sawyer-Man lamp. (Source: *Electrical World*.)

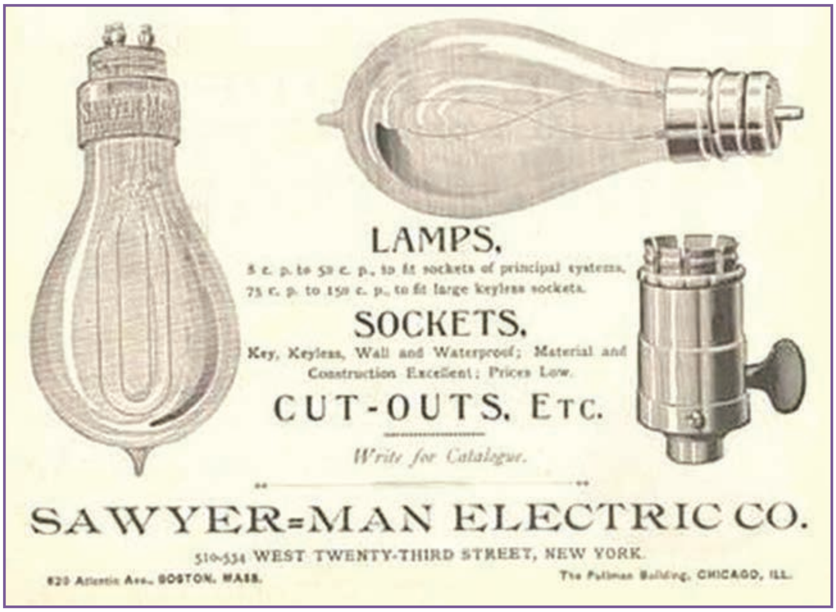

**figure 3.** A Sawyer-Man products advertisement. (Source: *Electrical World*.)

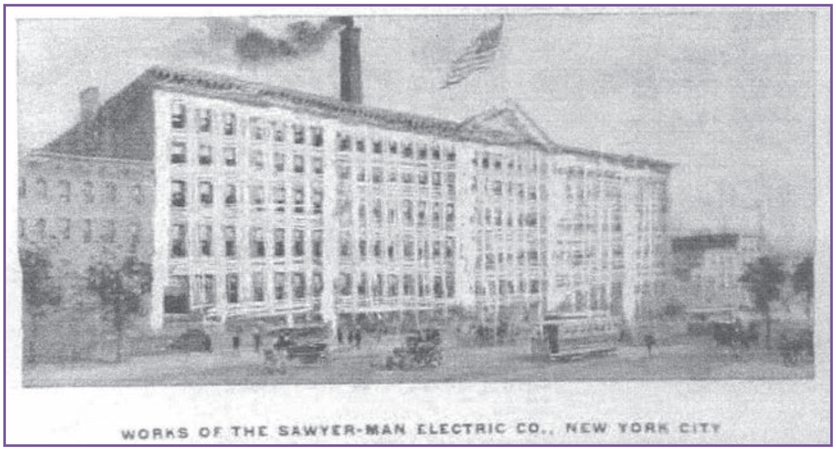


**figure 4.** The Sawyer-Man factory on West 23rd Street in New York. (Source: Sawyer-Man catalog.)

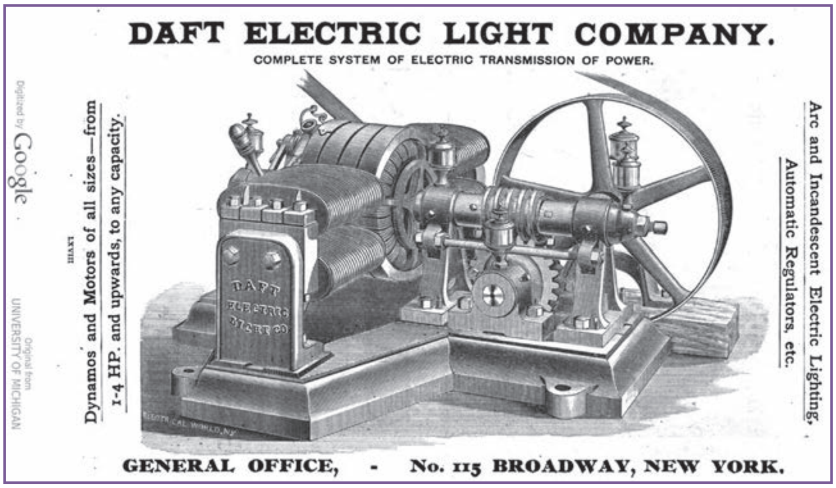


**figure 5.** A Daft Electric Light Company advertisement. (Source: Daft Electric Light Company catalog, 1887.)


**figure 6.** A United States Electric Lighting Co. ad for Maxim and Weston lamps. (Source: *Electrician and Electrical Engineer*.)

inventions of several inventors, especially the advanced arc light system of Edward Weston of New Jersey and the incandescent light system of Hiram Maxim. Hiram Maxim, an inventor from Sangerville, ME, later was best known for his machine gun but, at that time, had developed an incandescent light system at his office and factory at 43 Centre Street. He became the chief engineer of the United States Electric Lighting Co., and it was claimed that he installed the first electric lights in the city as early as 1879–1880 with an installation in the Equitable Building at 120 Broadway.

He engaged in litigation with Edison over the bulb concept, which was patented erroneously under the name of an employee. That patent was proven invalid, which left the concept open to Edison's use, or so it was claimed. Maxim went to London in 1881 to organize the United States Electric Lighting Co. offices there; he became a British subject in 1899 and was knighted for his inventions in military weaponry by King Edward VII in 1901. United States Electric Lighting combined the Maxim and Weston patents into its product line (Figure 6) and continued to operate at 59–61 Liberty Street, a space that probably included some assembly work, at least until its acquisition by Westinghouse in 1888.

### *Arnoux & Hochhausen Electric Company*

Another pioneer lighting company was formed by William Hochhausen, an inventor from Germany. After traveling the world, he settled in New York City in 1867. With a background in mathematics and physics, he pursued the development of telegraph and alarm systems and later generators for arc lighting and electroplating. By 1881, he had established, with Anthony Arnoux, the firm of Arnoux & Hochhausen to supply generators, arc lights, and electroplating equipment from a combined office, showroom, and factory space in a former stable at 227 East 20th Street. The 9 April edition of *Scientific American* carried an advertisement for the company's products, but business must have been poor. It was revealed later that Arnoux, as treasurer of the company, had invested his personal funds and used his home as collateral to support the financially distressed company but apparently with no success. On 3 July, Arnoux sat down at his office desk and fired a 38-caliber bullet into his heart. An article in *The New York Times* the following day described a note to his wife that said his family would be better off without him. In other notes he declared the company had not been promoted well. Little seems to have been recorded subsequently with regard to the company or its fate.

### Excelsior Electric Co.

Hochhausen persevered, and a new company, the Excelsior Electric Co. was organized that same year to develop, manufacture, and market his inventions (Figure 7). Though often confused with the Excelsior Power Company in several instances, including this author's previous article on Daft (see the "For Further Reading" section), Excelsior Electric appears to have been maintained as a separate entity from the Excelsior Power Company. Excelsior Power had provided customers with mechanical power, first by shafts driven by steam engines, and then replaced that system with electric motors. The aforementioned installations of the Daft system on Spruce Street would appear to have been Excelsior Power Company installations, though the properties may have belonged to Excelsior Electric Co., but no definitive data have been found. The confusion is understandable for, at that time, Excelsior (in Latin meaning "ever upward") was a name applied to many products and businesses. A century earlier, it had been adopted as the New York State motto; it was also the theme of a poem by John Greenleaf Whittier and was even used to describe a common packing material.

Hochhausen's designs were claimed to be superior to Edison's for the ability to combine incandescent and arc light systems and compensate for burned-out bulbs in a circuit. The Excelsior Electric Co. was located at 66–68 Duane Street, with lighting for office and loft buildings as its primary business. Hochhausen became embroiled in litigation with Edward Weston over water-cooled dynamos in a battle that ultimately led to the decline of Excelsior. It was acquired in 1890 by Thomson-Houston of Lynn, MA, one of the founding partners of General Electric. Thomson-Houston, a leader in the arc light industry, also acquired the Brush Electric Co. of Cleveland that had been founded in 1879 by Charles Brush, who is recognized by most historians as the most significant pioneer of arc lights. Brush, like Thomson-Houston and Edward Weston, was a pioneer who, so far as is known, did not establish manufacturing facilities in New York City, though all were commercially active there.

## The Major Pioneers

### The Edison Works

Thomas Edison needed space to manufacture components for his legendary Pearl Street power station. Lamp production had been established in Harrison, NJ, but heavy equipment assembly was best located near the point of installation. Aside from the elimination of the expense of transportation, close proximity of component manufacture to the location of use allowed rapid communication between factory staff

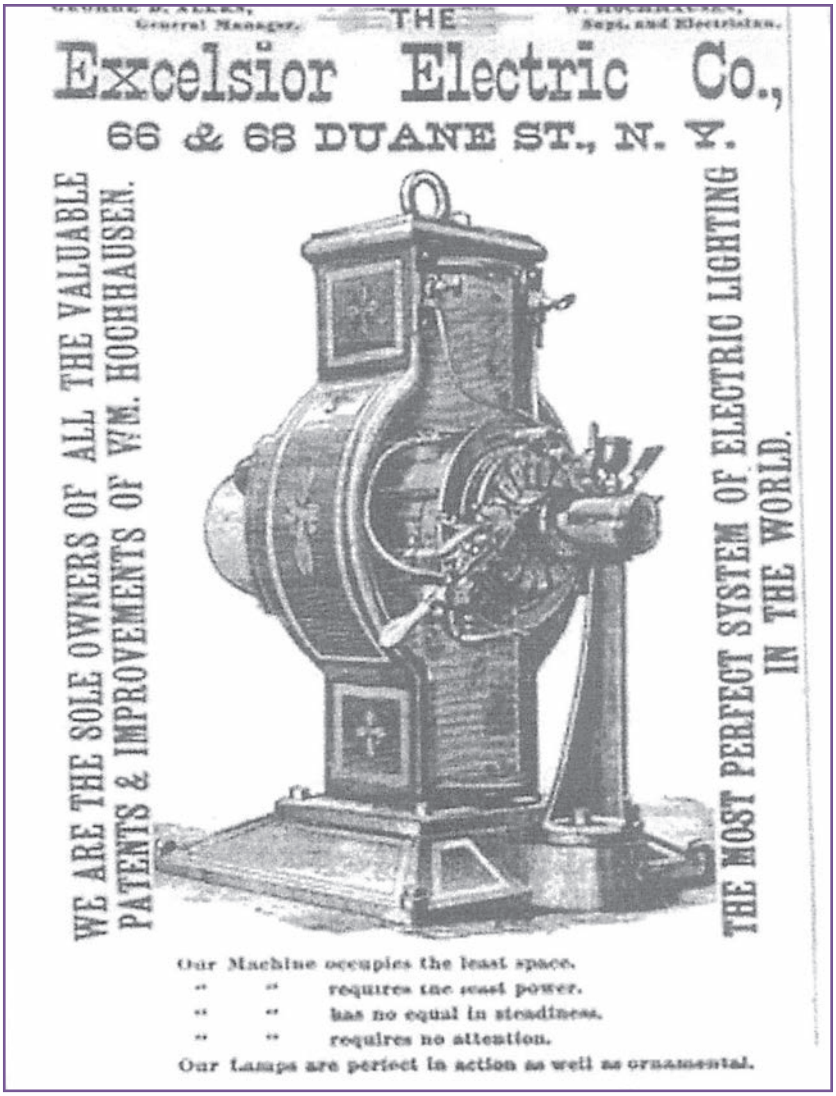


**figure 7.** An Excelsior Electric Co. advertisement. (Source: *Electrical World*.)

and the installation and test crews. Such proximity was a vital concern, as much had yet to be learned with regard to the sustained operation of the components.

Three Edison manufacturing operations were established in Manhattan. The first was the Edison Machine Works at 104 Goerick Street (Figure 8), founded in March 1881 near the present site of the Williamsburg Bridge. It consisted of several buildings; the first was a heavy industrial building converted from a former iron works. There, the generators and related hardware were assembled; those included machines sent to Paris and also, probably, were sent to London for the demonstration plant at Holborn Viaduct, which preceded the Pearl Street operation by eight months. The factory also supplied generators of different sizes for varied applications. It employed several hundred men and was also used for the design and testing of new components. An additional property behind it was acquired for storage, as the demand for space grew so extreme that lathes were set up outside the main building and powered by belts from inside the building. Space limitations and labor issues led to a relocation to Schenectady in 1885, a move that formed the basis of the later General Electric Company facilities in that city.


**figure 8.** The Edison Machine Works at 104 Goerick Street in New York, circa 1883. (Source: Edison General Electric promotional publication.)

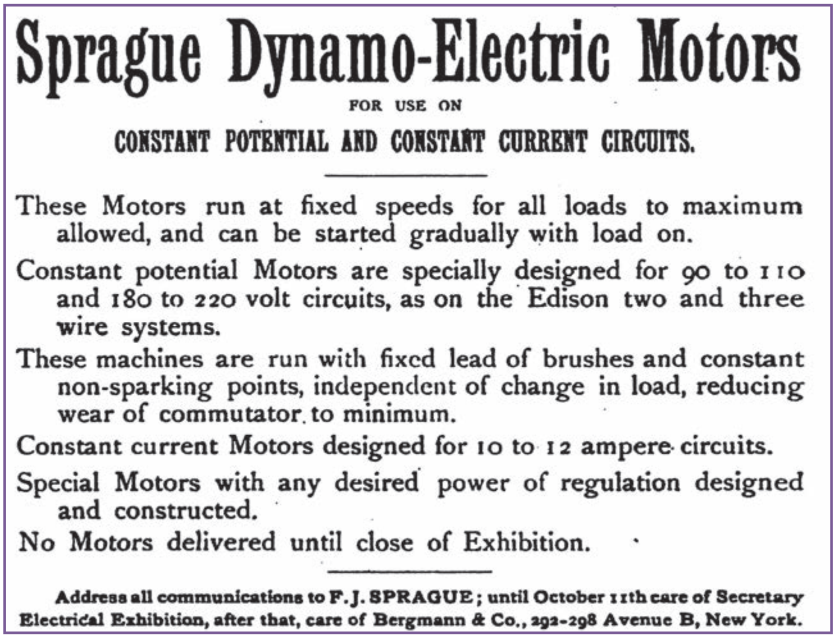


**figure 9.** A Sprague Dynamo-Electric Motors advertisement. (Source: a Sprague advertisement distributed at the Philadelphia International Electrical Exhibition held in September 1884 by the Franklin Institute.)

That same month, the Edison Tube Works was established to manufacture the conduits used for the underground distribution circuits. Manufacturing began at 65 Washington Street and grew to require a staff of 100 men. The Edison Shafting Works was established on Wooster Street in 1884 to provide belts, pulleys, and other mechanical components and became part of the Tube Works late in 1885. Both merged into the Machine Works in December 1885.

A fourth company, Bergmann & Co., was founded by former Edison employee Sigmund Bergmann in 1881 to supply lighting fixtures, switches, fuses, and related components from a plant at 108–114 Wooster Street. The need for space forced a move to a large building at 292–298 Avenue B near East 17th Street, which was obtained as part of the purchase of the business of a competitor. The initial Bergmann plant may have shared the Wooster Street space of the Edison Shafting Works. Bergmann products were distributed internationally for Edison Lighting systems installed in other countries. As the Edison companies shifted production to Schenectady, the Bergmann operation was merged into the Edison Machine Works in 1886. That same year, the Edison United Manufacturing Company was established as a marketing agency with an office at the

65 Fifth Avenue address. Three years later, it was reorganized as the United Edison Manufacturing Company and, subsequently, as the Edison General Electric Company after acquisition of the Sprague motor company.

### *Sprague Electric Motors and Railways*

Frank J. Sprague, best known for his pioneer work with electric railways, developed, in 1884, a constant-speed industrial motor that was ideal for application to individual machines, and it soon surpassed the products of all of his competitors. Moreover, it was the only type approved for use on Edison's lighting circuits, and Sprague became the leader in the field of motor development (Figure 9). The initial development and marketing of his motor was located at the Bergmann plant on Avenue B, but component manufacturing and assembly were dependent on the Edison Machine Works. After the move of the Edison companies to Schenectady was completed, Sprague leased space uptown in the Union Lead Works building on West 30th Street in January 1887. He eventually moved his operations to New Jersey, as had Daft before him. The Sprague Electric Railway and Motor Company was merged into the Edison General Electric Company in 1889.

### *Ball Electric Light Co.*

Manhattan was also selected for the factory of Ball Electric Light Co. of Toronto, Canada, to supply customers in the United States. Ball offered motors and an extensive array of arc and incandescent lighting systems in North America as well as internationally. Initially located at 18 Cortlandt Street, a large factory was constructed at 281–289 Ninth Avenue/400–416 West 27th Street, with New York offices located at 404 West 27th Street (Figure 10).

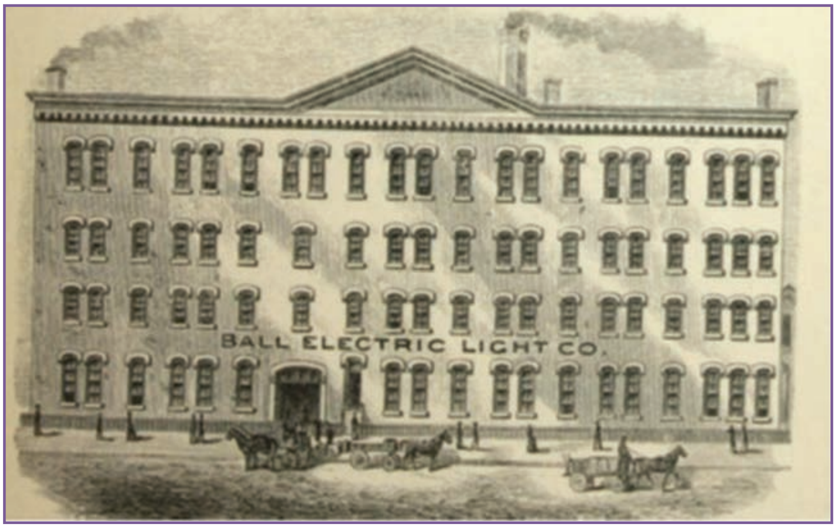


**figure 10.** Ball Electric Light Co.'s New York factory on Ninth Avenue at 27th Street. (Source: Ball Electric Light Co. catalog.)

### *Crocker-Wheeler*

Lower Manhattan, however, remained the center for electrical companies through the 1880s. After Daft and Edison, the most significant pioneer to locate in that area was the Crocker-Wheeler Company, which manufactured generators and motors for both ac and dc systems. Crocker-Wheeler, founded by the partnership of Francis Crocker and Schuyler Wheeler in 1888, was located at 39 Cortlandt Street until space limitations forced a move of the factory to New Jersey. The most significant ac innovator after Westinghouse, with a more extensive product line than ac pioneer Thomson-Houston of Lynn, MA, (later the founding partner of General Electric), Crocker-Wheeler claimed to have exhibited more variations of equipment than Westinghouse at the 1893 Columbian Exposition in Chicago.

That event is generally cited as the point of the victory of Westinghouse in the competition with Edison's dc proponents, but clearly Westinghouse was not alone in the promotion of ac systems, nor was the competition the simple two-party "clash of the Titans" battle portrayed in virtually every historical treatment. As a point of fact, there were a number of players on both sides of the ac versus dc dispute, and the issues were not so simple or as clear-cut as the popular versions allege. The Crocker-Wheeler factory move was completed by 1896, though lettering on the huge new factory proclaimed the Cortlandt Street address of its business offices. Unlike the competition, Crocker-Wheeler created an entire town, appropriately named *Ampere*, and the factory was said to be the largest and most technically advanced of the day.

## Uncertainties of Time

In many instances, it is difficult to describe with certainty the businesses mentioned, for there is minimal information on record. That is especially true of the smaller companies that disappeared or were absorbed into larger entities. As in the case of the later myriad automobile, aircraft, and radio pioneers, the electrical innovators saw alliances made and broken, equipment reused or rebuilt, and facilities relocated—all such changes were usually attributable to disputes, patent litigation, or financial distress. Furthermore, the products varied substantially according to customer request, technical evolution, competition, component availability, and financial constraint.

In many instances, companies and innovators failed economically after devising workable schemes.

In many instances, companies and innovators failed economically after devising workable schemes. A primary source of data for this article was descriptions, notices, and advertisements in trade publications, such as *Electrical World*, which was the leading trade journal of the day. Another source was the surviving catalogs of the companies. It is difficult to ascertain the accuracy of promotional materials as to the duration of the production and sale of a product and whether or not it sold in significant numbers. The picture is further distorted by the frequent lawsuits, patent infringement accusations (both real and alleged), and company acquisitions.

Innovation rarely comes from a single innovator at a single point in time, much as that theme may make an interesting story. Rather, it occurs when available knowledge, market demand, material, and technical development all reach the point where a new step or technological direction is feasible. In most instances, a number of informed people see the potential; some of those propose but fail to act, or they may lack the capital necessary to pursue development. A few develop practical hardware, and the best of those compete for business. The field of competitors is then winnowed by finances, opportunity, market interest, and product quality until only a few remain. Though the innovators mentioned here competed in New York City, their ultimate survival required successful competition with companies located elsewhere. In arc lighting, the most significant of those were the Brush Electric Co. of Cleveland, OH; the Thomson-Houston Company of Lynn, MA; and the Weston Electric Co. of Newark, NJ.

Those companies with the financial strength and the best product enjoyed success, but, eventually, all were acquired by larger companies with greater resources and deeper market penetration. The rare few, such as Crocker-Wheeler, remained independent to become strong players in the field. Still, it was those with extensive national or even international operations that became the leaders; in the United States, that was General Electric and the Westinghouse Electric and Manufacturing Company. Nonetheless, those overlooked (and now long forgotten) pioneer entrepreneurs and innovators that clustered in lower Manhattan in the 1880s played a major and sometimes a leading role in the launch of a new industry. Though forged in competition, their innovations advanced the United States to international prominence in the electric light and power industry.

## Acknowledgment

The author would like to thank Mary Ann Hellrigel of the IEEE History Center for her generous assistance in determining the locations and details of the early Edison factories in New York City and also Michael Wares for his assistance in locating ancient maps of Manhattan in the period under discussion.

## For Further Reading

T. J. Blalock, "Ampere, New Jersey [History]," *IEEE Power Energy Mag.*, vol. 9, no. 3, pp. 78–91, May/Jun. 2011, doi: 10.1109/MPE.2011.940407.

J. J. Cunningham, "Forgotten Pioneer: Leo daft and the excelsior power company [History]," *IEEE Power Energy Mag.*, vol. 16, no. 4, pp. 108–120, Jul./Aug. 2018, doi: 10.1109/MPE.2018.2819038.

# Corrections

In two previous articles by Joseph J. Cunningham, "AC Network Centennial" [1] in the March/April 2022 issue of *IEEE Power & Energy Magazine* and "Distributed Generation" [2] in the November/December 2022 issue, under "For Further Reading," the book listed as the "St. Louis Electric Handbook" should be listed as the "New York Electric Handbook." The same error occurs in the photo captions for Figures 1, 2, 3, and 6 in the "Distributed Generation" article. The author regrets any confusion these errors may have caused.

## For Further Reading

*New York Electric Handbook*, American Institute of Electrical Engineers, St. Louis, MO, USA, Sep. 1904.

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[1] J. J. Cunningham, "AC network centennial: Years of distribution networks [History]," *IEEE Power Energy Mag.*, vol. 20, no. 2, pp. 64–73, Mar./Apr. 2022, doi: 10.1109/MPE.2021.3134345.

[2] J. J. Cunningham, "Distributed generation in 1900?: How the Edison Co. of New York met short-term needs [History]," *IEEE Power Energy Mag.*, vol. 20, no. 6, pp. 82–89, Nov./Dec. 2022, doi: 10.1109/MPE.2022.3199899.

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*Date of current version: 21 June 2023*

# meet the candidates

## *PES president-elect, secretary, and treasurer*

BEGINNING IN AUGUST, ELECTIONS will be held for the positions of IEEE Power & Energy Society (PES) president-elect, secretary, and treasurer. The candidates are as follows:

- ✔ president-elect: Claudio Cañizares and Farnoosh Rahmatian
- ✔ secretary: Mazana Armstrong and Ramakrishna Kappagantu
- ✔ treasurer: Juan Carlos Montero and Dean Sharafi

The successful candidates will serve for the term of 2023–2024. To learn more about the candidates before casting your ballot, read the biographies and candidate statements that follow.

### Candidates for PES President-Elect

#### *Claudio Cañizares*

University of Waterloo, Waterloo, ON, Canada

Candidate Statement

I have unique experiences and broad knowledge of PES and IEEE, given my multiple successful activities and leadership positions in my 37 years of being an active member and volunteer. Based on my open and transparent approach as PES leader, witnessed by many members and volunteers with whom I've had the pleasure of collaborating, and on my recent experience as IEEE division director, I believe that I can provide the required stewardship of PES to properly serve its broad academic, industry, and worldwide membership.

I appreciate President Jessica Bian's inclusive, transparent, and generous leadership style, and thus, if honored by being elected PES president, I plan to follow a similar approach. Furthermore, besides facilitating and supporting all of the great ongoing work by PES members and volunteers, I'll focus on enhancing the impact and relevance of PES to the world's net-zero future for which the power grid will be the backbone, as well as increasing the growing PES relevance and leadership role within the IEEE, properly reflecting its size, for which I've been pushing as director.

> I appreciate President Jessica Bian's inclusive, transparent, and generous leadership style.

Biography

I have been at the University of Waterloo since 1993, where I am a University of Waterloo professor, Hydro One chair, and Waterloo Institute for Sustainable Energy executive director. My highly cited research with industry and government partners has focused on relevant and practical aspects of power and energy systems in the context of markets and grid-edge technologies, like microgrids. I am the *IEEE Transactions on Smart Grid* editor in chief; IEEE Division VII director; a Fellow of the IEEE, Royal Society of Canada, and Canadian Academy of Engineering; and have received multiple awards and recognitions from Waterloo and PES.

I have been a very active member of PES since 1986, contributing significantly to its technical activities and holding technical leadership positions in multiple committees, working groups, and task forces. I now play a leadership role in PES and IEEE as an active member of the PES Governing Body and Executive Committee, IEEE Technical Activities Board and Board of Directors, and several associated committees.

Accomplishments

I have held 52 PES and IEEE membership and leadership positions, in particular:

- ✔ Member, Technical Activities Board Nominations & Appointments Committee, 2023–2024
- ✔ Member, Fellow Committee Strategic Advisory Working Group, 2023
- ✔ Director and director-elect, Division VII, 2021–2023
- ✔ Member, Ad Hoc Committee to Coordinate Response to Climate Change, 2022–2023
- ✔ Member, Ad Hoc Committee on Fellows Processes, 2022

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*Date of current version: 21 June 2023*

- ✔ Editor in chief, *IEEE Transactions on Smart Grid*, 2020–present
- ✔ Chair, *Electrification Magazine* Steering Committee, 2019–present
- ✔ Past chair, chair, vice chair, and secretary, Power System Dynamic Performance Committee, 2013–2020
- ✔ Chair, Task Force "Microgrid Dynamic Modeling," Power System Stability Subcommittee, 2018–today
- ✔ Editor and lead, Smart Grid Technical Activities Committee's white paper "Microgrids: Utility Challenges and Opportunities," 2018–2022
- ✔ Editor in chief, *Proceedings* Special Issue "Electricity for All: Access to Electricity Issues and Solutions for Energy-Disadvantaged Communities," 2018–2019
- ✔ Technical Program chair, Innovative Smart Grid Technologies Latin America, 2016–2017
- ✔ Member, Editorial Board of the *Proceedings of the IEEE*, 2016–2021
- ✔ Co-chair, Task Force "Microgrid Stability Analysis and Modeling," Power System Stability Subcommittee, 2014–2018
- ✔ Chair, Task Force "Microgrid Control," Power System Stability Controls Subcommittee, 2010–2014
- ✔ Chair and secretary, Power Systems Stability Controls Subcommittee, 2006–2011
- ✔ IEEE Fellow (2007), Senior Member (2000), Member (1991), and Student Member (1986)
- ✔ Chair, Task Force "Impact of Industry Restructuring on System Dynamic Performance," Power System Stability Subcommittee, 2005–2010
- ✔ Chair, Voltage Stability Focus Group of the Power System Stability Subcommittee, 1997–2002
- ✔ Secretary, Voltage Stability and Long-Term Stability Working Group, 1994–1997.

I have received 20 IEEE PES awards and recognitions, in particular:

- ✔ Best Paper Award, 2022
- ✔ Technical Council Outstanding Technical Report Award, 2020
- ✔ Technical Committee Service Award, 2019
- ✔ Outstanding Power Engineering Educator Award, 2017
- ✔ Technical Committee Distinguished Service Award, 2017
- ✔ IEEE Canada Electric Power Medal, 2016
- ✔ PowerTech Best Student Paper Award, 2015
- ✔ IEEE Fellow, 2007
- ✔ Technical Council Outstanding Technical Report Award, 2005.

## Farnoosh Rahmatian

NuGrid Power Corp, Vancouver, BC, Canada

### Candidate Statement

The global energy infrastructure demands a greater level of resiliency and flexibility, and PES offers an ideal platform for embracing and addressing this challenge. As a candidate for IEEE PES president-elect, I am honored to have the opportunity to contribute to this crucial mission.

With three decades of involvement in various PES activities, I have witnessed firsthand the passion, expertise, and mentorship shared among PES members. These core values epitomize PES and make our membership a driving force for serving our communities.

My primary objective is to increase member engagement in solving the greatest challenges of our time, including mitigating and adapting to climate change, while simultaneously developing members' careers. We must nurture young and innovative minds and foster collaborations with experienced professionals, both locally and globally, to develop the right solutions for tomorrow.

We must also cherish and leverage the existing synergy between industry and academia, one of the core strengths of PES, to address power and energy-related challenges and achieve a more resilient and sustainable energy future "for the benefit of humanity."

### Biography

Dr. Rahmatian is a cofounder and president of NuGrid Power Corp. He has contributed to several techniques for power system measurement and automation over the past 30 years. He is a professional engineer and a Fellow of IEEE for contributions to optical voltage and current sensors. He is a past chair of the PES's Technical Council, active at PES Power System Relaying and Control, as well as Power System Instrumentation and Measurements committees. He is also active in the International Council on Large Electrical Systems (CIGRE, Distinguished Member), International Electrotechnical Commission, the Canadian Standards Association, and the North American Synchrophasor Initiative. His present technical focus is on wideband optical sensors, synchronized measurement systems, digital substations, integration challenges of distributed energy resources, high-speed measurement of voltage and current, traveling-wave–based fault location, and grid resiliency efforts. Rahmatian has over 100 technical papers and 12 patents to his credit.

### Accomplishments

I have served on the PES Governing Board as vice-president of technical activities (2018 and 2019) and on the PES Technical Council for 10 years (various leadership/officer roles including the chair). For the past three decades, I have been heavily involved in PES technical committees, chaired the Power System Instrumentation and Measurements Committee, and have contributed to technical standards and reports through various PES technical committees, including having chaired three working groups. I established various process improvements for the PES Technical Council and contributed to reorganizing PES technical committees in the 2015–2016 timeframe. I have been active in the PES Industry Technical Support Leadership Committee for the past four years, currently chairing the PES Corporate Engagement Program. I have also been active on the PES Long-Range Planning Committee for several years, currently chairing Subcommittee 5 on Climate Change.

I have a strong track record for working well and efficiently with all PES leaders/volunteers: a team-first approach.

I have been a member of the IEEE Photonics Society, IEEE Instrumentation and Measurement Society, and IEEE Standards Association. Currently, I serve as the PES Technical Council liaison to the CIGRE Technical Council and helped establish the memorandum of understanding in place between IEEE (PES) and CIGRE. I also currently serve as the liaison between PES and the IEEE Sensors Council.

I am a Fellow of IEEE for my technical contributions. I have participated and presented at numerous IEEE and PES conferences and panels over the past 30 years. I have served as the PES Technical Council's Technical Program coordinator for IEEE PES General Meetings 2015 through 2017, managing the technical panels (~100) and the conference paper review process (>1,000). I have also served as a reviewer for several IEEE and PES journals and conferences.

## Candidates for PES Secretary

### *Mazana Armstrong*

British Columbia Hydro, BC, Canada

Candidate Statement

The power and energy industry is facing significant challenges to meet emerging needs for electrification and reduction in carbon emissions. At the same time, we are experiencing an unprecedented increase in the frequency and severity of the climate change-related weather events impacting the power system infrastructure. Supply chain disruptions and workforce decline triggered by the pandemic and political conflicts are further contributing to the criticality of the situation.

In my position with a large North American utility, I see the challenges that lie ahead for our industry and I believe IEEE PES plays a major role in helping us work together to find solutions. I am passionate about shaping the future direction of IEEE PES and I am enthusiastic about our visibility to the public and remaining relevant to the future generations.

If elected as secretary, my goal is to revive activities of the PES History Committee, help reshape our IEEE PES brand in view of the major changes that are upon us, and strengthen IEEE PES's position within the industry for generations to come.

Biography

Dr. Mazana Armstrong is the manager of the Transmission Stations Engineering Division at BC Hydro. She has over 25 years of professional experience in operations, maintenance, and design of high-voltage electric power systems, specifically electrical aspects of 69-kV to 500-kV transmission systems. Armstrong's professional contributions include standards development addressing electrical safety of the public, power utility workers, and facilities in close proximity of electric power systems.

Armstrong holds a degree in electrical engineering from the University of Zagreb, Croatia, and an M.A.Sc. and Ph.D. in electrical engineering from the University of British Columbia, Canada. She is a registered professional engineer in British Columbia, and a Senior Member of IEEE. Armstrong has been an IEEE PES volunteer for over 20 years. Most recently, she served as IEEE PES vice president for Chapters. Armstrong is an IEEE PES Distinguished Lecturer and a Member of IEEE Standards Association.

Accomplishments

IEEE PES has over 800 professional and student chapters worldwide, delivering technical presentations and networking events to over 40,000 members. As IEEE PES vice president Chapters (2018–2022), I led several important initiatives within PES Chapters organization:

- ✔ Implementation of health tracking for professional and student chapters to enable growth of high-performing chapters delivering outstanding service to the membership
- ✔ Establishing student chapters leadership organization in all IEEE regions, mirroring the organization of professional chapters
- ✔ Establishing the High-Performing Student Branch Chapter Program and Outstanding Student Chapter Award, both providing financial assistance to student chapters
- ✔ Annual student chapter chair training was launched virtually in 2021 and in person in 2022 for the first time in all IEEE regions. Professional and student chapter chair training is essential in ensuring the health and longevity of PES chapters.
- ✔ Initiation of the PES Mentoring Program by the PES Student Chapters Committee has been a major success. Student chapter activities and their growth support student retention and successful transition of students to professional members. Student chapters are the key to the future of PES as a volunteer organization.

My past accomplishments include the role of PES regional representative for the United States and Canada and chairing the local organizing committee for the 2013 IEEE PES General Meeting in Vancouver, BC, Canada. In 2011, I was the IEEE Vancouver section chair and the centennial committee chair to mark 100 years of IEEE in Vancouver. Efforts included a significant public outreach, with the City of Vancouver declaring the Engineering Week and unveiling of the IEEE monument at Science World. We published 100 years of the Vancouver section history book for the occasion, raising public awareness of the IEEE brand.

Prior to that, I held the roles of section treasurer, secretary, and vice chair. I actively participate with IEEE PES technical committees in development of technical standards.

### *Ramakrishna Kappagantu*

Eficaa Ensmart Solutions Private Limited, Telangana, India

#### Candidate Statement

The secretary's key responsibility is to work with the PES president, staff, and other leaders to ensure a smooth order of business and maintain PES governance documents at all levels clear, specific, and consistent.

Having served as member of IEEE Board of Directors, Member and Geographic Activities Board, Region10 (R10) Director, PES Governing Board, Member and Geographic Activities chair of Member Engagement and Life Cycle Committee, and in other leadership roles, I have an understanding on the breadth of IEEE. Having responsibly run R10 and other meetings, I understand the advance work needed to construct an agenda, develop and provide supporting material, read and act on governance documents, and ensure proper documents maintenance. I have significant R10 experience in keeping governance documents current and up to date when necessary. I currently serve on the IEEE Governance Committee in 2023–2024.

I work well with staff and believe that a strong partnership between staff and volunteers can get work done efficiently and effectively. As secretary, I will work with the PES Governing Board and staff to place appropriate items on the board agenda. Additionally, I will provide overall supervision of keeping meeting records, activities, and membership for submission to the PES Governing Board.

#### Biography

Ramakrishna Kappagantu graduated in Electrical from Malaviya National Institute of Technology, Jaipur, India, did an M.A. in automation and control from the Post Graduate School, Jawaharial Nehru Technical University, Hyderabad, India, and obtained a Ph.D. (Electrical) from the National Institute of Technology, Tiruchirappalli, India.

With over 39 years of leadership/managerial experience in the Indian power sector (i.e; National Thermal Power Corporation and POWERGRID), currently Kappagantu is chief technical advisor at Eficaa EnSmart Solutions Private Limited for Technical, Strategic, and New Initiatives. He earlier made significant contributions toward management of 55 Gigawatt Southern Regional Grid, its complex real-time operations, power markets, supervisory control and data acquisition-energy management system, and smart grid development in India.

> The secretary's key responsibility is to work with the PES president, staff, and other leaders.

Actively volunteering for over 30 years in IEEE and PES, he served many leadership roles, namely IEEE board member and delegate from 2015 to 2016 as R10 director, PES Governing Board, and Member and Geographic Activities boards. Currently Kappagantu is PES R10 representative and serving on the IEEE Governance Committee, IEEE Service Awards, and Member and Geographic Activities Awards.

An eminent speaker, Kappagantu is published in reputed journals, conferences, and has steered many IEEE international conferences and PES workshops.

#### Accomplishments

My major accomplishments in PES and IEEE include:

- ✔ As PES member at large, spearheaded in R10, PES Global Workshops for member development. Brought together members, nonmembers, industry, research, and academia with policy makers, regulators and government agencies to discuss challenges/opportunities with all stake holders on local needs and emerging technologies. These workshops triggered signing five PES corporate partnership agreements ensuring sustained technical activities and membership growth.
- ✔ As member at large for PES philanthropic initiatives, streamlined PES funding pattern and selection of smart village projects. Introduced engagement of PES students and young professionals from local chapters for internships, academic projects, and entrepreneurship opportunities in IEEE smart village projects.
- ✔ As PES R10 representative, introduced bi-weekly review meetings and new volunteer roles in the five zones of PES R10 for member development and technical activities coordination that engage chapter leads and ensure member satisfaction.
- ✔ As R10 director, rejuvenated R10 young professionals and women in engineering affinity groups by classifying regional activities into zones, starting off self-sustainable events like the HardTech Summit, SYWL (student, young professional, women in engineering, life member) Congress. Introduced young professional and women in engineering tracks in all R10 flagship events.
- ✔ Created an Ad Hoc in R10 to assess requirements and needs of industry members, young professionals, and graduate students, with focus on entrepreneurship, innovation, internships, and skill development.
- ✔ Sustained R10 membership growth; best in IEEE regions is an example of my volunteer leadership efforts. Introduced regional member benefits, like member medical insurance (India), membership dues payment

in local currency, and discounted entry to Visvesvaraya Technological and Birla Museums. Helped council and section leadership to build membership in China.
- ✔ Mandated review and revision of section/council/region governing documents across R10.
- ✔ My industry experience and classic interpersonal relations helped converting IEEE strategies into tangible and tactical actions, like coordination with local sections/chapters to kick off IEEE/PES Smart City Workshop Series, Global Sister Society Agreements' and joint awards with national societies awards' coordination, IEEE-eta kappa nu (HKN) new chapter installations, etc.

## Candidates for PES Treasurer

### *Juan Carlos Montero*

ICE Operation and Control Division of the Costa Rican Electrical System (DOCSE)

Candidate Statement

I am Juan Carlos Montero and I work at the System Operator in Costa Rica. From my homeland, I have seen the value of IEEE PES as a global organization, and I am proud to be part of a great community. For the last two years, I have been working in the IEEE PES treasurer position, looking to promote a use of our community with a global focus and following the IEEE PES Governing Board vision.

I have been an active IEEE PES Governing Board member for seven years, giving me the opportunity to participate in the identification of the hot topics for IEEE PES and the energy industry. We should promote IEEE PES as global organization so our members and volunteers can continue creating amazing technical activities that improve our life.

If elected as IEEE PES treasurer, I will continue working to seek growth with the support of our volunteers worldwide. IEEE PES accomplishes great things through their volunteers, and we should provide them the tools to make their activities easier for them.

Biography

Juan Carlos Montero is the current IEEE PES treasurer and the former IEEE PES vice president of Membership and Image. He has previously held several other volunteer leadership roles within PES at the local and international levels. He currently is the IEEE CAPANA council chair. He works in the Costa Rican Power System Operator and has more than 20 years' experience at his company. He is currently the electrical operational planning coordinator at the Costa Rican National Power Control Center. He also has been part-time professor at the University of Costa Rica for more than 10 years. Mr. Montero received the Bachelor and Licentiate degrees on Electrical Engineering from the University of Costa Rica. He is an IEEE Senior Member.

Accomplishments

Mr. Montero has participated on several IEEE and IEEE PES roles on an international level:

- ✔ Current IEEE PES Treasurer 2022–2023
- ✔ IEEE chair 2022–2023 Central America and Panama Council
- ✔ IEEE elected chair 2020–2021 Central America and Panama Council
- ✔ IEEE spokesperson on Global Power System Transformation Consortium
- ✔ IEEE PES vice president Membership and Image 2016–2020
- ✔ IEEE PES Long-Range Planning Committee member 2014–2020
- ✔ IEEE PES Power System Operation, Planning, and Economics Committee member
- ✔ IEEE PES Nominations and Appointments Committee member
- ✔ IEEE PES Social Media Committee chair 2012–2015
- ✔ IEEE PES Central America Chapters representative 2011–2015
- ✔ IEEE PES Costa Rica Outstanding Engineer Award 2011
- ✔ IEEE PES Costa Rica Chapter chair 2007–2008
- ✔ IEEE Costa Rica Section vice chair and other board positions.

### *Dean Sharafi*

Australian Energy Market Operator, Perth, WA, Australia

Candidate Statement

Dear members of IEEE PES,

I am honored to present my candidacy for a position on the governing board of the IEEE PES. With over three decades of experience in the power and energy industry and a deep understanding of the latest trends and challenges facing our field, I am confident that I can make valuable contributions to the society.

If elected, I will support PES's mission to advance the knowledge and expertise in the power and energy sector. Working diligently to strengthen our society's connections with industry and academic communities, I will promote sustainability, innovation, and collaboration, and ensure that the society remains at the forefront of technological advancement. I will also foster diversity, equity, and inclusion and work actively to create a welcoming environment for members from all backgrounds, and to ensure that diverse perspectives are represented in all decision-making processes.

Thank you for considering my candidacy. If elected, I promise to work hard to uphold the values and mission of IEEE PES and to serve our community with integrity and dedication.

Biography

Dean Sharafi is heading up the System Design and Transformation Group of the Australian Energy Market Operator. Sharafi holds a degree in applied physics, a degree in electrical engineering, and a degree in business management. He has around

30 years of experience in power system engineering, including power system protection, HV systems, asset management, and power system and electricity market operation.

He is a member of Australian Institute of Management, CIGRE, Engineers Australia, and a Senior Member IEEE. Sharafi has also been a sessional academic and actively involved with IEEE PES initiatives and CIGRE Working Groups over the last decade and has served as a member of the Governing Board of IEEE PES from 2017 to 2022.

Sharafi has published many papers on power system protection, condition monitoring, asset management, and power system operations.

Sharafi is also the author of his memoir, *The Unwilling Revolutionary.*

## Accomplishments

I have contributed to PES in different roles, performing as chair of the Western Australian Chapter, chapter representative for Australia and New Zealand, chair of the Scholarship Plus initiative from 2007 to 2017; and serving on the Governing Board as the region representative for Asia Pacific from 2017 to 2022. I have also been the chair of PES conferences in Region 10, supporting these events and ensuring they are successful and a foundation for membership growth in the region. I have attended most of these events and presented as a Keynote speaker or a panelist and have supported them with setting up international advisory committees and finding speakers from the industry.

Furthermore, I have been active on the technical activities of PES, contributing to white papers and podcasts. I have presented PES globally, leading to important agreements, such as signing of corporate membership programs with organizations on behalf of PES. I have contributed to identification and selection of distinguished lecturers for the IEEE PES Distinguished Lecturer program.

Cooperating with and attending the editorial board of *Power & Energy Magazine*, I have served as the guest editor for September/2021 October of *Power & Energy Magazine*, bringing the Australian perspective on energy transition and renewable energy integration. I am also a regular contributor to the magazine on different topics related to our industry.



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# in memoriam

## *Hyde M. Merrill*

HYDE MCCUNE MERRILL WAS born in 1943 and passed away peacefully in his home in Utah on 7 December 2022, surrounded by his loving daughters. Dr. Merrill earned degrees in mathematics and electrical engineering from the University of Utah and electrical engineering from MIT. He was a distinguished alumnus of the University of Utah Electrical Engineering Department. Dr. Merrill was a registered professional engineer in New York State and a Fellow of the IEEE "for contributions to decision analysis considering conflicting objectives and risk in electric power systems." He was active on several IEEE Power & Energy Society (PES) committees, and he chaired the 1995 Power Industry Computer Applications (PICA) Conference and chaired the PICA Policy Committee for four years.

During his career, he worked at Merrill Energy, LLC, which he founded

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Hyde M. Merrill

to provide advanced risk, engineering, and economic analyses for participants in modern energy markets. Dr. Merrill was an adjunct professor at Rensselaer Polytechnic Institute and later returned to the University of Utah as an adjunct in the Merrill Engineering Building, named after his grandfather.

He was a distinguished alumnus of the University of Utah Electrical Engineering Department.

Weeks before his death, he delivered a plenary session at the North American Power Symposium.

Dr. Merrill was the author of more than 40 technical publications and numerous articles. Dr. Merrill was also a history buff with a near-photographic memory as well as an avid reader and a consummate storyteller. He served for two years as the associate editor of the "History" column for *IEEE Power & Energy Magazine*.

# PES meetings

*for more information, www.ieee-pes.org*

THE IEEE POWER & ENERGY Society's (PES's) website (http://www.ieee-pes.org) features a meetings section, which includes calls for papers and additional information about each of the PES-sponsored meetings. Please check the conference website for the most current information.

## July 2023

**IEEE PES General Meeting (GM 2023),** 16–20 July, Orlando, FL, USA, contact Roseanne Jones, roseanne.jones@ieee.org, https://pes-gm.org/

**IEEE International Future Energy Challenge (IFEC 2023),** 26–28 July, Hannover, Germany, contact Jens Friebe, friebe@ial.uni-hannover.de, http://energychallenge.weebly.com/

## August 2023

**IEEE Electric Ship Technologies Symposium (ESTS 2023),** 1–4 August, Arlington, VA, USA, contact Julie Chalfant, chalfant@mit.edu, https://ests21.mit.edu/

## September 2023

**IEEE International Smart Cities Conference (ICS2 2023),** 24–27 September, Bucharest, Romania, contact George Cristian Lazaroiu, clazaroiu@yahoo, https://attend.ieee.org/isc-2023/

## October 2023

**IEEE PES Innovative Smart Grid Technologies Europe (ISGT Europe 2023),** 23–26 October, Grenoble, France, contact Bertrand Raison, bertrand.raison@g2elab.grenoble.inp.fr, https://ieee-isgt-europe.org

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## November 2023

**IEEE PES Innovative Smart Grid Technologies Conference Latin America (ISGT LA 2023),** 6–9 November, San Juan, Puerto Rico, contact Alex Nassif, nassif@ieee.org, https://ieee-isgt-latam.org

**IEEE PES/IAS PowerAfrica Conference (PowerAfrica 2023),** 6–10 November, Marrakech, Morocco, contact Abdelbari Redouane, abdelbari04@gmail.com, https://ieee-powerafrica.org/

**IEEE PES Innovative Smart Grid Technologies Conference Asia (ISGT Asia 2023),** 21–24 November, Auckland, New Zealand, contact Nirmal Nair, N.nair@auckland.ac.nz, https://ieee-isgt-asia.org/

**IEEE Sustainable Power and Energy Conference (iSPEC 2023),** 29–30 November, Chongqing, China, contact Min Liu, min-liu@csee.org.cn, http://ieee-spec.csee.org.cn/2023/

**IEEE Transportation Electrification Conference and Expo Asia-Pacific (ITEC Asia-Pacific 2023),** 28 November–1 December, Chiang Mai, China, contact itecap-info@rmutl.ac.th, https://itec-ap2023.com/

## December 2023

**IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC 2023),** 6–9 December, Chiang Mai, Thailand, contact Praditpong Suksirithawornkul, praditpong.suksirithawornkul@hitachienergy.com, https://ieee-appeec.org/

## January 2024

**IEEE PES 2024 Joint Technical Committee Meeting (JTCM 2024),** 9–13 January, New Orleans, LA, USA, contact Dan Sabin, d.sabin@ieee.org, https://pestechnical.org/

**IEEE Electrical Energy Storage Application and Technologies Conference (EESAT 2024),** 29–30 January, San Diego, CA, USA, contact David Rosewater, dmrose@sandia.gov, https://cmte.ieee.org/pes-eesat/

## February 2024

**IEEE PES Innovative Smart Grid Technologies (ISGT 2024),** 19–22 February, Washington, DC, USA, contact Kathy Heilman, kathy.heilman@ieee.org, https://ieee-isgt.org/

## May 2024

**IEEE PES Transmission and Distribution Conference and Exposition (T&D 2024),** 6–9 May, New Orleans, LA, USA, contact Carl Segneri, carlsegner@sbcglobal.net, https://ieeet-d.org/

## July 2024

**IEEE PES General Meeting (GM 2024),** 21–25 July, Seattle, WA, USA, contact Roseanne Jones, roseanne.jones@ieee.org

For more information on additional technical committee meetings, webinars, and events, please visit our IEEE PES calendar: https://www.ieee-pes.org/meetings-and-conferences/conference-calendar.

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In addition, while the Electricity Directive demanded large suppliers to offer these innovative contracts to consumers, the reality is that in most countries it has been up to new market entrants to voluntarily offer them, at least in those countries where they are a novelty. The dynamic electricity price contract in Belgium offered by ENGIE is a notable exception to this trend.

This directive also allowed consumers to participate in all electricity markets to provide demand-side flexibility to the system. But, again, the European association for digital and decentralized energy solutions (Smart Energy Europe, or SmartEn) reported in 2022 that this is unfortunately not yet the case in most European countries. And even in those countries where demand-side flexibility can access multiple electricity markets, often it is only industrial customers who can access, while aggregated households' loads cannot yet do so.

Lastly, but most importantly, consumers are only able to make informed choices in electricity markets if they receive information that they can understand. Article 10 of the Electricity Directive granted consumers the right to have access to a summary of the key contractual conditions written in concise and simple language. But surveys carried out in several European countries hint that the information provided to consumers is still far too complex, which leads to a far too limited understanding of electricity markets by consumers. A survey carried out in 2021 by the Norwegian consumer organization Forbrukerrådet shows that 47% of Norwegian consumers do not know whether their contracts are on a dynamic or a fixed electricity price tariff. Similarly, a survey carried out by the Belgian Energy Regulator in the same year also shows that half of the Belgian consumers do not know whether they have a fixed or a variable electricity price tariff.

## How Can These Hurdles Be Overcome?

The question now is how these issues can be addressed and what steps are needed to ensure that consumers can truly become active participants in electricity markets. There are at least five areas where European and national policymakers should focus their attention.

First, the latest electricity market design review has not yet been transposed in most European member states, despite a December 2020 deadline. While it is true that the COVID-19 pandemic and the ongoing energy price crisis disrupted the work of lawmakers and pushed them to deprioritize the transposition of European legislation, it is also true that more demand-side flexibility would have in part contributed to keeping electricity prices under control. This situation was recognized by the European Commission in its toolbox released in October 2021 to support member states' efforts to tackle high energy prices. In addition, to address the possible worsening of the energy price crisis, in autumn 2022 the European Commission approved a binding target to reduce electricity demand at peak times by 5%, which highlights the importance of demand-side flexibility.

Second, a thorough review of administrative requirements for installing rooftop solar panels is way overdue. Over the past decades, national and local policymakers have put in place regulations aiming to achieve policy goals that are now conflicting with the goal of tackling climate change. On the one hand, there are regulations striving to protect historical and natural heritages and city permits are often needed to be able to install photovoltaic panels on buildings' rooftops. On the other hand, there are regulations protecting individual rights in collective properties, which often lead to decision-making rules in multiunit buildings that are not conducive to decisions being made. These two goals now conflict with the rapid rolling out of a large number of solar panels on European rooftops. National and local policymakers should review administrative requirements to find a better balance between these conflicting policy goals.

Third, European legislation is probably not sufficiently prescriptive, as requirements envisaged on time frames for grid connections and on the burdensomeness of administrative procedures are quite vague. Clearer requirements would help in making sure that consumers truly enjoy the rights that are granted to them in legislation. The European Commission has proposed to accelerate permitting procedures for solar panels by setting a deadline of one month, but the measure is only temporary. This prescriptive, outcome-based approach should become the standard in European policymaking.

Fourth, in many European countries, electricity grids are a bottleneck to the deployment of solar panels. This problem is more of an issue for large renewable energy projects, but in many cases, as explained earlier, it also affects rooftop photovoltaic panels. Although in the long term it is likely that distribution grids will need to be expanded, the procurement of flexibility at the distribution level can mitigate existing issues at least in the short term. SmartEn reports that only operators in the United Kingdom and in The Netherlands procure flexibility from their customers at the distribution level in a systematic way, while there are some trials ongoing in another handful of countries. Energy regulators across Europe should reform the existing remuneration mechanisms to incentivize flexible procurement from their customers by distribution system operators.

Lastly, even if, since well before the publication of the Clean Energy Package in 2016, the mantra of the European Commission has been that the energy system should be designed around consumers, evidence shows that existing regulations are not effective in engaging them. This situation highlights that there is a need for further investigation of consumers' understanding, behavior, and preferences when it comes to energy, and that there is a need for regulations designed around this insight. Households' contributions will be fundamental to achieving a fossil-free electricity system, which is now more urgent than ever.

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Jaume Loffredo

# consumer empowerment

## lessons from the European Union

THE KEY PILLAR OF THE EUROpean Union (EU) carbon policy is to achieve carbon neutrality on the continent by 2050. The two enablers to meet are the deployment of new wind and solar capacity to replace fossil fuel power generation and the electrification of end uses that today are dependent on fossil fuels, such as heating and transport.

As the sun does not shine and the wind does not blow at all times, the renewable-based power system of the future will increasingly require the active participation of consumers through demand-side flexibility. The International Energy Agency forecasts that, by far, the biggest demand-side flexibility potential will need to come from buildings and transport, with industry coming as the next important option.

As the European Commission is currently considering changes to the functioning of the EU electricity markets, this is the ideal time to understand whether the current legislation adequately empowers them to become active participants in these markets.

### Status of Consumer Participation in EU Power Markets and Its Hurdles

Article 15 of the Electricity Directive 2019/944 grants consumers the right to sell the electricity that they generate and to have their photovoltaic panels connected to the grid within a reasonable time frame. However, in countries like Estonia, Poland, Romania, and Bulgaria, the time frame for obtaining a grid connection is often quite long, reportedly because of an insufficient grid capacity due to a lack of investments. In Bulgaria, consumer organizations report that the time frame for a grid connection can be up to three years.

In addition, while the EU Electricity Directive says that active customers should not be subject to disproportionate administrative requirements, unfortunately, consumers in countries like Malta, Italy, and Germany need to submit applications for multiple authorizations to different bodies (municipalities, distribution system operators, regulators) to be able to lawfully install a photovoltaic panel. This requirement discourages many consumers from even considering switching to renewables, due to the excessive complexity of the process.

Even when consumers overcome all of these hurdles, in many cases they receive a very low level of remuneration for the electricity they feed into the grid, despite the fact that the EU Renewable Energy Directive 2018/2001 grants them the right to receive payments reflecting the electricity market value. Public research done in 2022 in The Netherlands by the Dutch consumer organization Consumentenbond revealed that of 30 suppliers surveyed, 14 pay consumers less than 70% of electricity wholesale prices and six of them pay less than 15% of wholesale prices.

The key pillar of the European Union carbon policy is to achieve carbon neutrality on the continent by 2050.

The Electricity Directive also allowed consumers to have access to offers incentivizing them to use energy in a flexible way, so that they can contribute to the resilience of the electricity system. To this end, the Electricity Directive granted consumers with a smart meter the right to sign up for dynamic electricity price contracts, which are contracts foreseeing that the price paid by consumers is directly linked to hourly prices in day-ahead wholesale electricity markets.

Despite that, the Council of European Energy Regulators and the Agency for the Cooperation of Energy Regulators reported in 2022 that these offers were available only in 11 countries across Europe in 2021. Since the publication of this report, dynamic electricity price offers have been discontinued in France because, due to the recent increase in electricity prices, these are not competitive with the regulated tariff offered by Electricité de France.

(continued on p. 98)

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