Energy storage: Opportunities and challenges

As the dramatic consequences of climate change are starting to unfold, addressing the intermittency of low-carbon energy sources, such as solar and wind, is crucial. The obvious solution to intermittency is energy storage. However, its constraints and implications are far from trivial. Developing and facilitating energy storage is associated with technological difficulties as well as economic and regulatory problems that need to be addressed to spur investments and foster competition. With these issues in mind, the annual Energy Talk, organized by the Stockholm Institute of Transition Economics, invited three experts to discuss the challenges and opportunities of energy storage.
The intermittency of renewable energy sources poses one of the main challenges in the race against climate change. As the balance between electricity supply and demand must be maintained at all times, a critical step in decarbonizing the global energy sector is to enhance energy storage capacity to compensate for intermittent renewables.

Storage systems create opportunities for new entrants as well as established players in the wind and solar industry. But they also present challenges, particularly in terms of investment and economic impact.

Transitioning towards renewables, adopting green technologies, and developing energy storage can be particularly difficult for emerging economies. Some countries may be forced to clean a carbon-intensive power sector at the expense of economic progress.

The 2021 edition of Energy Talk - an annual seminar organized by the Stockholm Institute of Transition Economics - invited three international experts to discuss the challenges and opportunities of energy storage from a variety of academic and regulatory perspectives. This brief summarizes the main points of the discussion.

A TSO's Perspective

Niclas Damsgaard, Chief strategist at Svenska kraftnät, gave a brief overview of the situation from a transmission system operator's (TSO's) viewpoint. He highlighted several reasons for a faster, larger-scale, and more variable development of energy storage. For starters, the green transition implies that we are moving towards a power system that requires the supply of electricity to follow the demand to a much larger extent. The fact that the availability of renewable energy is not constant over time makes it crucial to save power when the need for electricity is low and discharge it when demand is high. However, the development and facilitation of energy storage will not happen overnight, and substantial measures on the demand side are also needed to ensure a more dynamic energy system. Indeed, Damsgaard emphasized that demand flexibility constitutes a necessary element in the current decarbonization process. However, with the long-run electrification of the economy (particularly driven by the transition of the transport industry), extensive energy storage will be a necessary complement to demand flexibility.

It is worth mentioning that such electrification is likely to create not only adaptation challenges but also opportunities for the energy systems. For example, the current dramatic decrease in battery costs (around 90% between 2010 and 2020) is, to a significant extent, associated with an increased adoption of electric vehicles.

However, even such a drastic decline in prices may still fall short of fully facilitating the new realities of the fast-changing energy sector. One of the new challenges is the possibility to store energy for extended periods of time, for example, to benefit from the differences in energy demand across months or seasons. Lithium-ion batteries, the dominant battery technology today, work well to store for a few hours or days, but not for longer storage, as such batteries self-discharge over time. Hence, to ensure sufficient long-term storage, more batteries would be needed and the associated cost would be too high, despite the above-mentioned price decrease. Alternative technological solutions may be necessary to resolve this problem.

Energy Storage and Market Structure

As emphasized above, energy storage facilitates the integration of renewables into the power market, reduces the overall cost of generating electricity, and limits carbon-based backup capacities required for the security of supply, creating massive gains for society. However, because the technological costs are still high, it is unclear whether the current economic environment will induce efficient storage. In
If the model features a monopolist storage firm interacting with a perfectly competitive power generation market, the effect is reversed. The firm internalizes the price it either buys or sells energy, so profit maximization makes it buy and sell less energy than it would in a competitive market, in the exact same manner as the classical monopolist/monopsonist does. This underutilization of storage leads to underinvestment.

If the model considers a vertically integrated (VI) generation-storage firm with market power in both sectors, the incentives to invest are further weakened: the above-mentioned storage monopolist distortion is exacerbated as storage undermines profits from generation.

Using data on the Spanish electricity market, the study also demonstrated that investments in renewables and storage have a complementary relationship. While storage increases renewables’ profitability by reducing the energy wasted when the availability is excess, renewables increase arbitrage profits due to increased volatility in the price.

In summary, Fabra’s presentation highlighted that the benefits of storage depend significantly on the market power and the ownership structure of storage. Typically, market power in production leads to higher volatility in prices across demand levels; in turn, storage monopolist creates productive inefficiencies, two situations that ultimately translate into higher prices for consumers and a sub-optimal level of investment.

Governments aiming to facilitate the incentives to invest in the energy storage sector should therefore carefully consider the economic and regulatory context of their respective countries, while keeping in mind that an imperfect storage market is better than none at all.
The Russian Context

The last part of the event was devoted to the green transition and the energy storage issue in Eastern Europe, with a specific focus on Russia.

Alexey Khokhlov, Head of the Electric Power Sector at the Energy Center of Moscow School of Management, SKOLKOVO, gave context to Russia’s energy storage issues and prospects. While making up for 3% of global GDP, Russia stands for 10% of the worldwide energy production, which arguably makes it one of the major actors in the global power sector (Global and Russian Energy Outlook, 2016). The country has a unified power system (UPS) interconnected by seven regional facilities constituting 880 powerplants. The system is highly centralized and covers nearly the whole country except for more remote regions in the northeast of Russia, which rely on independent energy systems. The energy production of the UPS is strongly dominated by thermal (59.27%) followed by nuclear (20.60%), hydro (19.81%), wind (0.19%), and solar energy (0.13%). The corresponding ranking in capacity is similar to that of production, except the share of hydro-storage is almost twice as high as nuclear. The percentage of solar and wind of the total energy balance is insignificant

Despite the deterring factors mentioned above, Khokhlov described how the Russian energy sector is transitioning, though at a slow pace, from the traditional centralized carbon-based system towards renewables and distributed energy resources (DER). Specifically, the production of renewables has increased 12-fold over the last five years. The government is exploring the possibilities of expanding as well as integrating already existing (originally industrial) microgrids that generate, store, and load energy, independent from the main grid. These types of small-scaled facilities typically employ a mix of energy sources, although the ones currently installed in Russia are dominated by natural gas. A primary reason for utilizing such localized systems would be for Russia to improve the energy system efficiency.

Conventional power systems require extra energy to transmit power across distances. Microgrids, along with other DER’s, do not only offer better opportunities to expand the production of renewables, but their ability to operate autonomously can also help mitigate the pressure on the main grid, reducing the risk for black-outs and raising the feasibility to meet large-scale electrification in the future.

Although decarbonization does not currently seem to be on the top of Russia’s priority list, their plans to decentralize the energy sector on top of the changes in global demand for fossil fuels opens up possibilities to establish a low-carbon energy sector with storage technologies. Russia is currently exploring different technological solutions to the latter. In particular, in 2021, Russia plans to unveil a state-of-the-art solid-mass gravity storage system in Novosibirsk. Other recently commissioned solutions include photovoltaic and hybrid powerplants with integrated energy storage.

Conclusion

There is no doubt that decarbonization of the global energy system, and the role of energy storage, are key in mitigating climate change. However, the webinar highlighted that the challenges of implementing and investing in storage are both vast and heterogenous. Adequate regulation and, potentially, further government involvement are needed to correctly shape incentives for the market participants and get the industry going.

On behalf of the Stockholm Institute of Transition Economics, we would like to thank Niclas Damsgaard, Natalia Fabra, and Alexey Khokhlov for participating in this year’s Energy Talk. The material presented at the webinar can be found here.
Julius Andersson conducts research in environmental and public economics, studying the environmental and distributional effects of climate change mitigation policies. He holds a PhD from LSE and is currently a postdoctoral researcher at the Stockholm Institute of Transition Economics (SITE) – Stockholm School of Economics. He is a research affiliate at the Mistra Center for Sustainable Markets (MISUM) and the Department of Geography and Environment at LSE.

Chloé Le Coq is Professor of Economics at the University of Paris II Panthéon-Assas (CRED) and Research Fellow at the Stockholm School of Economics (SITE). Her research investigates topics related to antitrust policy, industrial organization, and experimental economics, with particular focus on the energy markets and their regulation. Her recent work includes empirical studies on financial contracts, social innovation and experimental studies of the electricity auction.
Elena Paltseva

Stockholm Institute of Transition Economics (SITE)
Elena.Paltseva@hhs.se
www.paltseva.org

Elena Paltseva is an Associate Professor at the Stockholm School of Economics. Prior to joining the Stockholm Institute of Transition Economics (SITE), Paltseva has worked as an Assistant Professor at the Department of Economics, University of Copenhagen. Her research interests include Political Economics, Industrial Organization, Energy and Resource Economics, and Gender Economics.

Svante Strömberg

Stockholm Institute of Transition Economics (SITE)
Svante.Stromberg@hhs.se
www.hhs.se/en/persons/s/stromberg-svante/

Svante holds M.Sc. in Econometrics and a B.Sc. in Economics from Stockholm University. He works as a full-time research assistant for the Stockholm Institute for Transition Economics (SITE).

The Forum for Research on Eastern Europe and Emerging Economies is a network of academic experts on economic issues in Eastern Europe and the former Soviet Union at BEROC (Minsk), BICEPS (Riga), CEFIR (Moscow), CenEA (Szczecin), KEI (Kiev) and SITE (Stockholm). The weekly FREE Network Policy Brief Series provides research-based analyses of economic policy issues relevant to Eastern Europe and emerging markets. Opinions expressed in policy briefs and other publications are those of the authors; they do not necessarily reflect those of the FREE Network and its research institutes.