Large-scale energy storage: Economic Implications and Questions

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THE ROYAL SOCIETY

LARGE-SCALE ENERGY STORAGE

Some Economic Implications and Questions.

Royal Society

8 September 2023

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KEY MESSAGES FOR POLICY

- The **scale** of the storage requirement. Scale economies. Leads to familiar infrastructure questions of finance, ownership and regulation.

- The complexity of the interactions and choices, both **operational** and for **investment.** A coordination issue.

- Hitherto largely ignored questions of **conversion capacity** (in and out of storage)?

- Fundamental implications for how we address system reliability. Adequacy of stored energy **kWh** at least as important as adequate generating capacity **kW,** but poses very different questions.

THE MAJOR QUESTIONS

- How will major infrastructure be financed at a low cost of capital?

- How will very complex choices be coordinated? Both for investment and operations. Extensive storage adds complexity both through its intrinsically multi-period nature and its centrality in reliability management

- What is our policy for managing future reliability: how do we define criteria and determine needs? Economic and energy resilience.

- What does all this mean for organisation, regulation and markets?

SOLUTIONS. SOME COMBINATION OF …

- Novel market mechanisms and incentives to reward provision of storage capacity and conversion capacity.
- Elements of long-term contractual assurance for infrastructure providers, eg a regulated asset base approach, or government commitments
- Centrally driven coordination of investment plans. (eg France’s EDF and Germany’s Energiewende).
- Enhanced role for the National Grid
- The creation of a ‘central buyer’, to procure capacity, but also to buy power from generators and sell to retail suppliers and large consumers.
- Close cooperation between members of umbrella groups who implicitly assume responsibility for reliability (the US ‘power pool’ model)

Slide notes

I have been asked to talk about the economics of large-scale storage. Economics in this context is about securing the right combinations of generation and storage, the principles to guide our decisions, and the mechanics of getting where we want to be. The objective is to find market or other mechanisms for the outcomes we want, ie getting to low or zero carbon at an affordable cost compatible with an acceptable level of reliability and energy security.

This is not just about a theoretical optimisation, but also about national policies, institutions, coordination, markets, regulation and infrastructure?

There are several particularly important general lessons from the report that have general economic and policy implications:

1. First is the potentially huge scale of storage. With both scale and major economies of scale, we have typical infrastructure characteristics, that need to be financed as cheaply as possible.
2. Second, interactions between storage and generation choices and multiple other factors: including the demand side. The report illustrates just how complex this is.
3. Third, conversion capacity, for moving energy in and out of storage, will matter and has perhaps hitherto been largely overlooked.
4. Fourth is the whole issue of policy and planning for reliability of supply. Traditionally this was mostly about adequate margins of generation capacity required over peak demands – so-called needle peaks. But the new world demands a quite different understanding of reliability, when we are talking about, for example, wind drought. The issue then is of kWh energy rather than kW capacity – a major distinction.

So the report raises some very serious questions.

It is clear that the storage need has all the characteristics that we associate with large scale infrastructure. This possibly includes a natural monopoly, certainly substantial investment costs, long lived assets that are highly use specific, and a financial necessity for a cost of capital as low as possible. For private capital that would mean a high level of reassurance over future revenue streams and the future market and regulatory environment.

Second is the issue of some very complex choices, and their coordination, in systems that rely on storage. It's important to recognise that there are two distinct timescales here. One is **operational** - operating the system as efficiently and economically as possible with whatever is the current mix of assets. The second is about **necessary investment** - creating the best mix of assets for the future. In a perfect market efficient solutions on both timescales might be expected to result from market prices. But in the new low carbon world that looks increasingly like a pipe dream.

The conventional view of power sector markets was that the price signals in a competitive market derived from the immediate needs for the efficient operation of mainly generation assets, replicating what might happen in a fully optimised system such as the merit order. It also had to provide an incentive for adequate capacity. Various extra mechanisms have often been added that attempt to put a valuation on reliable supply; this is sometimes referred to as value of lost load or VOLL. In principle it was hoped that all this collectively would incentivise the right mix of assets, generation, networks and storage for efficient and affordable future systems. In practice the most that can be said is that experience has been mixed.

So what is new. Traditional spot markets were developed to deal with gas and coal powered generators, and to replicate a merit order based on SRMC. They were also largely designed by the employees of those generators They do not translate or adapt easily to low carbon technologies with more complex, probabilistic, intermittency and operating constraints. Storage adds new dimensions, by being intrinsically multi-period, requiring in addition that attention is paid to conversion capacities, and the very different nature of the reliability issue.

The simple metrics of short run cost that sit behind conventional market mechanisms **do not** capture the information or the complexity required. Investment choices, on the four-way balances between generation, transmission, storage, and conversion capacity, pose further questions, implying a need for coordination.

My third point may well be the most important public policy question for the future – the security and reliability of electricity supply. We all know that governments cannot stand aside from issues of energy security, and electricity security in particular, however much they might wish to. However, this is another dimension where the economic and policy calculus has to change radically, with some very different metrics.

Historically supply reliability in the UK has been about generating capacity – kW, and occasional insufficiency of kW to meet needle peaks. But future crises, if they relate to sustained weather related shortages, will be about kWh rather than kW. Threats of months of energy rationing require an entirely different way of thinking about reliability. Possibly once in a generation events, like the 1970s 3-day week, a covid crisis or curtailed gas supplies, may mean looking at not just energy supply planning but also the overall energy resilience of the economy.

Answering all these questions means great attention to the institutional and market structures of the sector. We have to decide who should own and operate large scale storage, on public or private ownership, integration with grid operation, guarantees for private capital, and so on.

All these issues are closely inter-related, and the report offers an indication of where we might find the answers. These must rest on some combination of the following:

- **Novel market mechanisms and incentives** to reward provision of storage capacity and conversion capacity.
- **elements of long-term contractual assurance for infrastructure providers,** e.g. a regulated asset base approach, or government guarantees.
- **Centrally driven coordination of investment plans**. Quite common internationally (e.g. France's EDF and Germany's Energiewende).
- Enhanced role for the National Grid
- The creation of a 'central buyer', to procure capacity, but also to buy power from generators and sell to retail suppliers and large consumers.
- Close cooperation between energy companies who implicitly assume collective responsibility for reliability (the US 'power pool' model)

In summary the economics for me is about:

- balancing the roles of markets, thus retaining a role for competition, and central coordination
- financing storage as essential infrastructure, and
- re-evaluating the policy approach to planning for reliable future systems

Possibly the most important observation of all, though, is that all these things take time, and the task is urgent. That means starting to address these issues now.