NORTHERN POWERGRID

DS3 Distributed Storage and Solar Study

A brief insight into domestic battery energy storage systems

The project

Growing levels of photovoltaic (PV) penetration on the low voltage (LV) electricity network are increasingly causing thermal and voltage issues, limiting the number of PVs that can be connected without reinforcing the electricity network. Battery energy storage systems (BESS) may not only provide a solution for such issues but also for issues associated with the expected increase in evening peak demand caused by the electrification of heat and transport. The Distributed Storage and Solar Study (DS3) project explored the potential for aggregator-controlled behind-the-meter BESS to address these issues by providing peak-shaving capability. The project monitored a cluster of 40 domestic BESS installed in 36 households, of which 27 had PVs, over a period of two years.

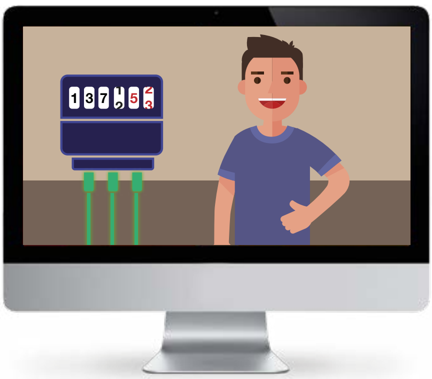
View the animation on YouTube at tinyurl.com/twq54we

Community benefit and learnings

The community consisted of tenanted homes that already had the benefits of solar PV. Participating tenants realised additional benefits of increased self-consumption.

This benefit, when added to the initial solar savings, had a material impact on the reduction of their electricity bills (up to £60 p.a. for a 2-3kWh BESS). Tenants were recruited through a tenant liaison officer they knew and trusted. They valued having a familiar face as a main point of contact and appreciated being able to freely ask questions. The majority of tenants were not tech savvy which, combined with difficulties accessing the properties, made proactively identifying and troubleshooting issues with intermittent data communication hard.

Size and aesthetics of the BESS were important for the tenants, hence its small size fitted nicely in the outhouse of the bungalows and was viewed as being out of the way. A larger BESS that had to be fitted internally might not have been as favourable.



The BESS required broadband to communicate their data and tenants were happy for the data to be transmitted using their connection. Where tenants did not have broadband, the project team funded and provided it; had this not been the case, monthly broadband costs would have erased any BESS savings.

Given the vast array of data and the need to calculate savings for the tenants, metered data with no gaps is essential for a third party intermediary to accurately check the savings and perform this service. Any third party community aggregated model will require streamlined, accurate and efficient data flows in order to pass on the savings to tenants, post taking an administration fee.

Tenants could easily ask for the BESS to be removed, if the savings per annum are not accurately portrayed to them in an easy to understand format. This would be even more apparent if a new tenant moves into a home, with solar and a BESS already installed, since the first year electricity bill will already contain the relative savings from the installed equipment.

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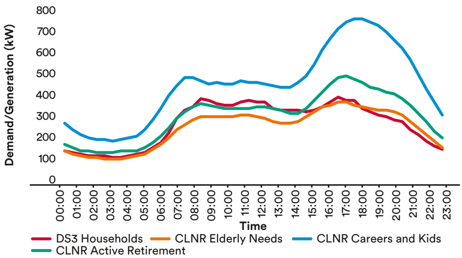
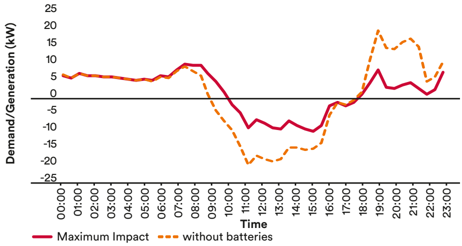
Network impact

The trial showed that there are a number of benefits from installing BESS, but that the impact varies depending on their mode of operation and the type of customer, as consumption behaviour varies significantly. DS3 profiles were compared to data from the CLNR[1] project which confirmed that the aggregated consumption was sensible. The demand patterns of the households closely matched those of the CLNR Elderly Needs and Active Retirement classes as most of the tenants of the DS3 households are retired.

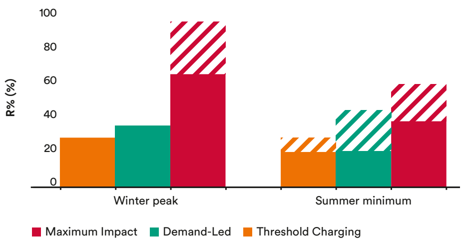


For consumers, the benefits come from increasing self-consumption by utilising local PV generation and where applicable exploiting time of use tariffs. For network operators, BESS can reduce the need for network upgrades as they can flatten the generation and load profiles. A number of BESS utilisation options were trialled to quantify and assess the impact they have on the electricity network. Unsurprisingly, their impact is significantly larger when they are forced to operate between certain times.



Although the impact BESS have on the network can double when operating in a network focused mode (Maximum Impact; force BESS to charge and discharge), there is still some network benefit even when the BESS operate in a customer focused mode and not being remotely controlled (Threshold Charging; charging when there is excess generation and discharging when there is excess demand).

- R% is the average percentage reduction in import/export over the high demand and generation periods;
- shaded area shows impact of BESS that are double the size.



[1]networkrevolution.co.uk

This benefit helps network operation and can be significant if there is widespread distribution of residential smart BESS. A higher household minimum demand can therefore be assumed when assessing domestic premises with PV and BESS which will allow for additional PV to get connected and an overall reduction in energy transition costs. This increase in assumed minimum demand can range between 55% and 125%, depending on the mode the BESS are operating in.

> **"For network operators BESS can reduce the need for network upgrades as they can flatten the generation and load profiles."…"A higher household minimum demand can therefore be assumed when assessing domestic premises with PV and BESS which will allow for additional PV to get connected and an overall reduction in energy transition costs."**

Network impact (Continued)

The network was also modelled using a power systems modelling tool which allowed us to explore additional scenarios and their corresponding impacts.

As expected, size and penetration levels have a positive impact on voltage problems but charging rate and BESS capacity should be set accordingly to ensure they can assist the network throughout the day. However, for an effective use of the BESS, the capacity should not be much larger than the daily demand. Modelling also confirmed that domestic BESS can resolve voltage constraints along the low voltage main and service cables, something that large scale BESS cannot.

BESS help reduce the evening peak demand which coincides with when people go home. The BESS can be fixed or on wheels and therefore in a world where the number of electric vehicles (EVs) increases and vehicle-to-grid (V2G) technology matures, they can help with the reduction of the evening peak demand.

Analysis showed that there was no economic benefit for the homes that had BESS but no PV, although the BESS did help network operation, especially if charged during the middle of the day to absorb the nearby PV generation.

The trial highlighted the importance of the timing and rates of charging and discharging. In some cases it was shown that it could be preferable for the network if BESS were forced to charge at a lower rate but for a longer period of time, as in summer the generation period turned out to be longer than the BESS maximum charging period (when charging at the BESS' maximum rate). On the other hand, in winter BESS did not need to be forced to operate in a certain way because generation was limited and evening peaks for this group of households were fairly small.

The results from this project would be 'super charged' if all homes were digitalised with smart meters. The benefits could include setting the charging and discharging rates of the BESS a day ahead based on accurate collected consumption data combined with weather forecast data, which could make the BESS operate much more efficiently. Smart meter data would also allow BESS providers to size them according to domestic consumption levels, ensuring the batteries are able to operate effectively.

"BESS help reduce the evening peak demand which coincides with when people go home. The BESS can be fixed or on wheels."

Market analysis

A cost-benefit analysis was performed to determine the economic feasibility of using BESS to resolve network constraints as opposed to conventional network reinforcement solutions.

This would involve forcing the BESS to operate at certain times and compensating the owners for doing so. Typical costs were used to cost up several reinforcement use cases which provided an indication of the costs related to certain network upgrades, as well as the BESS capacity that would be required to avoid or defer these upgrades.

A methodology was developed and presented in the main report[2] which allowed the calculation of a ceiling price and available compensation that could be offered under certain assumptions for each use case if BESS were used to provide a flexibility service and defer conventional reinforcements for a period of time or even completely avoid them. The rates for these use cases ranged from **£8.70–£79.28/kW/year** and **£26.81–£244.35/kW/year** respectively.

[2]Accessible at www.northernpowergrid.com/innovation

Market analysis (Continued)

With typical annualised costs ranging from £41.46–£119.89/kW/year for grid scale and domestic BESS respectively, it was concluded that there is potential for flexibility services from BESS to be an alternative to conventional reinforcements, especially where the BESS is already present. At the moment, there is little potential for BESS to be installed solely to alleviate network constraints as this could only be feasible when a limited amount of BESS could avoid high cost network upgrades. Given that there is network benefit even when BESS operate at the discretion of the customer (i.e. not being forced to operate at certain times but operate to increase self-consumption), a government incentive in the form of a small upfront capital support could be considered, which could help stimulate the uptake of BESS in certain areas that are expected to see constraints.

It is important to note that as BESS costs reduce and additional revenues (e.g. by providing Firm Frequency Response) could be contracted, it is likely that some business cases which are non-profitable now might need to be reconsidered in a few years.

Finally, the study tested the degradation of the BESS over the project lifetime and estimated that there should still be 80% of power charge left after 10 years, which was viewed as a positive.

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Conclusion

The domestic smart BESS marketplace in the UK has seen an increase in manufacturers and distributors, with new entrants and business models, since project inception in 2017 when the residential domestic smart BESS market was in its infancy.

Although it is still a nascent industry, it can potentially offer suitable solutions to the foreseeable change to the electricity generation and distribution network, especially if capital costs of the BESS continue to fall and market driven contracts can stack up and reward those homes willing to host BESS to respond to a future flexible grid.

The DS3 project has given some insights into a future flexible domestic electricity market, where smart BESS can be utilised to their maximum effect, benefiting consumers and the local network.

The trial has successfully concluded that BESS can be retrofitted into homes, and perform to the manufacturer's stated capabilities, whilst increasing the benefit of residential solar generation and aid in balancing the local low voltage network.

The speed of uptake of smart BESS with or without solar PV, or electric cars at home, will be propelled when there is a clear understanding of accurate residential demand and export, through the digitalisation of the domestic residential electricity market, and local settlement.

For more information see the full report on www.northernpowergrid.com/innovation

Acknowledgements

Northern Powergrid would first and foremost like to thank the tenants for agreeing to participate in this innovation project. The project would not have been feasible without their participation.

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Last but not least, a big thank you to Berneslai Homes for installing the batteries and resolving any operational issues on site and Element Energy who, along with TNEI, analysed the data and produced a series of insightful reports.

Project partners and collaborators
DS3 is a Northern Powergrid NIA funded project. Northern Powergrid's partners and collaborators are Moixa, Energise Barnsley, Element Energy, TNEI and Berneslai Homes.