Study conducted in partnership with
Power Circle, MälarEnergi, Kraftringen and InnoEnergy

The potential for local energy storage in distribution network

Summary Report

Major potential for local energy storage

Storing energy in batteries is the new black – especially since Elon Musk and Tesla got into the game. So just how will local energy storage using batteries impact the electrical supply network, consumers and the industry? According to a recent Swedish study initiated by Power Circle and conducted together with MälarEnergi, Kraftringen and InnoEnergy, batteries show great potential and can lead to cost savings and the expansion of renewable energy.

Currently, a major expansion of renewable energy is under way around the world in the shape of local electrical generation installations. This is a gratifying development, but it requires industry players to come together especially in the further development and implementation of smart supply networks. It will take smart technologies to allow the integration of major amounts of intermittent power into the grid.

Energy storage in batteries is one such smart technology with the greatest future potential – a potential confirmed by this recent study into the effects of energy storage installations in private houses and apartment buildings around Sweden. For example, the study showed that sharing a battery with a capacity of 0.8–1.3 kWh per apartment can reduce a building's peak load by 40 per cent. In addition to the cost savings for both end users and network owners, this kind of peak load reduction frees up major capacity in the electrical supply network, and this is exactly what renewable energy production needs.

Time to store energy

What is the potential in being able to store energy; how much can the end user save, what are the advantages for the electrical supply network and how can this energy storage help the expansion of green electricity?

Many battery storage pilots are under way all around the world to investigate how batteries can create value for the end user, electricity providers and the electricity distribution system as a whole. South Korea and California already have major battery factories and ambitious research and development programmes for battery energy storage. In Germany, a great amount of locally generated renewable energy has already been integrated into the electrical supply network and there are subsidies for battery systems to encourage private consumption. Calculations show that the use of reasonable sized battery storage can increase self-consumption from around 30 per cent to 60 per cent of energy use.

Despite its broad expertise and recognized R&D groups, there are few demonstration projects or preliminary studies into energy storage in Sweden. Studies into distributed energy storage are especially rare. Consequently, Power Circle, MälarEnergi, Kraftringen and InnoEnergy have carried out a study aiming at assessing the potential of local energy storage. Naturally, its principal underlying purpose is to enable greater integration of renewable energy production.

This publication summarizes the project and its most important conclusions – the full report [in Swedish] is available here: **http://goo.gl/0GC6zv**

> "A battery of around 1 kWh per apartment is sufficient to reduce peak load by 40 per cent in the entire building."

About energy storage and batteries

Today there are a number of different technologies and methods for storing energy. One of the most interesting alternatives is battery storage – especially lithium-ion batteries – where R&D is making rapid advances. This electro-chemical storage method is considered to be the technology group with the broadest area of application, to be sufficiently commercial, have the best cost-benefit trend and technical challenges that appear to be manageable. Compared to other electro-chemical storage technologies, lithium ion batteries also have the best conversion efficiency.

Analysis of the potential for energy storage at the electrical supply network and individual building levels

Energy storage can be located at different levels within the electricity supply network such as at the top of the transmission network, within the grid itself or with the individual electricity consumer. According to an analysis by the Rocky Mountain Institute, the further downstream in the supply network storage is located, the more benefits it provides.

The most important conclusions drawn by the Rocky Mountain Institute can be summarized as follows:

- Distributed batteries at the household level – downstream of the electricity meter – can contribute most to the electrical system.
- Several benefits should be combined to make the battery as cost-effective as possible.

Accordingly, based on these conclusions, an important part of this investigation was studying the potential for energy storage as a means for landlords and house owners to manage volatility in peak loads.

Apartment blocks: 1 kWh per apartment has a major impact!

In the study, we simulated three small apartment buildings in Uppsala, Sweden. The simulations assumed that the apartments no longer had their own connections to the electricity supply network – this would be a natural consequence of installing batteries in the building – but instead shared a connection and divided the bill for electricity from the supply network per apartment through metering. In the case of energy storage in the building, technological security resides in the storage which is then dimensioned to cope with peak load and thus meet the supply contract main fuse rating without risk.

The simulations with the Uppsala apartments show that a shared battery equivalent to 0.8-1.3 kWh per apartment (and an assumed power/energy ratio of 1:2) can reduce a building's peak load by 40 per cent. Or in practical terms, a building with 60 apartments could achieve this output with a battery as small as those used in Tesla electric cars.

This naturally means major opportunities to reduce electricity charges for landlords and tenants alike. And for network owners, energy storage means freeing up yesterday's probable over-dimensioned output plus an additional 40 per cent for other purposes.

Private houses: heating is the crucial factor

The simulations were based on three different categories of private houses: those with district heating, those with electrical heating and private houses with heat pumps.

The potential savings by cutting peak loads are lower in the case of private houses than apartment buildings. This is because so many private houses have main fuse ratings between 16 and 25 amps while most electricity providers in Sweden today have

16 amps as the lowest rating for private houses. The opportunity in decreasing main fuse rating one level down is therefore limited. Though it can be done, energy storage would not be a cost-effective solution if the objective is to reduce peak load.

For the purpose of this study, we have instead used the electricity tariff currently applied by e.g. Sollentuna Energi. The tariff comprises two components – a fixed fee and a flat-rate power-based fee that varies according to the seasons. However, even using these assumptions there was seen to be less potential for houses than for blocks with multiple apartments.

- We conclude that energy storage would be too expensive, especially in the case of private houses with electrical heating and regardless of lithium ion battery cost trends. This is because more than 13 kWh would be needed to reduce the peak load by 20 per cent and as much as 200 kWh to reduce it by 40 per cent.
- Private houses with district heating already have a lower electricity requirement and therefore a smaller peak load (5.1 kWh/h). Thus private houses with district heating require a 3 kWh battery to reduce peak loads by 20 per cent and 4 kWh to reduce them by 40 per cent.
- Private houses using heat pumps have a somewhat larger peak load (11.1 kWh/h), which would require a 5 kWh battery to reduced peak load by 20 per cent and a 9 kWh battery to reduced it by 40 per cent.

In both of the last two house types, an investment at today's battery system prices would provide a repayment of the investment in just over 16 years. In the case of an investment at the assumed battery system price of 10 years hence, the repayment time would be just over 6 years.

"Using a shared battery equivalent to 0.8-1.3 kWh per apartment could reduce a building's peak load by 40 per cent"

Local energy storage – the most important conclusions

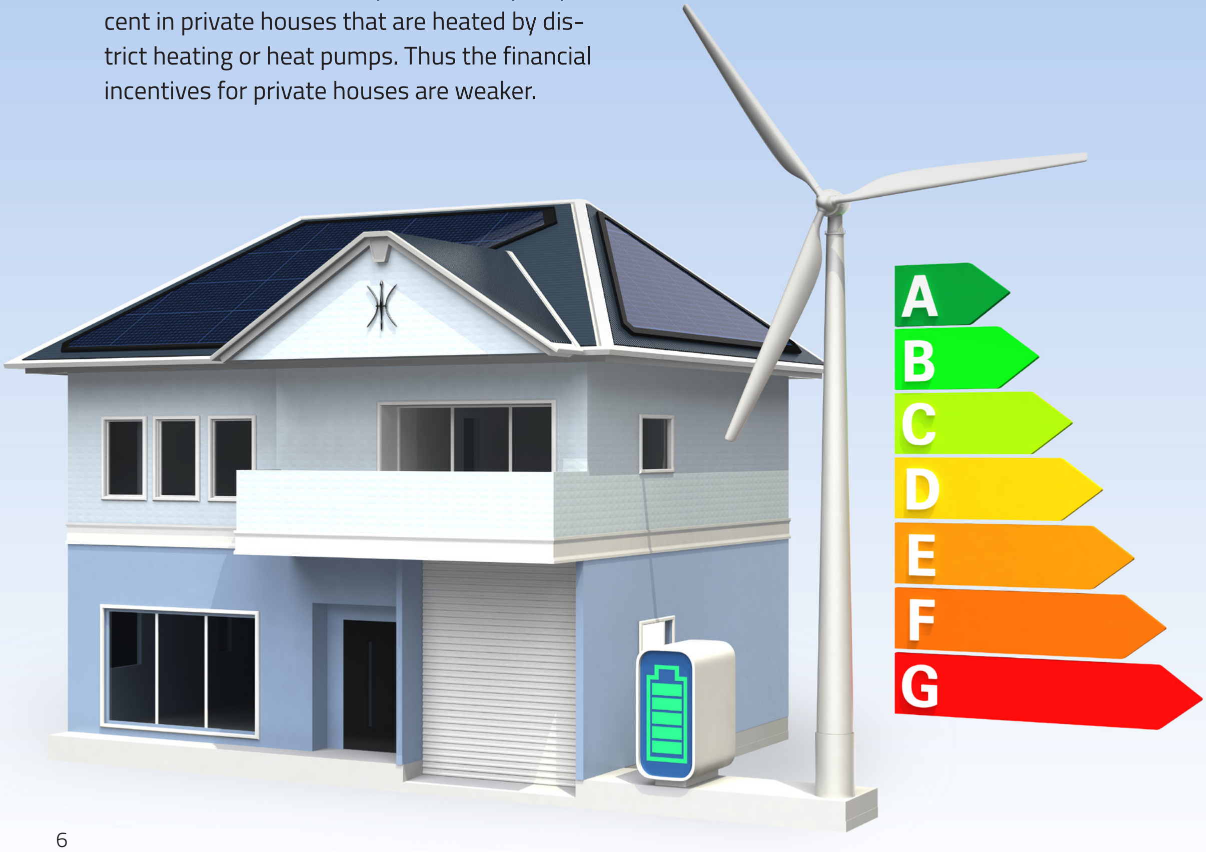
For landlords:

- There is great potential for freeing up load from a property's fixed contract level by reducing the main fuse rating in the contract. By using a shared battery of just 0.8-1.3 kWh per apartment could reduce e.g. an apartment building's peak load by 40 per cent.
- With collective metering and shared batteries in apartment buildings, the repayment time for a battery investment is 5-7 years, and it should be noted that in the simulation the properties had relatively few apartments, namely 18, 27 and 36 respectively.
- This presents attractive financial incentives for e.g. tenant-owner associations, although the individual apartment owners lose the service and security associated with having their own electricity supplier and the ability to choose their electricity provider themselves.
- For private houses the repayment time is longer, around 16 years. This figure applies to batteries that can reduce peak loads by 40 per cent in private houses that are heated by district heating or heat pumps. Thus the financial incentives for private houses are weaker.

For electricity supply networks:

By allowing individual properties – private houses and apartment buildings alike – to reduce their main fuse rating in contracts, capacity that the supply network owners currently reserve for precisely these specific buildings is freed up. If similar methods are introduced on a larger scale, it will mean that the supply network owners' new-found capacity can be used for other purposes or to avoid capacity expansion.

> "This creates opportunities for the establishment of small-scale wind and solar power generation."



Reducing peak loads also enables supply network owners to avoid fees for excess losses from the regional supply networks during periods of high peak loads. Over time, this could also lead to lower power supply contracts vis-à-vis the principal power grid, which would mean savings for the electrical supply network owner.

For the expansion of renewable electricity generation:
Reduced peak loads and lower main fuse ratings in contracts will provide great potential for freeing up capacity in the supply network. The "new" capacity can be used for such things as new residential areas, the deferral or avoidance of supply network expansion, or it could also be used for new electricity production. This creates opportunities for the establishment of small-scale wind and solar power generation.

Wind turbines also have the characteristic of generating harmonics in the electricity supply network, which is somewhat of a problem from the network's standpoint. Energy storage installations have technical characteristics which mean they are able to function actively as filters to "clean" electricity before it reaches the grid. Thus local energy storage at wind farms provides for clean, predictable electricity to the grid.

Three recommendations for the future

1 Enable network owners to exploit the benefits of energy storage

Regulations that allow network owners to own, operate and control energy storage linked to the network within the operating area are necessary to safeguard supply and quality. The regulations would also need to address the barriers that currently hinder the introduction of energy storage to both the market and the supply network.

2 Create incentives for shaving peak loads in properties

There are financial incentives for buildings with multiple apartments to remove the individual connections to the mains by introducing collective metering and installing solar cell arrays and/or energy storage. This would allow peak load reductions and savings through a lower main fuse rating in contracts. The same principle applies to private houses, but because many house owners have already reduced their peak load to 16 amps there is often nothing to be gained by reducing it further.

The recommendation is therefore to adapt the range between main fuse ratings for properties and introduce an alternative for lower main fuse ratings for private houses.

3 Further studies and demonstrations

This study has shown that there is a potential for battery storage to result in cost savings for both property owners and apartment tenants. Further study should therefore be carried out into battery storage in e.g. other applications and other kinds of building. In addition to studies, real-world demonstrations are also recommended as they would help test the technology and its reliability and map out installation and service costs.

> "Create regulations that allow network owners to own, operate and control energy storage"

www.innoenergy.com

In partnership with:

www.powercircle.com

www.kraftringen.se

www.malarenergi.se

Jointly financed by:

Energimyndigheten

www.innoenergy.com

INNOENERGY IS SUPPORTED BY THE EIT,
A BODY OF THE EUROPEAN UNION