PV AND BATTERY SOLUTION BOOKLET

Smart Cities Marketplace 2023

The Smart Cities Marketplace is managed by
the European Commission Directorate-General for Energy

ENERGY

European Commission

Publisher: Smart Cities Marketplace © European Union, 2023

Completed in: November 2023

Author: Smart Cities Marketplace managed by
the European Commission Directorate-General for energy
smart-cities-marketplace.ec.europa.eu | European Commission
| DG ENER

2023 version is updated by: Lorenz Van Damme (Th!nk E)

2023 version contributors: Leen Peeters (Th!nk E)

2023 version proofreading by: Gabi Kaiser, Siora Keller (Steinbeis 2i)

2020 version written by: Han Vandevyvere (VITO / EnergyVille),
Egon Troch (Th!nk E)

2020 version contributors: Leen Peeters (Th!nk E)

Graphic design: Agata Smok agata@think-e.be (Th!nk E) for the Smart Cities Marketplace,
European Commission DG ENER

Cover photo: Getty Images

Inner cover photo: Kaspars Upmanis on Unsplash

Typeface: EC Square Sans Pro

WHAT IS THE SMART CITIES MARKETPLACE?

The Smart Cities Marketplace is an initiative supported by the European Commission bringing together **cities, industry, SMEs, investors, banks, research and other climate-neutral and smart city actors**. The Smart Cities Marketplace Investor Network is a growing group of investors and financial service providers who are actively looking for climate-neutral and smart city projects.

WHAT ARE THE AIMS OF THE SMART CITIES MARKETPLACE?

The Smart Cities Marketplace has thousands of followers from all over Europe and beyond, many of which have signed up as a member. Their common aims are to **improve citizens' quality of life, increase the competitiveness of European cities and industry** as well as to **reach European energy and climate targets.**

WHAT CAN THE SMART CITIES MARKETPLACE DO FOR YOU?

Explore the possibilities, **shape** your project ideas, and close a **deal** for launching your smart city solution! If you want to get directly in touch with us please use info@smartcitiesmarketplace.eu

WHAT AND WHY

↑ © Julian Wildner on Unsplash

What and why

The overall goal of the transition in the electricity system is to increase the share of renewable energy sources in buildings and neighbourhoods. The large-scale roll-out of photovoltaic (PV) panels and battery energy storage systems (BESS) play an important role in this perspective.

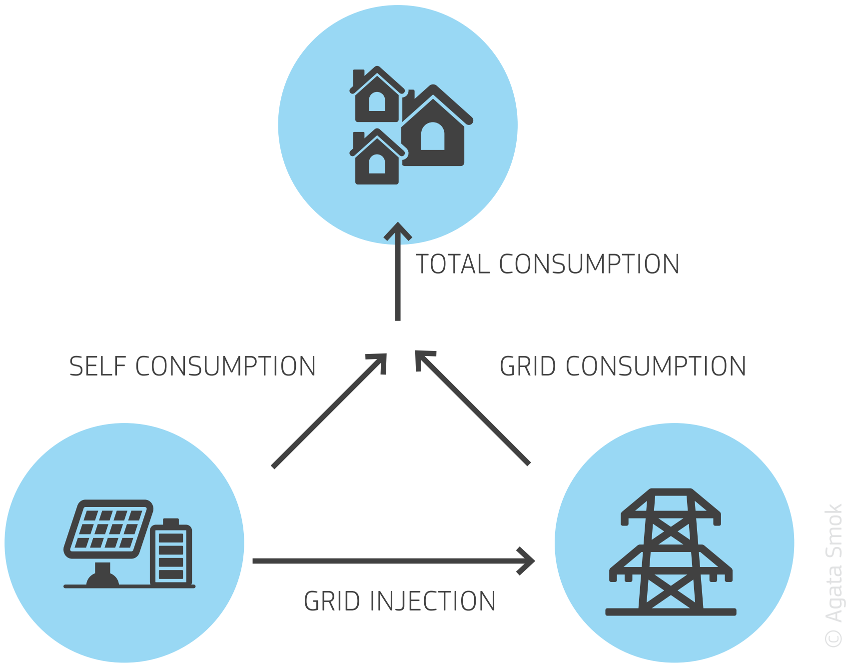
PV panels produce renewable electricity, and batteries could store it for times when electricity is needed but not available from renewable production. This combination significantly increases the **share of renewable energy** in electricity consumption and, therefore, contributes to the reduction of greenhouse gas emissions.

PV and batteries not only allow to decrease energy consumption from the grid, they also make it possible to control the peak power demand and the timing of grid consumption and injection. This way, they play an important role in **stabilising the grid**, reducing losses and averting costs to increase grid capacity for increasing electricity demand and injection. They can help to reduce local black-outs and could guarantee the availability of electricity in case a black-out occurs nevertheless.

PV and batteries allow the end consumers to **reduce electricity costs** and significantly lower dependency on fluctuating electricity prices.

Furthermore, batteries do not always need to be static devices installed in a house or business. Through the rise in popularity of electrical cars the number of households with a battery system in the driveway has grown accordingly. These car batteries are prime candidates to be used to store energy produced by PV panels and deliver services to the grid.

Both batteries and PV invertors have the capability to aid the power quality of the grid, which prolongs the lifespan of electrical devices.



CITY CONTEXT

↑ © Qusai Akoud

City context

In general, it is expected that the electricity demand will increase. Not only are people using more and more electrical devices (smart phones, tablets, etc.) but an electrification of both space heating (with heat pumps) and mobility (electrical cars, e-buses, e-bikes, etc.) is expected to increase energy demand.

Both the increase in electricity consumption and the **increase of decentralised power generation** challenges the grid which is often sized on less connections, smaller consumptions and a top down centralised electricity production.

The challenge rises as electricity is not necessarily produced at the same time it is consumed. Without any flanking measures, this could lead to **congestion problems** and a lower power quality, which can shorten the lifespan of electric devices and cause blackouts. It also limits the achievable share of renewable energy.

These problems are **local in nature** and can occur in any street or neighbourhood in all cities and municipalities. Because of the local nature of this challenge, cities and municipalities that are better informed and promote the solutions in a targeted way, will be least confronted with the consequences of congestion problems.

One of the solutions that is already implemented, specifically to reduce overvoltage problems, is called curtailment. This involves solar invertors shutting down at a certain voltage before it can reach levels where the voltage could damage devices connected to the grid. However, the downsides of this measure is that on sunny days in neighbourhoods with a large number of solar installations, production will be lower compared to the theoretical potential.

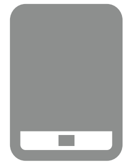
One of the crucial measures to solve this challenge is to **shift certain electricity demands in time** to align them maximally with the renewable electricity production. This is also referred to as **flexibility**.

Through demand side management, the consumption of some devices can be shifted in time without the end consumer having to change behavior, such as heat pumps for space heating or production of domestic hot water, air conditioning, swimming pool heating, electric vehicles etc. However, some appliances are not flexible in nature, such as electricity for cooking, ironing, hair drying etc.

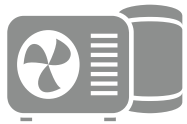
In future, more dynamic pricing of electricity can result in a financial incentive for citizens and companies to shift their energy consumption as energy consumption at one point of the day will be more expensive then another.

Further reading: E-BUS Solution Booklet and smart-cities-marketplace.ec.europa.eu/insights/

Electricity demand will increase:



DEVICES



HEATING

VEHICLES

PV and batteries allow to use electricity produced from renewable sources for appliances that cannot easily be shifted in time. By storing the electricity from the solar panels in the battery when electricity demand is low, the grid isn't overloaded by injecting too much electricity when the sun is shining. Later in the evening, electricity from the battery can be used instead of electricity from the grid when everyone is using electricity at the same time, while no more renewable energy is available. This way, the grid balance is guaranteed, and the share of renewable energy sources in the electricity mix can be further increased.

Further reading: Electric Vehicles and the Grid and smart-cities-marketplace.ec.europa.eu/insights/

To further increase power quality and renewable share and to further reduce electricity costs, people and organisations with a connection to the same electricity line can organise themselves in a **Local Energy Community** (LEC).

SOCIETAL AND USER ASPECTS

↑ © Davide Pietralunga

Societal and user aspects

Stakeholder support and citizen engagement

PV panels are generally well accepted in society. The public understands that they are important to increase the share of renewable energy and decrease dependency on fossil fuels. PV panels are installed and maintained by local workforce and, therefore, benefit the local economy.

The effective market uptake of small-scale building level and neighbourhood **batteries** shows delays compared to projections. Besides pricing and potential return on investment, end-consumers and decision makers lack of information and understanding of the technology hold back implementation.

Some evolutions are expected to further increase stakeholder engagement

- ✓ The expected market increase of building integrated PV panels (BIPV) further contributes to social acceptance since they are less of a visual barrier.
- ✓ Sharing or renting (public) roof space facilitates to participate in PV projects, typically in the form of energy communities.

In current regulation, neighbourhood batteries pay standard grid tariffs, while their objective is to support the grid in congestion and power quality aspects. In grids where further enforcement is not possible, well-controlled neighbourhood batteries could be part of the solution.

When dealing with battery energy storage systems, it is crucial to respect all **safety measures** required for the transport, installation, and use of the selected battery type.

Like with any other device, these safety measures are designed to protect the end consumer.

Lessons learned

To realise the roll-out of PV and battery installations, social acceptance of the solutions is very important, especially **in a residential area:**

- **Take actions on customer engagement.** Take time to explain the concept, what customers may expect and listen to their concerns.
- **Take into account** that the comfort level of the households involved must be guaranteed at all times.
- **Maximise user-friendliness** of the PV and battery system. The most user-friendly system is one that doesn't require user interactions.
- **Limit the need for house visits** by requiring technologies and management systems that are tested, robust and remotely manageable in case of issues.
- **Select partners with care.** For instance, the partner that has to go in the houses for customer service should be experienced in this to minimise the inconvenience for the end users. Demand a fast response time in case a problem occurs.
- When working with the local authorities, it may be useful to **involve a legal expert** for the installation of a neighbourhood battery. If the right connection is made with legislation, local authorities may feel more confident with approving the project.
- **The lead-time for battery energy storage systems can be long.** The order should be given well ahead to meet project milestones. Keep this in mind when planning the project.

User-friendly

Best technology

Customer engagement

Non-stop comfort

Legal experts

Good planing

Best experts

Tested, robust and remotely manageable in case of issues

TECHNICAL SPECIFICATIONS

↑ © Han Vandevyvere

↑ © Han Vandevyvere

Technical specifications

Description – components of the system

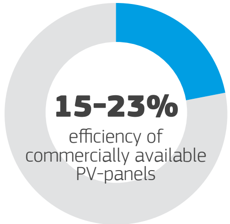
PV panels

In most cases, the panels are installed **on rooftops**. In order to withstand wind forces, the panels should be well fixed or stabilised with the use of ballasts. Either way it should be made sure that the roof can manage the additional weight.

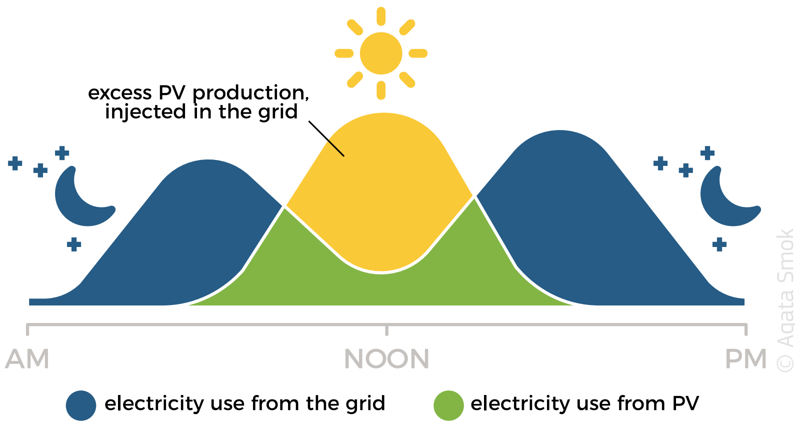
Since urban space is very valuable and the visual appearance of standard rooftop PV panels can, in some cases be undesirable, more and more types of **building integrated PV panels** (BIPV) are developed. Examples are roof tiles, flexible, foldable, translucent and/or colored panels.

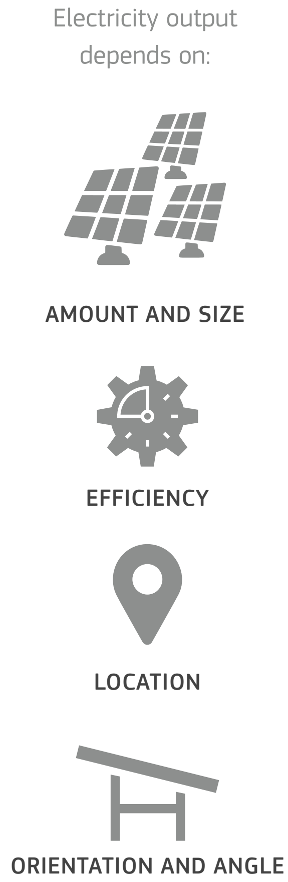
The **electricity output** depends on the amount, the size and the efficiency of the panels, but also on the location, orientation and angle. Since the panels produce electricity from solar radiation, electricity is only produced during daytime. In summer, the production is significantly larger than in winter because the increased amount of hours of sunlight in a day. During hot days, however, solar production is limited since the efficiency of solar panels decreases at high temperatures. Commercially available PV-panels have an efficiency of 15-23%.

In most installations an inverter converts the variable direct current (DC) from the solar panel to alternating current (AC) before the electricity is used. In combination with batteries, including from e-vehicles, the invertor DC/DC conversion from the solar panels to an electric car is now also possible.



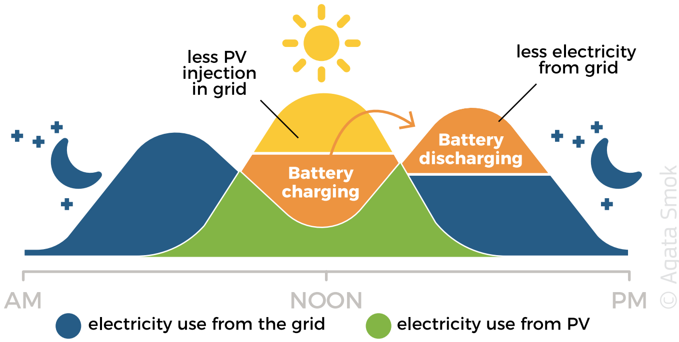
When the building's electricity demand exceeds the PV production, the surplus demand is delivered by the grid. When the PV production exceeds the electricity demand, the excess production can be injected into the grid.



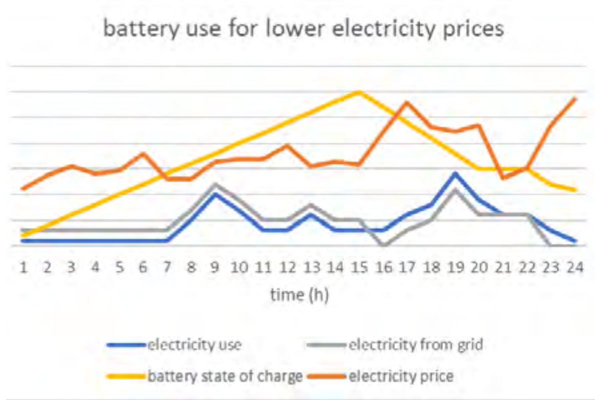


Use of battery energy storage system

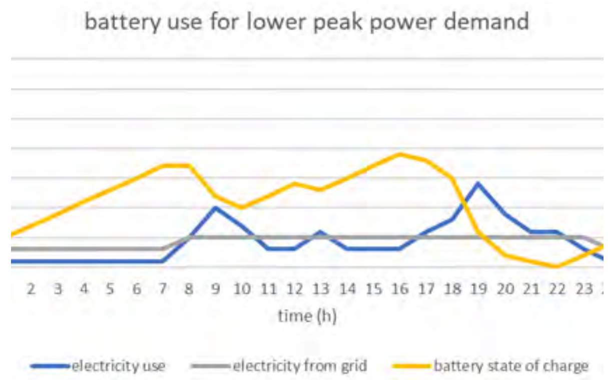
Batteries are used to store electricity on a daily basis in the ideal case. This makes them highly suitable to charge electricity when the production of renewable electricity is larger than the electricity demand and to discharge when more electricity is needed than can be produced from renewables. In combination with PV panels, the battery increases the degree of self-sufficiency and self-consumption.



At times when PV production is low, the batteries can also be charged with electricity from the grid when prices are low, thus excess electricity (from most likely renewable sources) is available from the grid. This electricity can then be used when electricity prices are high. This can improve both the business case and the share of renewable energy in the region. Do note that for this business case the difference between the highest and lowest price needs to be at least larger than the grid costs.



Another way to use the batteries is for reducing peak demand and, therefore, using a smaller grid connection. To do so, the battery is charged during (excess) PV production and during moments of low electricity consumption. During high consumption the battery can be discharged.



When power quality on the grid is poor or even during black-outs, the battery can be used to guarantee power availability and power quality within the building (entirely or for vital functions only), improving comfort and prolonging the lifespan of indoor devices.

Applicability

PV and batteries have the highest added value in buildings or neighbourhoods where a high level of electrical devices and/or a high number of PV causes congestion and voltage issues on the electricity line.

But also, in neighbourhoods without grid capacity problems, PV and batteries can contribute in increasing the share of renewable energy and balancing the grid nation-wide.

The solution can be applied on a single building, a building block that with multiple tenants and even on the scale of an energy community (neighbourhood battery system).

> Because a rooftop PV system can make it more complex to insulate the roof afterwards, in most cases it is advised to insulate the roof before installing this solution. The same remark goes for other parts of the building when installing BIPV panels.

It's perfectly possible to add a battery system to an existing PV system to get to the same result.

> Batteries use energy to operate, even when they are not charging or discharging. This is because of the need for a **Battery Management System (BMS)** to constantly monitor the state of the battery, and possible cooling or heating needs. Battery cells have certain operating temperatures between which they need to be kept for safety reasons.

Other interesting ways to provide flexibility to the grid exist:

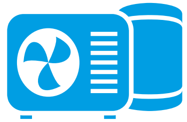
- → heat pumps for space heating
- → production of domestic hot water
- → air conditioner
- → swimming pool heat pumps
- → electric vehicles (in a vehicle-to-grid appliance)

These flexible devices can contribute in a complementary manner and allow to select a smaller battery, which is beneficial for the project's feasibility.

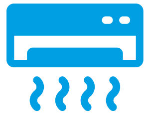
PV and batteries are very suitable for shifting loads on an hourly or even daily basis.

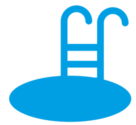
It is, however, not suitable for:

- → seasonal storage. Due to losses and the limited number of cycles a year, the PV production in summer cannot be stored until winter.
- → fluctuations on a basis of seconds. Some devices (e.g.,microwaves) have a very unstable electricity use profile, which causes grid profile pollution. This phenomenon is not something that batteries can solve but should be solved by a better design of the devices.


HEAT PUMPS


HOT WATER


AIR CONDITIONER


SWIMMING POOL HEAT PUMPS


ELECTRIC VEHICLES

Selection, sizing and design of battery system

A wide variety of battery types is available on the market. They differ in chemistry, size, capacity, energy density, efficiency, lifespan, environmental impact of production, rate of charging and discharging, etc. Because of these differences, each battery type has its own strengths and weaknesses and the choice of battery strongly depends on the application it is used for.

Depending on the electricity profile of the project, the right energy capacity of the battery (kWh) and power of the inverter (kW) is to be selected and the appropriate choice for a one-phase or a three-phase battery to be made. To do this, measurements are required that show the peak power demand, the electricity consumption profile, the electricity production profile and the loads that are already flexible and can be shifted in time without the use of a battery.

With a most European households already having a smart meter it should be possible to extract at least the current profile of energy use and the peak power demands. It should be noted that this data is generally collected on a larger timeframe (e.g., 15 minutes), it is thus possible to miss large, short peaks of power consumption. It is thus still advised to do a proper study of the installed devices.

Since these choices can have a large impact on the performance of the system, the feasibility and safety of the installation, it is advised to contact an **experienced engineering company and installer.**

Batteries use energy to operate, even when they are not charging or discharging. This is because of the need for a **Battery Management System (BMS)** to constantly monitor the state of the battery. Additionally, battery cells have certain operating temperatures between which they need to be kept for safety reasons, heating or cooling might hence be required.

Further reading: [Building Integrated PV](#) and [smart-cities-marketplace.ec.europa.eu/insights/](#)

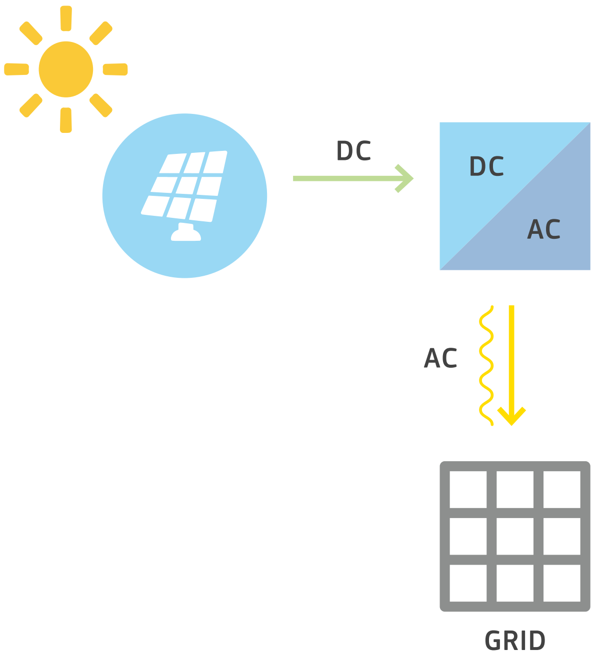
↑ © Justin Lim

Technical basics

Photovoltaic system

In a photovoltaic (PV) system, solar panels will convert sun rays into energy.

This energy is Direct Current (DC) to be able to use it with regular household appliances or return it to the grid we need to convert it to Alternating Current (AC). This conversion happens in the inverter. The AC electricity generated here can be sent to the grid.

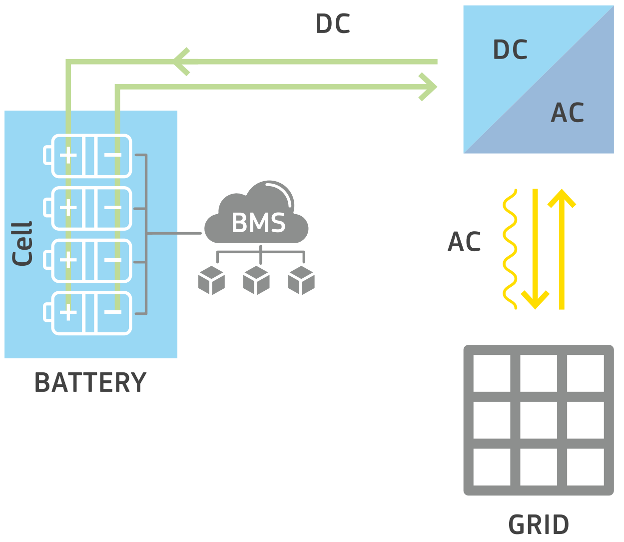


© Agata Smok

Battery

The core of a battery system is the battery cell. It can store energy chemically.

Multiple of these battery cells are combined to form a battery. Within the battery, there is also a **Battery Management System (BMS).** This system will monitor the state of the battery cells (voltage, temperature,...) to keep the battery within its operating window. It can also communicate with the inverter to reduce the current drawn from the battery if necessary. A battery delivers DC to be able to use it on the grid it needs to be converted to AC. This is done by the inverter. The AC generated by the inverter can be used on the grid.



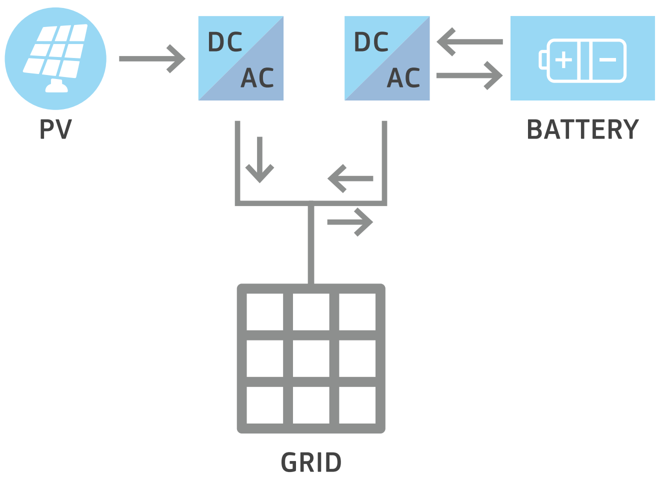
© Agata Smok

PV-battery combinations

There are two common ways of combining PV and battery systems:

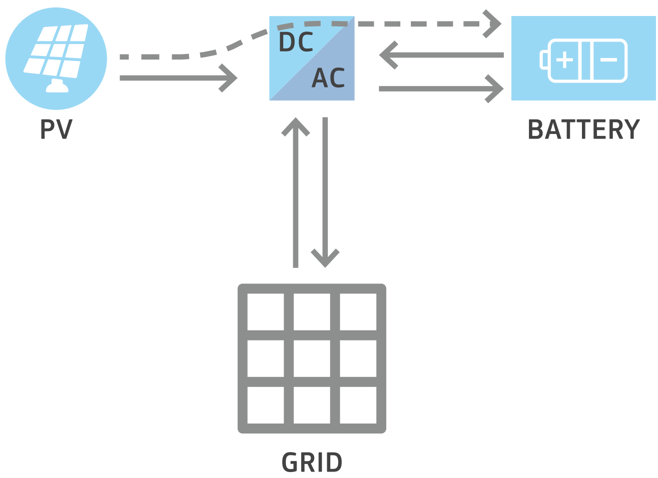
Situation A

Both the energy coming from the solar panels and the energy coming from the battery are converted from DC to AC. This option is easiest if there is already an existing solar installation where a battery is added. The downside of such a system is that energy coming from the solar panels to the battery is converted from DC to AC and from AC to DC. Each of these conversions causes losses since inverters do not operate at 100% efficiency.



Situation B

In this case, both the solar panels and the battery system are connected to the same inverter. Energy can now not only flow between either the solar panels and the grid or the battery and the grid, but also from the solar panels to the battery without the need for a conversion to AC. Energy flowing from the solar panels to the battery will still, however, need a DC/DC conversion since the solar panels and battery do not operate at the same voltage level.



Lessons learned

The **market for battery systems** is not fully developed yet. This can lead to several issues:

→ Some manufacturers of battery systems do not yet have a product that is meeting the expectations regarding functionality, quality and robustness.

→ Some manufacturers do not yet have a distributer in all member states, which results in the batteries not being available everywhere.

→ The customer service as provided by the manufacturers is currently very limited. This forms an issue regarding maintenance and repair.

→ Some manufacturers even sell low quality batteries, while they claim it to be otherwise.

To deal with these issues, some measures can be taken:

→ Be critical when buying a battery and do not just believe the advertisements. Ask for references, go to sites, ask for a demo trial, ask them to be present at installation etc. Take into account that it may take several months before the product is delivered.

→ Make contingency plans in the early project phase.

→ Do a market survey of available technologies, components and alternative suppliers.

→ Fix contracts with the battery manufacturer including penalties for delays and payment milestones.

Lessons learned

Besides the battery itself, the **integration within new or existing infrastructure** is an important challenge as well:

- → Tailor-made: since the grid characteristics are different in each context, systems have to be designed separately for each case.
- → Interoperability: since a lot of devices come from different manufacturers, the communication between them is challenging.
- → Limited plug-and-play solutions are available yet.

So, the success of both hardware and ICT integration strongly depends on:

- → The level of interoperability of the different devices and systems in a project.
- → The knowledge and experience of the technology providers and designers of the overall system. So far, organisations with this type of expertise are very limited. Be critical and ask for references.
- → Involve manufacturer of the batteries in the startup of the project and make the scope very clear in the contract.
- → In a pioneer project, pre-test all components.

Practical example 1

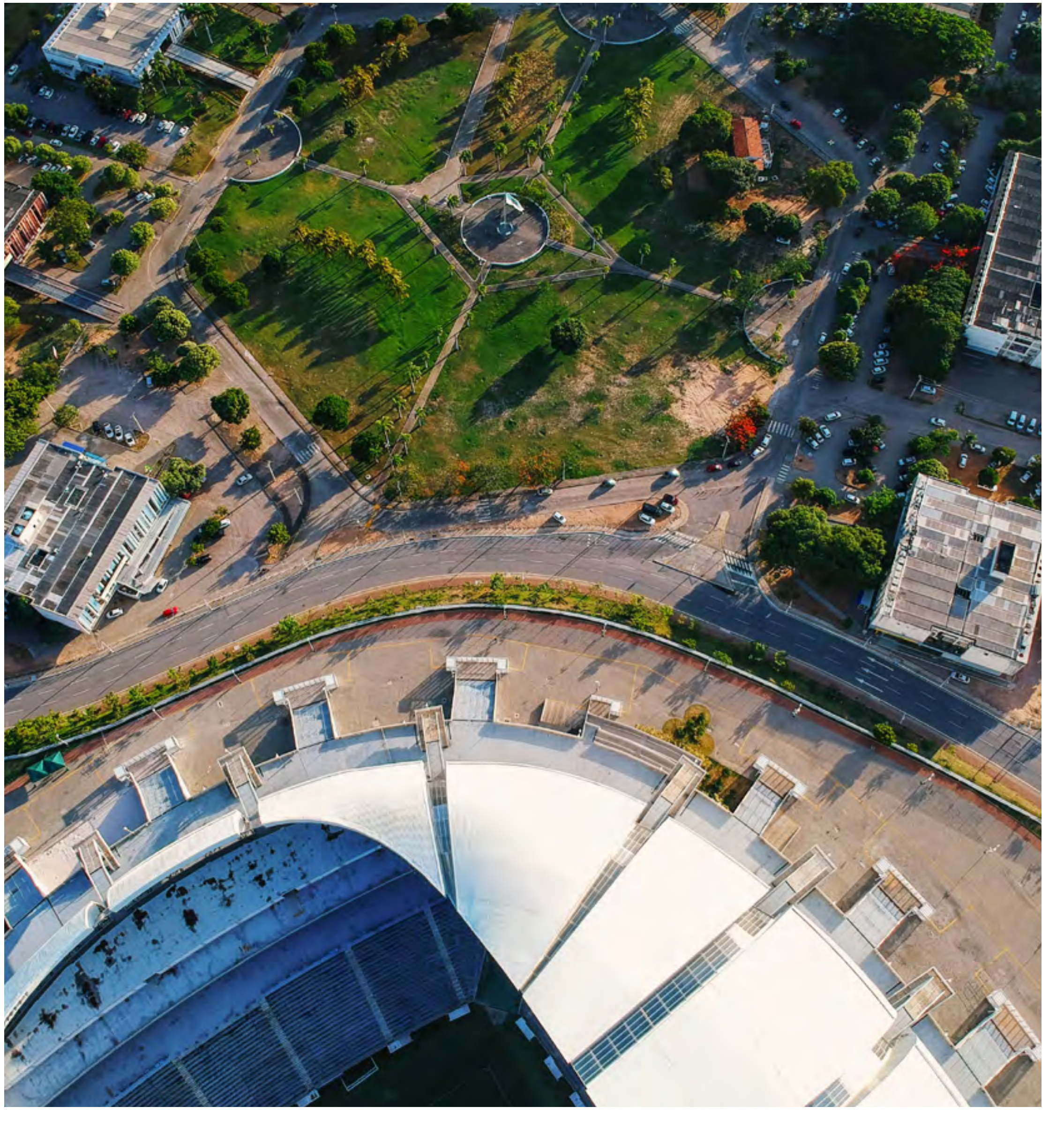
CASE STUDY

With three-phase connections, it is important to select the right products and to connect them with the right phase. If not, the electricity from the PV panels may be fully injected into the grid on one phase, while the battery is charged fully with electricity from the grid on another phase, doubling the stress on the grid instead of lowering it. The same remark is valid when discharging the battery to use the electricity for electric devices in the building. So, when there is a three-phase connection, connecting PV and batteries to all three phases should be considered. If not, the impact and stress on each of the phases increase until the feeder should be taken into account.

Practical example 2

CASE STUDY

Safety issues with regard to multiple phase buildings should be tackled. A single-phase battery bank coupled to one of the three phases of a building, allows the battery inverter to uncouple that one phase from the grid. When the battery runs empty, there is no more power on this phase. Devices with a three-phase connection are then connected to two phases with power and one phase without power. This is not a safe scenario and will cause damage. If a single three-phase battery bank is coupled to the three phases, this risk does not exist - with three single-phase battery banks, it does.



↑ © Pedro Menezes

BUSINESS MODELS AND FINANCE

↑ © Rawpixel on Unsplash

Business models and finance

Description – possible business models

Several ways can be used to generate revenue with the PV and battery system:

→ Charge when renewable electricity production is high, discharge when it is low;

→ Minimise peak power demand to minimise the load on the grid;

→ Minimise consumption during peak demand on the grid.

The way the PV and battery system is used strongly depends on the regulation and incentives that are in place, the local grid needs and may vary from one region to another.

The **economic feasibility of the PV and battery system** is defined by the costs and revenue coming from the interaction with the grid. But also avoided costs for increasing grid capacity and increasing the lifespan of devices have an important impact. Pricing schedules and incentives can vary from one region to another and from one consumer to another. Therefore, the economic feasibility of batteries should be determined for each project separately.

The business case of a coupled solar and battery installation can be further improved by using a dynamic tariff if available. Solar production in itself doesn't combine well with dynamic tariffs, since, in general, the moments with most solar energy production are the moments with the lowest energy prices. A battery can be used to store the solar energy until the prices increase again. Dynamic tariffs become most interesting when other flexibility options such as heating systems are also included.

When the owner of the building, the PV and battery energy storage system and the users of the building are all the same, the **business model** is simple as both the costs and the benefits belong to the same person/family/business. However, when the owner structure is different, clear agreements should be made and officialised. When a certain scale is reached, an Energy Services Company (ESCo) can be considered to develop the system.

Further reading: Urban Freight Logistics and smart-cities-marketplace.ec.europa.eu/insights/

Further reading: Building Envelope Retrofit and smart-cities-marketplace.ec.europa.eu/insights/

Economic performance indicators

Total cost of ownership (TCO) and return on investment (ROI)

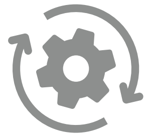
The total cost of ownership gives an estimation of the direct and indirect costs and benefits over a certain period.

The return on investment shows how much gain or loss results from a certain investment, compared to this investment.

The costs that should be considered are:

INVESTMENT COST

MAINTENANCE COST



REPLACING THE INVERTER

1. **Investment cost:**
   a. Materials and installation of PV panels, inverter and connection to the electric installation,
   b. Materials and installation of battery system and connection to the electric installation.
2. **Maintenance costs:**
   a. For PV panels this is generally very limited. Cleaning is a possible form of maintenance for PV installation. The need for cleaning, however, depends heavily on the local environment. In dusty environments with little rain cleaning regularly is needed to retain efficiency, while in other environments with little dust and abundant rain cleaning might be unnecessary altogether. Also the slope of the panels will have an influence on the cleaning needs.
   b. The battery system itself generally needs no specific maintenance.
3. **Replacing the inverter every 10 to 12 years:**
   a. Replacing the battery system after its life span (see below),
   b. An additional insurance fee (if relevant),
   c. Recycling contribution.

The life span of PV panels is about 25 to 30 years although a gradual decrease in efficiency of about 0.3 to 1 % each year is expected.

The life span of batteries differs between each project since it strongly depends on:

→ Type of battery,

→ The way the batteries are used (number of cycles, average depth of discharge, etc.),

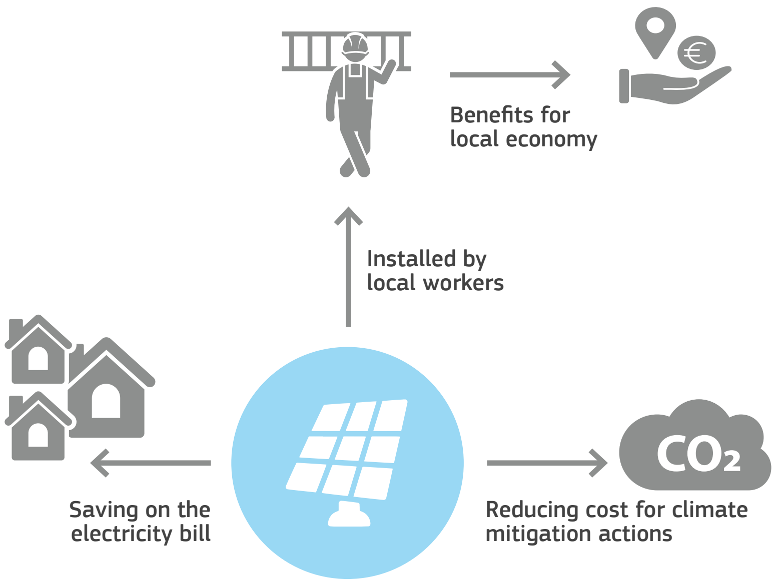
→ The conditions in which the batteries are kept (temperature, humidity, etc.).

Revenue comes from:

- → Reduction of electricity (kWh) used from the grid,
- → Reduction of peak power demand (kW) from the grid,
- → Electricity injected in the grid,
- → Providing flexibility to the grid by shifting electricity consumption and injection in time (this decreases the pressure on the grid which means costs for intensifying the grid are averted),
- → Less damage to indoor devices by improving power quality,
- → Government support.

Depending on the region, some subsidies and/or remuneration schemes are available. These can have a significant impact on the feasibility and the sizing of the installation. Some examples:

- → Netting: the electricity that is delivered to the grid can be extracted from the annual energy consumption on the bill. The amount of energy that can be extracted from the energy use, is limited to the amount of electricity taken from the grid,
- → Feed-in-fee,
- → Subsidies,
- → etc..



© Agata Smok

Primary and secondary benefits accounting

For government administrations it should be noted that PV panels are installed and maintained by local workers and, therefore, benefit the local economy. On top of this, they help in reducing costs for climate mitigation actions. So, the savings are far greater than just the savings on the electricity bill.

↑ © Kateryna Hliznitsova on Unsplash

Replication opportunities and boundary conditions

The replication potential of this solution is maximal where simultaneity between production from PV-panels and electricity consumption is limited and end-consumer electricity price fluctuations are substantial. Some common cases:

- → In a **residential building** where the children go to school and the parents go to work, the solar production will be larger than the electricity use during office hours. However, when combined with batteries, the electricity can be stored so it can be used for cooking, cleaning, washing, lighting and watching television in the evening.
- → The profile of an **office building** shows more simultaneity with the profile of PV production. Most of the time the electricity produced by the PV panels can directly be used in the office building. Especially during winter, but even during autumn and spring, there is little to no excess PV production. This makes it harder to find a feasible business case for battery systems in office buildings or business centers.

- → Depending on the profile of electricity consumption and PV generation potential, levering from a single building to a group of buildings or neighbourhood can bring additional benefits (including power quality).

- → Businesses that want to guarantee operations might look into batteries as a backup power supply. In this case the inverter is already bought as a part of the back-up power supply. Enlarging the battery pack of such set-up to enable optimising PV use and benefiting from dynamic pricing, could be beneficial for the business case.

New market arrangements, service providers, contractual arrangements etc. all need development. Note that the regulatory barriers concerning support conditions and taxations have an important impact on the business case as well. At this moment, **remuneration schemes for services provided by batteries are missing** in most Member States. This is expected to evolve quickly over the coming years. Offering flexibility to the grid is, after all, a valuable service. Batteries will, however, have to compete with other devices such as heat pumps, that can also deliver flexibility at a lower installation cost, since, such device is often already in place.

↑ © Getty images

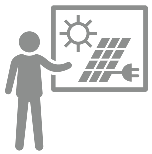
Lessons learned

Analysing the synergy between residential solar and batteries, Solar Power Europe showed that European residential solar and storage soared by 44% to 140.000 installed units in 2020. This marks the first time more than 100.000 storage systems were installed in Europe in a 12-month period, with annual installation capacity also reaching GWh scale first time, and setting a new milestone in the European energy transition.

The period when home insurance companies would be holding back the installation, there were too little and not sufficiently advanced home battery systems, and there was too little experience among installers, seems to be behind us. More and more automated and plug and play systems are being offered, with several being ready to offer flexibility services to the market with the aggregated batteries.

While home batteries are becoming more and more common, neighbourhood batteries remain a scarce element. A potential exemption to the grid tariff is not self-evident. There are several solutions with which the neighbourhood battery needs to compete, among others, flexibility offered locally through, e.g., heat pumps, electric vehicles, and home batteries, as well as investments in enforced grid infrastructure. The former includes devices already installed and hence income through flexibility is an added value, not a necessity.

The latter, i.e., thicker cables and renewed substations, are currently more cost-effective and come with a higher operational guarantee, in most European contexts. Neighbourhood batteries are hence not yet a competitive solution, aside from specific congested grids with no room for expansion of grid enforcement.



↑ © Los muertos crew on Pexels

GOVERNANCE AND REGULATION

↑ © Los muertos crew on Pexels

Governance and regulation

Description – governance and regulatory barriers

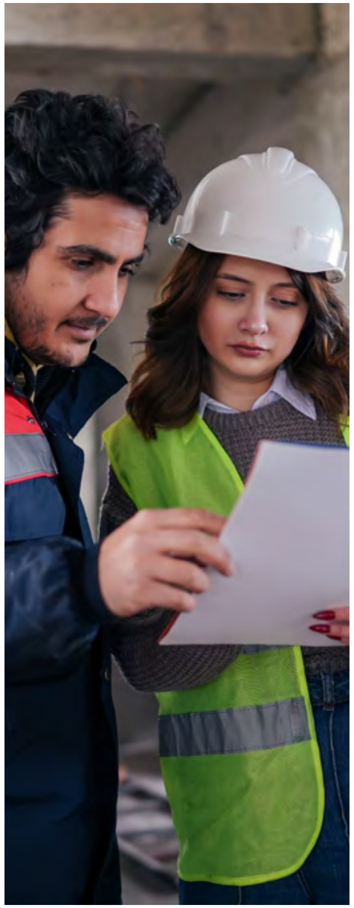
The European Clean Energy Package has created room for batteries, and active consumers with smart devices. However, there is a lack of legislation and regulation that drives the demand for flexibility services. Open and transparent flexibility markets would, however, enhance the business case for home batteries, enabling new and innovative business models.

While the Clean Energy Package has improved the enabling framework for batteries, there are still steps to be taken:

- → Current business cases for residential batteries remain substantially dependent on subsidies, opening the flexibility market would enable an improved business case and reduce the demand for subsidies;
- → Recycling of the batteries is to be scaled up further, ensuring that the valuable materials in these systems can be reused;
- → To reduces Europe's dependency on import, research on alternative battery technologies is one step. Enabling these to be tested in pilots in the built environment is another needed step;
- → In order to better understand the potential of residential storage systems as contributors to grid congestion, a better overview of where they are located and an overarching communication standard on how to activate them for grid services is needed;
- → For local governments in areas with an increasing penetration of PV and a challenge in grid enforcement and expansion, a supportive framework for residential batteries that can deliver services, could be a cost-effective measure.

The community of Sonnen, Germany

Sonnen was one of the first companies offering well designed and thoroughly engineered future-looking home batteries. The batteries, installed throughout Germany, can connect in a coordinated manner. This aggregated storage capacity, combined with a selection of generation assets, allows Sonnen to operate as a supplier in the German energy market. It generates income for the Sonnen battery owners who decided to participate. Through value stacking, combining income through self-consumption of their own generated PV and participation in the energy supplier activities of Sonnen, they improve the business case for their home storage system.

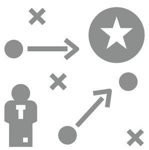


↑ © Yunus Tug on Unsplash

Measures to support replication

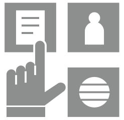
The administrative procedure to install a PV and battery system and to collecting the benefits is complex. In some member states, these procedures can take up to 6 months or more before approval, if they exist at all. There is a strong need for a clear regulatory framework throughout all layers of government. All stakeholders that are involved in the process of approval should have clear guidelines on the requirements and how to check them.

The criteria for approval should be clear, transparent and relevant. The time of approval should not be too long in order to make sure the **procedure** doesn't become a barrier by itself.



A clear **long-term vision and approach** towards a carbon-free energy system based on renewables should allow for unambiguous policy and clear communication. Furthermore, the role of the DSO in facilitating this transition, hence enabling PV and battery integration, should not be underestimated.

Not every home battery is relevant, needed, or can deliver a business case. However, with increasing renewable energy penetration and a need to decrease dependency on fossil fuel imports, combined with further electrification, flexibility at all levels is needed.



Clear, unambiguous, easy-to-find information about the technology should be made available to all stakeholders. This means both the end consumers, investors, installers, etc. It should also be very low level since most people do not have a technical background, especially regarding batteries. Informing the end consumer on aspects affecting efficiency and correct sizing of the combined PV-storage system matching the residential demand profile and the other flexible assets are important to ensure the appetite for home energy storage systems does not drop.

Supporting the innovation of integrated systems that **enable managing all flexible assets in a grid-interactive** way should be encouraged. Such combined systems will automate the overall behind-the-meter flexible assets and can avoid peak loads, as well as provide specific congestion services to reduce curtailment and ensure smooth grid operation. Integrated systems can further combine the flexibility of an electric vehicle with other flexible assets and might even make the addition of a home battery unnecessary in some cases.

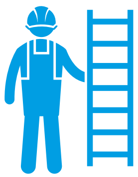
Not every residential building needs a storage system. Cooperation with the distribution grid operator will allow to focus support and information campaigns on those areas where grid congestion is expected to occur first, and regular curtailment might already be a reality. Such an approach might be relevant in case financial support is available, but would not allow to support a high amount of systems. Increasing the installation of home batteries in congested grids will not only deliver benefits for those who can afford storage systems but also reduce curtailment on PV installations of other consumers in the area.

Lessons learned

Each country has its own safety regulation for transportation, fire regulation, recycling etc. **Safety regulations should be standardised across all EU countries** so that less administrative work is required and safety trainings can be more efficient.

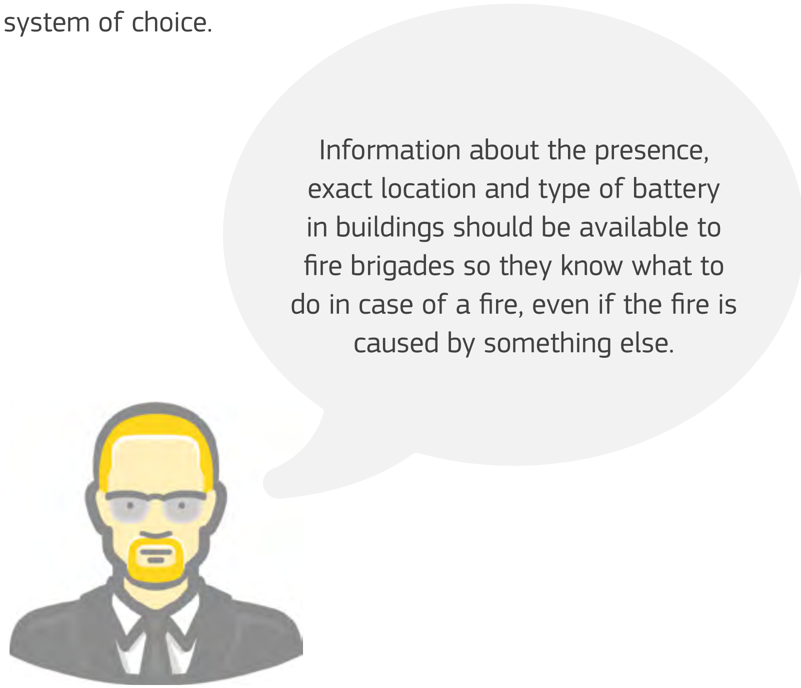
This means that a company that transports batteries from one member state to another, should meet the requirements of all member states that it crosses, which increases administration and the costs for the end client.

For both transport, installation and use, **safety regulations should be developed separately for each specific type of battery chemistry**, application and location. In most Member States, safety regulations are not adequate yet. Often experience from one type of batteries has led to safety regulations that are used for all types of batteries., however, different types of batteries have different safety issues. This means that for some types of batteries some requirements may be too strict. But it also means that for certain types of batteries, the safety requirements are not rigorus enough. Research is required so that adequate safety requirements are set up for each individual type of battery (including second life batteries).



Local authorities and fire brigades have very little experience with storage systems at district or residential level. As a result, it takes a lot of time to convince authorities about the safety of a battery system. Information about the presence, exact location and type of battery in buildings should be available to fire brigades so they know what to do in case of a fire, even if the fire is caused by something else.

Under current market regulation, a good relationship with the **DSO** is important to get approval for system of choice.



↑ © Frank Veltmans

GENERAL LESSONS LEARNED

↑ © Han Vandevyvere

General lessons learned

- **PV and battery installations can significantly contribute to increasing the share of renewable energy in an urban context and improve power quality.**
- The market currently offers several systems that are easier to install and especially automated in their operation. Furthermore, many systems are ready to be coupled to react to market signals to offer services to the low voltage market, or as part of an aggregated set of devices deliver services to the energy market.
- Such additional services enable a higher penetration of renewables, less curtailment, as well as an improved business case for such small scale assets.

This solution booklet describes and gives lessons learned, based on the experience from several PV and battery projects funded by the EU. Both the user, technology, financial and regulatory aspects are considered, since they all contribute to the final success of a project.

↑ © Frank Veltmans

↑ © Mariana Proenca on Unsplash

USEFUL DOCUMENTS

↑ © Kelly Brito on Unsplash

Useful documents

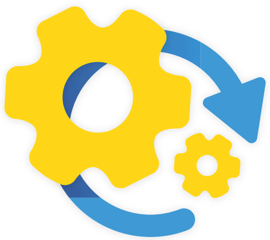
- DREEAM
- Elsa
- GrowSmarter
- REMOurban

↑ © Getty images

Smart Cities Marketplace

The Smart Cities Marketplace is a major market-changing initiative supported by the European Commission bringing together cities, industries, SMEs, investors, researchers and other smart city actors.

The Marketplace offers insight into European smart city good practice, allowing you to explore which approach might fit your smart city project. Discover our digital brochure here.



Matchmaking

The Smart Cities Marketplace offers services and events for both cities and investors on creating and finding bankable smart city proposals by using our Investor Network and publishing calls for projects.

Investor network

Call for Applications – Matchmaking Services

Project finance masterclass

Focus and Discussion groups

Focus groups are collaborations actively working on a commonly identified challenge related to the transition to smart cities. Discussion groups are fora where the participants can exchange experience, cooperate, support, and discuss a specific theme.

Focus and Discussion groups

Community

Scalable Cities

A city-led initiative providing a large-scale, long-term support for the cities and projects involved in the Horizon 2020 Smart Cities and Communities projects.

Scalable Cities

PV AND BATTERY SOLUTION BOOKLET

Smart Cities Marketplace 2023

The Smart Cities Marketplace is managed by the European Commission Directorate-General for Energy