EVective storage
Vorarlberg, Austria
Case study

Partner: Voralberger Elektroautomobil Planungs- und Beratungs GmbH
Author: Stefan Hartmann
Contact: Stefan Hartmann, Weidachstraße 6, Bregenz, Austria
Case studies are contributing to AlpStore WP6
Lead Partner: B.A.U.M. Consult, Ludwig Karg, Patrick Ansbacher, Anja Lehmann
1. Energy storage for the Alpine Space

1.1 Challenges and Constraints

Prosperity of the Alpine Space depends on the availability of energies. Fortunately enough, Alpine countries are predestined for multifaceted decentralised generation of power from renewable energy sources (RES). Many of those are intermittent and matching generation and consumption is quite a task. While controlling the generation may cause negative economic effects and consumption management offers limited potential, intelligent storage technologies can provide for cost effective buffering in metropolitan as well as scattered habitats. In its Energy Roadmap 2050 the EC claims that “storage technologies remain critical” and refers to “batteries, fuel cells and hydrogen, which together with smart grids can multiply the benefits of electro-mobility both for decarbonisation of transport and development of RES”. The EC calls the Smart Grid “a fully integrated network-planning for … distribution, storage and electricity highways” and calls for innovative instruments to finance the necessary investment - including Public Private Partnerships.

While the extension of pumped hydro storages meets natural and societal barriers, other technologies can bring added value to homes, towns and regions. However, there is a lot of uncertainty with decision makers as to the viability of small, medium and large-scale storages. With explorative and piloting actions AlpStore partners assessed which mixture of technologies will best fit the Alpine Space needs. They assessed storage and mobility concepts in regional and municipal planning and investigated needs and potentials to integrate these important areas of regional activity.

1.2 Opportunities and Benefits

Energy storage is not an end in itself, but a means to an end. Besides intelligent grids, storage systems will be key enablers for a future mostly renewable energy supply. The ultimate objective of energy storage is to help meeting human needs such as lighting, motion, heating, cooling, transport, information, products, etc. For that purpose, energy is required and depending on how these needs are addressed, the required form of energy might be electricity. As these needs are fundamental, the provision of energy must be secure, reliable, and affordable, but also non-detrimental to the climate and ecologically friendly.

A broad consensus exists that an energy supply system that fulfils these criteria must be mainly based on Renewable Energy Sources (RES) on a worldwide scale by the middle of the 21st century at the latest. Sun, water and biomass are a natural capital of the Alpine Space. It is necessary to use them for the production of energy. An analysis of the potentials of different RES shows that a suitable mix of renewable energies will be dominated by electricity generating technologies making use of the intermittent sources of solar radiation and wind power. At this point storage comes into play on a larger scale than ever before.

1.3 The AlpStore Project

The AlpStore project concentrated on the Alpine specific challenges and opportunities related to energy storage. Partners in seven countries investigated the short, medium and long term requirements for storage. They created regional master plans for the deployment of both stationary and mobile technologies. Pilot implementations in all participating regions have shown the feasibility of storage in public infrastructure, business parks, enterprises and smart homes. From there the
STORM concept and guidelines for decision makers, planners and practitioners (available from the AlpStore website www.alpstore.info) have been derived.

<table>
<thead>
<tr>
<th>AlpStore Project Partners</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.A.U.M. Consult GmbH (Lead Partner)</td>
<td>Germany</td>
</tr>
<tr>
<td>ALOT s.c.ar.l. - Agency of East Lombardy for Transport and Logistics</td>
<td>Italy</td>
</tr>
<tr>
<td>AGIRE Local Energy Agency of the province of Mantova</td>
<td>Italy</td>
</tr>
<tr>
<td>Autonomous Region of Valle d’Aosta</td>
<td>Italy</td>
</tr>
<tr>
<td>Euroimpresa Legnano s.c.r.l.</td>
<td>Italy</td>
</tr>
<tr>
<td>Voralberger Elektroautomobil Planungs- und Beratungs GmbH</td>
<td>Austria</td>
</tr>
<tr>
<td>European Centre for Renewable Energy</td>
<td>Austria</td>
</tr>
<tr>
<td>Freshsmile</td>
<td>France</td>
</tr>
<tr>
<td>University of Technology Belfort-Montbéliard</td>
<td>France</td>
</tr>
<tr>
<td>Public Power Utility Allgäu</td>
<td>Germany</td>
</tr>
<tr>
<td>Energy and Environmental Centre Aallgäu</td>
<td>Germany</td>
</tr>
<tr>
<td>P + M Rothmoser GmbH &amp; Co. KG</td>
<td>Germany</td>
</tr>
<tr>
<td>Research Centre Energy Economics</td>
<td>Germany</td>
</tr>
<tr>
<td>RDA-BSC Business Support Centre Kranj</td>
<td>Slovenia</td>
</tr>
<tr>
<td>University of Ljubljana, Faculty of Electrical Engineering</td>
<td>Slovenia</td>
</tr>
<tr>
<td>Municipality Jezersko</td>
<td>Slovenia</td>
</tr>
<tr>
<td>University of Liechtenstein, Chair for Sustainable Spatial Development</td>
<td>Liechtenstein</td>
</tr>
<tr>
<td>University of Lugano, Advanced Learning and Research Institute</td>
<td>Switzerland</td>
</tr>
<tr>
<td>Kraftwerke Oberhasli AG / Battery Consult GmbH</td>
<td>Switzerland</td>
</tr>
</tbody>
</table>
The AlpStore activities have been focussing on the following objectives:

- Using storage and electric vehicles in the energy provision system will become a key in ensuring stable energy supply in all Alpine regions. With reliable energy provision, regions stay attractive as living habitats, working spaces and recreational sites. The consortium partners investigated latest technology, assessed the potentials and deployed it in pilot cases.

- The transnational AlpStore team developed the STORM-concept. It stands for “smart storage and mobility” and describes a model to develop and decide upon holistic solutions to increase regional RES supply and outbalance volatility with appropriate buffering means.

- Requirements of scattered habitats have been emphasized as well as combined business and living habitats in metropolitan areas. With intelligent storages, both can become self-contained energetic cells on the grid. New power systems integrating mobility and energy supply enable the establishment of entrepreneurial collectives managing such local generation, storage and consumption cells.

- AlpStore has shown how electric mobility brings improvements for the Alpine Space connectivity and new business opportunities. Integrating mobility into the energy system can close the cost gap of electric mobility. To assess these opportunities AlpStore compared battery EVs with gas and hydrogen solutions.

- Twelve test site implementations with a variety of stakeholders and Alpine Space technology
companies provided reliable input to sensitise political and business decision makers for new opportunities in the combined field of mobility and energy provision. Visiting tours and experience exchange workshops have been offered. Big conferences in Italy and Germany attracted more than 500 participants.

1.4 The STORM Concept

STORM stands for “Smart Storage and Mobility”. It is a model to develop and decide upon holistic solutions to increase regional RES supply and outbalance volatility with appropriate buffering means including mobile storage.

The general STORM workflow comprises for steps:

1. **Investigation of future regional generation and consumption patterns**

   This task will normally have been accomplished by developing a Strategic Energy Action Plan (SEAP) or similar regional energy plan. Such a plan describes the potentials of reducing energy consumption and providing the rest from regional sources as possible.

   It should be an integral part of a regional energy plan to describe not only the technical potentials but also the willingness of the stakeholders and the financial potentials of a region to implement such an energy plan. To that end, the energy plan should describe the needs and objectives of as many interest groups as possible.

2. **Investigation of storage needs and assessment of regional potential**

   The more ambitious a region will be to achieve self-supply the more likely it will need a comprehensive storage plan. While with low penetration of grids with fluctuating generation (below 40%) in most cases means of generation and demand side control will sufficient to maintain stability of the system, with higher penetration the need for storage will quickly increase.

   As described in the AlpStore Whitebook and the guidelines for decision makers and practitioners there is quite a choice of storage technologies with a big variety of characteristics. Some of those highly depend on local givens to be used (e.g. hydro pump stations or large biogas tanks). So it is not only necessary to assess the needs for storage but also the potentials of local implementation of such systems. As is true for the generation systems, there may be quite a difference between the technical and economical storage potentials and the real potentials. The latter depend on questions of acceptance and the will to use the chances.

3. **Development of a master plan for the renewable energy use and storage until 2030**

   Having carefully assessed the generation and consumption patterns, a regional storage master
plan can be derived. Using the technological and financial hints from AlpStore experts, the storage master plan shall describe

- Overview of the status quo of the existing regional energy system
- Overview of the status quo of the envisioned future energy system (typically derived from a SEAP and describing regional energy generation and consumption as well as the future energy related grids (power, gas, mobility))
- Future Energy Storage Requirements (possibly for 2020, 2025, 2030)
- Potentials for Regional Storage including potentials of mobile storage (gas, H2 and electric vehicles)
- National and regional framework for future storage systems
- Visions and goals of the regional community
- Roadmap to establish the regional storage farm describing various scenarios
- Concrete measures and projects for the next few years

All regions involved in AlpStore have developed such Storage Master Plans (StoMP).

4. Implementation of the master plan by pilot installations

While the StoMP is a long term strategic plan, practically the region needs an implementation plan at least for the first steps. Such implementation plans cover specific projects and describe the pilot installation process in detail.

It is a question of motivation and “time to market” to not wait with practical steps until everything is ready in the plan. Therefore AlpStore proposes to implement “no regret measures” during the development phase (see the AlpStore guidelines for a list of such measures).

More detailed information about the STORM concept, including recommendations for local and regional authorities, regional energy utilities and investors, can be found in the AlpStore White Book as well as in the AlpStore Guidelines for decision makers and practitioners. They are available from the AlpStore website (www.alpstore.info).
2. Storage technologies for the region Vorarlberg - general frame conditions and objectives

2.1 Actual and future regional energy system

Energy Situation Vorarlberg

Vorarlberg is a region where hydro power plays an important role in the production of electricity. More than three quarters of the sold electricity in Vorarlberg comes from hydro power plants. The rest of the sold electricity comes from gas fired power plants (8 %), wind (4 %) and biomass (4 %). The electricity of these power plants is purchased by the Vorarlberger Kraftwerke AG. Vorarlberg has therefore no nuclear, gas or oil fired power plant in operation. The CO₂ emissions with 28 g/kWh are lower compared to the national and the European level, because of the high amount of renewable energy sources. The share of renewable energies in the heating sector is also high. The biggest share has still gas followed by renewable sources like geothermal, biomass and solar thermal. The rest of the heat consumption is covered by oil.

Mobility Situation Vorarlberg

The total number of cars in 2012 has been 193,000. The share per inhabitant is therefore relative high. Vorarlberg has been one of the first model regions for e-mobility in Europe and the first one in Austria. Today are about 450 BEV on the roads and 150 public charging stations have been built by the Vorarlberger Kraftwerke AG. The BEVs are exclusively charged with renewable energies, which have been additionally built during the VLOTTE project in form of photovoltaic power plants and a small hydro power plant. The EVs in Vorarlberg have proven their suitability for daily use.

Storage Situation Vorarlberg

Vorarlberg is located in the Alps. The electricity production is therefore characterized by storage and pump storage hydro power plants. The amount of water from the lakes Silvretta-see, Kopssee, Vemuntsee and Lünersee is processed in several stages. This means that the water is used a bunch of times to produce control and peak energy. The hydro power plant group of Illwerke operates as a water and energy management unit. The nominal capacity of the turbines in 2012 has been 1,812 MW and the input power of the pumps has been 999 MW. The annual output of all pump and storage power plants has been 2,722 GWh. Other storage systems are not in operation.

Future Energy System

Electricity will have a special role in the energy system of the future. A key element in supplying energy in the future involves a drastic expansion of tapping renewable energy from sunlight, water and biomass. It is to be expected that the future energy supply of households and industry will increasingly be based on electricity. Vorarlberg is moving towards an “electricity society”, i. e. other sources of energy will progressively be supplanted by electricity (e. g. by using heat pumps or moving into e-mobility). The demand for electricity will therefore rise in these areas. In addition to that energy efficiency will also play a major role. The combination between energy savings, energy efficiency and tapping renewable energy sources will be characteristic for the future energy system.
Future Storage System

The future energy storage system in Vorarlberg will be characterized by hydro storage and pump storage power plants like it is today. With this storage system short term and long term aspects can be covered. With the planned construction of Obervermuntwerk II further steps are taken to a sustainably integration and continued expansion of renewable energy in Europe. The mass rollout of electric vehicles will also lead to an additional storage capacity till 2050. Other storage systems like battery storages will become more and more interesting in the near future. It is hard to predict how big the actual potential for these storage systems really is. Beside the discussion about storages for the electricity system, storages for the heat production play an important role in the future energy park of Vorarlberg. In this sector the decentralized storages will play a major role. Especially solar thermal, geothermal and biomass heating systems need storages to provide heat all day long. It will be necessary that all these heating systems are equipped with these water storages. The capacity for heating storages will therefore also increase.

2.2 Regulatory framework

Energy Autonomy Vorarlberg 2050

Energy autonomy Vorarlberg is the central energy policy program of the State of Vorarlberg, which was initiated in 2007. Austria’s westernmost province, Vorarlberg, had set itself an ambitious target: achieving energy self-sufficiency based on renewable energy sources by 2050 and so becoming independent of price rises and supply shortfalls affecting oil and natural gas. This long-term strategic goal has been supported in a unanimous decision by all political parties.

The process “Vorarlberg’s Energy Future” is intended to implement a sustainable energy supply system step by step and make a valuable contribution to climate protection. This long-term strategy relies upon four pillars: energy saving and energy efficiency, increased employment of renewable energy, new mobility strategies and investment in research, development and education.

In a first phase, a vision process was carried out in ten workshops. Based on these results concrete measures, how to implement the vision process, have been developed. In this participatory process experts but also representatives of interest groups have been involved. In the near future, by 2020, Vorarlberg wants to achieve at least the energy policy goals set by the EU (20-20-20). So the task was to draw up an action plan that describes specific measures on the one hand for the next about 10 years, which are suitable to achieve the 2020 targets and on the other hand can classify the goals of the energy autonomy. In 2011, an extensive portfolio of measures was adopted, the so-called “101 measures for our grandchildren”.
3 Pilot projects “2nd Use Battery” and “Embroidered Battery”

In 2009 Vorarlberg started with one of the biggest e-mobility projects in Europe. The main goal of the VLOTTE project was to bring electric vehicles to the market. Building up public charging infrastructure and renewable energy facilities have also been two important issues in the project.

In the end of 2014 there were already roundabout 450 EVs in Vorarlberg registered. This amount of cars doesn’t have a big impact to the grid at the moment. But this could change very fast, especially when even more EVs run on Vorarlberg’s roads. A higher amount could stress the grid at hot spots like shopping centers. The expansion of renewable energy sources like photovoltaic proceeds also very fast. In the future it will be necessary to bring the production and the demand side together to ensure a stable energy supply. Battery systems could be one possible way to support that approach.

Another important question will be “What will happen with the batteries from the EVs?” Second use applications could be another possible use case for energy suppliers like Vorarlberger Kraftwerke AG in the future. For that reasons VLOTTE decided to build up a pilot in whom 2nd Use Batteries from EVs will be used to store and to balance the energy of a photovoltaic power plant.

At the moment battery systems based on Lithium-Ion or ZEBRA have the highest market share in EVs. New battery concepts could become more and more interesting in the near future, for example to extend the range of electric vehicles. For that reason VLOTTE supports the development of a new battery system based on embroidered materials in a second pilot activity.

Both pilots are developed in a first step independently from each other. After both of them have proven their functionality they shall be merged into one system.
3.1 Characteristics of the field test

“2nd Use Battery”

Location

The pilot will be implemented at the Vorarlberger Kraftwerke AG in Bregenz. The electric vehicles (EVs), which are mainly in use for daily business trips, are placed in a parking garage. This parking house is equipped with a photovoltaic system and with adequate charging infrastructure. The goal of the pilot activities is to manage supply and demand side with stationary batteries. The best prerequisites for implementation are therefore given at the chosen place.
**Purpose of the pilot**

The first pilot activity “2nd Use Battery” handles with the topic of shifting renewable energy production with 2nd Use Batteries from EVs. The main goal of this pilot activity is to show how 2nd use batteries work under real life conditions and to demonstrate the technical feasibility of such systems. In a further step the battery shall be implemented into a Virtual Power Plant (VPP) in the Smart City Rheintal project, which is funded by the Climate and Energy Fund Austria.

**Technology**

The used batteries and the equipment came mainly from two broken electric cars. The used technology for the battery system is a ZEBRA battery (molten salt battery). The battery uses molten salts as an electrolyte and offers both a high energy density and a high power density. These thermal batteries can be stored in their solid state at room-temperature for long periods of time before being activated by heating. Rechargeable liquid metal batteries are mainly used for electric vehicles and potentially also for grid energy storage, to balance out intermittent renewable power sources such as solar panels. They have therefore been the best choice for this application.
Case study - EVective storage, Vorarlberg, Austria

Fig. 5: Location Vorarlberger Kraftwerke AG
Objectives

The main goals of this pilot are

- Demonstrate the feasibility of 2nd Use Batteries of EVs as a storage systems
- Integrate the battery system into a Virtual Power Plant
- Operate the battery system in a Virtual Power Plant with developed algorithm

Regional Stakeholders

The battery system was developed together with partners from the region. The Vorarlberger Kraftwerke AG provided two ZEBRA batteries and the charging equipment of two broken EVs. VKW was also responsible for the total implementation process. E-Car Services is a specialist in repairing EVs based on ZEBRA batteries. They constructed and implemented the battery storage in the parking house of the VKW. In a last step the University of Applied Science Vorarlberg (FHV) developed a control system and programed the algorithm to manage the battery system. They also took care about the implementation to the Virtual Power Plant in the project of Smart City Rheintal.

“Embroidered Battery”

Location

The Embroidered Battery is developed and constructed in Dornbirn at the Research Institute of Textile Chemistry and Textile Physics of the University of Innsbruck. The battery is developed under laboratory conditions.
Purpose of the pilot

In the second pilot activity “Embroidered Battery” a new type of battery will be developed and tested. The goal is to prove the theoretical assumptions with a prototype of such a battery.

The application of technical embroidery in electrochemical cells thus allows:

- Construction powerful battery systems
- Rapid charging is possible
- Higher peak power can be delivered
- More concepts cathode during charging
Therefore, a significant weight reduction in the electrochemical energy storage can be expected. This can lead to better battery systems with higher energy density.

**Technology**

In standard battery applications a metal foil serves as current collector. The active mass is coated on the surface of the foil and then charged/discharged through the transfer of electrons form the foil to the active mass. The metal used to manufacture the foil depends on the electrode reaction and is chosen with regard to following aspects: Chemically stable, no passivation, no side reaction, sufficient conductivity, affordable costs. In a standard LiFePO$_4$ accumulator the cathode is manufactured from aluminium, while the anode is made from copper.

A mixture of LiFePO$_4$, carbon and organic binder is used to manufacture the cathode. The addition of a few percent of carbon is required to achieve sufficient conductivity inside the coating as a requirement to charge/discharge all parts of the active mass. In case insufficient conductivity is observed inside the active mass, the coating is not fully available for charge/discharge cycles, which then lowers the capacity of the battery as only a share of the active mass is used. In the case of the LiFePO$_4$ battery the anodic reaction is an intercalation of Li-ions into graphite layers, thus the active mass at the anode is formed by carbon, with a copper foil as plane current collector.

To avoid short circuits, both half-electrodes are separated by a porous diaphragm which permits transfer of charged ions (Li$^+$), however avoids contact of the two solid electrodes. The charge transfer in the electrolyte is achieved by movement of Li$^+$ ions, thus a LiPF$_6$ solution in propylene-carbonate / dimethylcarbonate serves as conduction electrolyte. To permit transfer of Li$^+$ ions from the porous cathode to the anode both solid electrodes have to be porous.

The electrodes thus have to exhibit a number of properties, which are in conflict to each other:

- mechanical stability
- good electric conductivity
- high porosity for Li$^+$ transport
- high density of active components (e.g. LiFePO$_4$)

The conductivity of the active mass limits the possible thickness of the layer formed at the surface of the metal foil. Thus typical thickness of a battery electrode material is in the dimension of 50 µm with a mass of 20 mg/cm$^2$. An increase in thickness of active layer could have significant advantages for the overall capacity of a battery concept. An increase of the conductivity by addition of higher amounts of carbon is not productive as this indirectly reduces the effective share of re-dox-active component in the electrode layer.

When thicker electrode layers should be used, the current should be fed directly to the place of the active material in the layer. This can be achieved by use of current collectors for which different concepts have been proposed in the literature e.g. porous metal foams, carbon mesh, metal wire fabric.

Every concept to construct a porous conductive structure has specific advantages but also disadvantages, e.g. porous structures are difficult to prepare and the homogenous filling with active cathode material is difficult, similar problems of filling are observed when fibre mesh or wire fabric is
used. This material has to be cut into the final form which then leads to risks of short circuits through the open fibre ends present near the cut sides.

**Embroidered Materials**

A flexible approach to produce a conductive structure e.g. from aluminium wire or copper wire is technical embroidery. By technical embroidery conductive 3D-structures can be produced with high flexibility form a wide range of different materials.

![3D Electrodes](image)

**Fig. 7: 3D Electrodes**

**Mathematical Approach**

The thickness of the active material layer on the electrode directly will influence the performance and the overall capacity of a battery. For a given application the capacity will grow with thickness of the active material layer, however this will not be a linear increase as also the weight for housing and non electroactive components will grow. While the increase in capacity can be assumed to be directly proportional to the thickness of the layer, the increase in mass of the non-active components will be lower.
A simple mathematical formulation for the estimated capacity can be based on standard battery data, which then are extrapolated for growth in thickness of the active material. The potential of embroidered current collectors can be assessed by numerical simulation of cell performance and weight as function of active layer of electroactive material. In the presented calculation the following basis was made for the calculations.

For a given construction 28% of the total cell weight was assumed to be the active mass, 72% of the cell weight are non-active components, housing, electrolyte, carbon, separator and current collectors. A standard cell was defined with a certain thickness of the active layer, which exhibits an specific energy of 150 Wh/kg of cell respectively an energy density 225 Wh/l. The change in active layer thickness was considered to increase the mass of non-active components by a certain percentage of the increase in active mass, thus not the full increase in thickness the active system will be reflected in the energy density data.

Experimental Assessment of embroidered electrodes

In the experimental work at the institute two researchers investigate the performance of wire based current collectors in comparison to the plane electrodes as reference system. The electrodes are studied under low oxygen and low moisture atmosphere in an Ar-chamber to avoid uncontrolled effects due to Li-corrosion. Charge discharge curves have been investigated for electrodes with increasing layer thickness and thus increasing mass of active material, to evaluate the advantages of a wire based current collector.

Objectives

The main goals of this pilot are:

• Demonstrate the feasibility of embroidered battery
• Built new battery based on embroidered materials
• Merge battery with 2nd Use Battery
Regional Stakeholders

The Research Institute of Textile Chemistry and Textile Physics of the University of Innsbruck in Dornbirn is responsible for the implementation. They are supported by other regional textile companies (Smart Embroideries) in Vorarlberg.

3.2 Storage technologies and frame conditions

The developed storage systems have proven their functionality but they are still prototypes. Such systems will play a minor role in the storage market in Vorarlberg. The storage system number one will still be hydro storage and pump storage power plants in the future.

3.3 Research design and schedule

The project started with a detailed planning process of both two pilot activities. In a first phase basic concepts have been developed through a brainstorming process before the detailed planning of the pilot activities started. In a next phase the hardware and software for the realisation of the pilots were organized before the construction of the pilots began. Both pilots have been developed independently from each other. At the end of the project the pilots should be merged to one.
3.4 Implementation process

Both pilots “2nd Use Battery” and “Embroidered Battery” could be implemented in time and with the planned budget. Both of them have proven their functionality but they are still prototypes. The development of prototypes makes the implementation even more difficult. Main reason for that is the missing experience with such systems. This makes also the planning process more time-consuming and leads to deviations in the implementation process. That is also a reason, why the evaluation process and the merge of both systems had to be postponed in the project.
4 Main outcomes and benefits

The main outcome of both pilot implementations was the demonstration of the technical feasibility of new battery systems. Both of them have different use cases.

Pilot 1: “2nd Use Battery”

Within the Alpstore project the following function and uses cases could be implemented.

- Detailed concept of “2nd Use Battery” developed
- Battery storage system prove functionality
- Active charge management in use
- Shifts of power at location demonstrated
- Implementation of “2nd Use Battery” to VPP

Beyond the general use cases the “2nd Life Battery” fulfills other technical requirements. The battery storage can be charged with electricity from the local PV power plant during the day and will be discharged in the night. EVs in the parking garage can therefore be charged by night with the self-produced electricity from the PV power plant. Through the integration into a Virtual Power Plant (VVP) the storage can also be operated with prices from the power exchange. The possibilities to run the battery storage are depending on the local requirements.

The main benefits of this pilot are:

- Voltage support
- Integration of renewable energies
- Reduce CO2 and Sox, NOx emissions
- Flexible storage system

Pilot 2: “Embroidered Battery”

Within the Alpstore project the following function and uses cases could be implemented.

- Detailed concept of “Embroidered Battery” developed
- “Embroidered Battery” developed
- Battery storage system prove functionality
- Measurements and comparison with other battery systems
- Merge both pilot activities
- Evaluation of both pilot activities realized

Beyond the general use cases the “Embroidered Battery” fulfills other technical requirements. Through the use of 3D electrodes a significant weight reduction in the electrochemical energy storage can be expected. This can lead to better battery systems with higher energy density. The main benefits are therefore:

- Construction powerful battery systems
- Rapid charging is possible
- Higher peak power can be delivered
5 Conclusions

5.1 Regional potential of the tested local options

“2nd Use Battery”

The charging of EVs can stress the local grid at places with a high amount of consumption. With a raising amount of EVs in the future, the peak loads at such places, which result from the charging, will probably increase. Therefore it is necessary to cut such peak loads by shifting the charging of the EVs or other energy consumers to reduce the impacts to location and the local grid. Beyond that decentralized production of energy with renewable sources at different locations will play an important role in the future. The production of such power plants (e.g. photovoltaic) can also have impacts for the local grid. In both ways, demand side (consumption of energy) and supply side (production of energy), the local grid may be faced with challenges, especially at hot spots (high energy consumption and production). For that reason it will be necessary to balance the supply side (e.g. photovoltaic) and the demand side (EVs). The matching of the production with photovoltaic power plants and the EV needs (charging) ensures, as much as possible, a self-consumption approach. Furthermore a sustainable mobility supply for EVs with renewable energy sources can be guaranteed.

One reason for that issue can be a stationary storage system, like battery storage, which compensate the supply and the demand side in both ways. With the pilot activity “2nd use battery” a “smart” storage was developed and implemented at the parking garage at the VKW. Therefore 2nd use batteries are used as a storage system. The prototype has proven its functionality. Because of the missing long-term experiences a larger roll out doesn't make sense.

“Embroidered Battery”

New battery storage systems will also play an important role in the future. For that reason a new battery system based on “embroidered” electrodes was developed and realized by the University of Innsbruck. The innovative storage system was implemented, tested and evaluated by the University. Also in this case the implemented pilot was scaled on a prototype base. A bigger role out doesn't make sense at the moment because of the missing long term experiences. It could be shown that with the use of 3D electrodes a significant weight reduction in electrochemical energy storage can be expected. This can lead to better battery systems with higher energy density.

5.2 Follow-up plans

Both systems will also be operated after the Alpstore project. Long-term experiences shall be gained with both of the systems. Furthermore, both systems shall be evaluated with the existing process, which was implemented in the Alpstore project.

5.3 Transferability to other Alpine regions

The developed pilots are both prototypes. A transfer to other Alpine regions makes it therefore difficult. Other regions can profit from the experiences what VLOTTE gained in the project.
Legal disclaimer

The work done in the project “AlpStore: Strategies to use a variety of mobile and stationary storages to allow for extended accessibility and the integration of renewable energies” (AlpStore) and the establishment and update of this publication received funding from the European Territorial Co-operation Programme “Alpine Space” 2007-2013 (European Regional Development Fund), under a subsidy agreement concluded between the Land Salzburg and B.A.U.M. Consult GmbH München / Berlin (Lead partner of the project).

The sole responsibility for the content of this publication lies with the authors. It does not necessarily reflect the opinion of the European Communities, the ETC-ASP Managing Authority, the ETC-ASP Joint Secretariat, or the Land Salzburg. None of these authorities and institutions is responsible for any use that may be made of the information contained therein.

Copyright

© B.A.U.M. Consult GmbH, Gotzinger Str. 48, 81371 Munich, Germany. Copies of this case study – also of extracts thereof – may only be made with the permission of and with reference to the publisher and if a sample copy is provided.