NEWSLETTER 2 · November 2017

Storage4Grid VISION

The Storage4Grid vision is to provide utilities and end-users with **new tools for optimal grid planning, use and evaluation of storage technologies**. Storage4Grid pre-designs new storage control models and interfaces built upon existing standards and suitable to support scalable and cost-efficient coordination of heterogeneous ESS.

Meeting in Bonn: Storage4Grid Business models, architecture and ESG Workshop

From August 1st to 3rd 2017, the Storage4Grid consortium gathered in Bonn (Germany) to discuss about the business models and the general architecture to be developed during the project. On the 3rd day, the External Stakeholder Group (ESG) workshop allowed the consortium to get acquaintance with the ESG members and get early valuable feedback about the Storage4Grid approach and initial developments.

Meeting in Bolzano: Storage4Grid Italian pilot site and SMX hands-on training

Storage4Grid partners met in Bolzano (Italy) from November 14th to 16th 2017 for the last plenary meeting of year 1. The partners had the opportunity to visit the Italian pilot site and drive EVs. A hands-on training on one of the project developments (SMX) was organised.

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731155

The Italian pilot site of Storage4Grid

Alto Adige – Südtirol is an alpine region in northern Italy, characterized by a high share of Renewable Energy Sources (RES), mainly hydropower, but the last decade showed a large increase in the amount of small, distributed PV plants connected to the low voltage grid. Edyna, the main DSO of the area, connects to its MV and LV grid more than 4.5 thousand PV plants with an overall installed power of 146 MW.

On the other hand, large predictable loads (e.g. from high-consuming, heavy industry) are quickly decreasing in the area. Distributed, less predictable loads (e.g. EV fast-charging stations) are taking their place. As of today, around 250 EVs are already active in Alto Adige - Südtirol, using a network of 35 public charging stations operated by the local utility Alperia, but the diffusion of EVs is currently growing significantly. Therefore, Alperia has already scheduled high investments to activate a larger number of charging stations within the next years.

In order to allow European utilities, such as Alperia, to pursue their ambitious development plan regarding the EV charging infrastructure, while avoiding heavy investments in strengthening the grid, Storage4Grid will study methodologies for planning, evaluating and controlling storage installations communicating and cooperating with EV charging systems. This scenario, called “Cooperative EV charging” will be tested in Bolzano, the capital of Alto Adige – Südtirol. The Bolzano test site will investigate the following two classes of EV charging systems:

1. **Residential case** - individual charging systems in use in private houses: private EV users mostly charge their vehicles at home, using a dedicated 3 kW charging box. Although many EV users also own PV installations, cars are mostly charged in non-working hours, causing a peak of demand during night.
2. **Commercial case** - large charging installations for EV company fleets: a number of companies are investing in fleets of EVs to support company operators. This causes the necessity to deploy charging parks characterized by significant load capacity, which is currently not possible in all LV radial grids.

The residential case will be tested in a private house provided with a PV roof plant of 9.6 kW, and 1 plug for classic charging of the EV. The house was provided by Alperia with an Energy Storage System (ESS) of 12 kWh.

The commercial case will be tested in the fleet garage of Edyna. The garage is provided with 10 charging stations (wall boxes) of different sizes. The ESS for this test site will be implemented within 2018.

Figure 1. The test site for the residential case - house of a prosumer with EV and ESS

Figure 2. The test site for the commercial case - EV fleet garage of Edyna

Learning more about Storage4Grid components /developments

Towards the optimal integration of storage - The unbundled smart meter approach

Smart grids are being implemented around the world with the aim of improving the efficiency of power networks. Smart electricity meters, which are an integral part of smart grids, are thus being adopted globally. Electricity meters are the most widely used smart meters, with over 82% of the market share in 2016.

Most countries are following emission control regulations to tackle the environmental effects caused by pollution. Policies that promote energy efficient practices are a part of these regulations. However, the use of smart meters in emerging applications, which indirectly support a higher share of RES-based electricity at the end-user level, is still at the beginning in many countries.

The unbundled smart meter (USM) with enhanced functionalities proposed by the Storage4Grid project will allow the optimal integration of storage in emerging intelligent distribution networks.

Smart meter extensions (SMX) are an essential part of this project, being used in all the demonstrators as a communication channel and a place to run basic applications, i.e. software agents. SMX is a cost effective and powerful Linux machine, capable of handling multiple connections and protocols, data security and data privacy.

The Raspberry Pi 3 single board computer has been chosen due to its quad-core architecture running at 900 MHz, its memory capacity of 1 GB of RAM and its storage capacity of up to 32 GB on SD-Card. Figure 3 shows the SMX Box, hosting the SMX Core and one or more SMX extensions i.e. a modular software, running on a dedicated small-form PC, namely the SMX hardware, which can host plug-in components providing added-value services.

Figure 3. The SMX Box.

Modelling the Smart Grid – How simulation supports the integration of renewable energy sources

Energy systems have to be increasingly flexible towards growing integration rates of renewable energy sources and rising numbers of electrical vehicles (EVs). They are foreseen to stress the existing grid infrastructures to a level where reinforcement becomes necessary. However, classic grid strengthening methods, (e.g. using thicker cables or different tap changer settings) are expensive and inflexible.

Recent technological developments make alternative solutions possible and attractive. The Storage4Grid project aims to take advantage of storage installations both at residential and grid-side levels to improve power quality by mitigating voltage flicker and effect of unexpected load peaks.

Storage4Grid's Decision Support Framework (DSF) plays a key role in an end-to-end solution for modelling, planning, integrating, operating, and evaluating distributed storage systems as a mean to enable renewable energy sources integration in large scale.

The DSF allows professional end-users like grid planners to investigate the effects of different scenarios by varying penetration levels of renewables, storage, and EVs. Furthermore, the framework supports the random or manual placement of batteries and renewables in the grid topology, and calculates the best possible positioning of storage. Additionally, professional end-users have the option of manually place and dimension storage units as well as testing different control strategies. Different control levels and deployment solutions will be emulated in the DSF as well, such as a central energy storage system controller at grid level, a local storage controller, and an energy router (power electronics device that manages the energy flow from/to different sources, loads, and storage systems).

The DSF simulation engine is developed based on open-source simulation software tools, and offers adapters for software integration of tools which are already used by the Distribution System Operators (DSO), for example PowerFactory or GridLab. External services like weather forecast providers, load profiles, and grid topology, will be integrated using standard connectors. To allow for seamless integration with the Storage4Grid system, the DSF will be interfacing with the central storage module DSF Data Warehouse (DSF-DWH) as well as the Grid Side Energy Storage System Controller (GESSCon), which calculates and distributes the global control profile for local energy storage systems.

Hereby, the goal is not only to show that additional storage at grid or end-user level can successfully solve stability and power quality issues in the grid, but also to allow a more detailed analysis of storage with respect to cost efficiency, technical feasibility, lifetime, and optimal control policies.

From the powerful features offered by the DSF a challenging task emerges: creating an intuitive graphical user interface (GUI) to interact with such a complex software tool. User expertise as well as feasible workflows, system behaviour, and recommendations need to be implemented and visualized in a naturally understandable way. Simulation state displays should be logical and comprehensible, the interface needs to be highly interactive to allow end-user intervention and a flawless interaction. Enjoyable user experience and task suitability are of high priority for the Storage4Grid development team. Therefore, the user interfaces are being developed in close collaboration with professional end-users.

Handling Data in Storage4Grid: many challenges, a full stack of solutions!

While Smart Grid solutions start to pervade also the distribution grid, controllable devices in the user's domain are also increasingly integrated with control and monitoring solutions, also thanks to the emergence of the Internet of Things (IoT) paradigm. In such a context, choosing the right ICT infrastructure and data management solutions becomes more and more critical and challenging.

Innovative Smart Grid Scenarios as the ones considered by Storage4Grid pose strong requirements supporting ICT, data management and control infrastructure:

- **Security**: to ensure that collected data can only be accessed by authorized parties, and control features are protected, therefore protecting privacy, and safety of users and equipment.
- **Scalability**: to keep solutions affordable as the number of users increase.
- **Modularity**: to facilitate the future introduction of new add-value features (e.g. intelligent algorithms, machine learning features, new business features) and controllable devices (e.g. new storage systems, new flexible loads) as they become available across the whole system.

- **Flexibility**: to allow monitor and control features to be spatially distributed, therefore allowing both scenarios where the system can be both controlled by one or more central entities (e.g. DSOs, aggregators) or used in fully decentralized scenarios where users are more autonomous and interact with each other with little or no mediation by traditional utilities e.g. leveraging block chain-based systems.

In research projects, teams are often tempted to re-invent the wheel and develop their own, ad-hoc data management solution, sometimes also featuring closed/commercial components. While this solution could be ideal in the short term, it does not pay off in the longer term – as it poses threats to how effectively such solutions can be adopted beyond the project.

In order to cope with this challenge, the Storage4Grid project has decided to adopt fully open solutions as depicted in Figure 4.

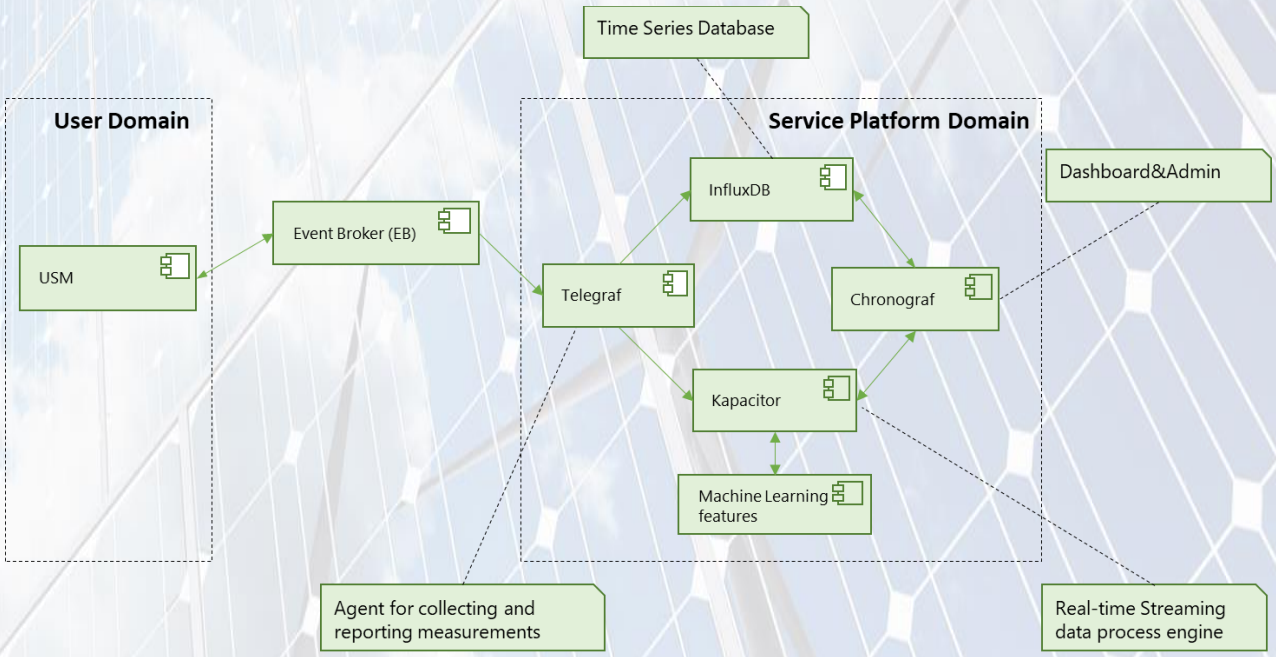

Figure 4. DSF-DWH Architecture.

In the user domain, the key component handling data collection and site-wide control aspect is a software agent running in a local field device, i.e. the SMX which is part of the USM. From this agent, data is transported to a project-wide central Data Warehouse (DSF-DWH), deployed in the utility or aggregator domain. Data transport occurs in event-oriented fashion, through an Internet-based communication link, secured through state-of-the-art security solutions namely Transport-Layer Security (TLS) and Open Virtual Private Network (OpenVPN). The Storage4Grid data collection approach is *fine-grained*: while the local USM can access all data available on the field (e.g. power, voltage, energy consumption, devices status) it is possible to control which properties are transported (and stored) in the central DSF-DWH.

The project team has chosen the tools to realize the DSF-DWH among well-established, open data storage solutions optimized to handle time-series data, keeping in mind the project requirements in terms of security, extensibility, scalability. More specifically, the well-known TICK stack has been adopted to realize the main

distinguishing features of the DSF-DWH, namely the time-series database (InfluxDB), a data collection agent (Telegraf), data processing component (Kapacitor) and a data virtualization dashboard (Chronograf).

At the time of writing, the TICK stack is integrated with a number of Storage4Grid solutions and it is currently being used to collect ESS status data from the Fur and Bolzano pilot, leveraging a secure VPN connection. During the project, the number and type of data sources integrated will be progressively increased, turning the DSF-DWH a useful tool for supporting operations and research activities in the project.

Dissemination activities

Storage4Grid session at the IoT Innovation and Networking Days

Presentations about:

1) The Storage4Grid Project (Riccardo Tomasi – ISMB)
2) Embedding Intelligence in Future Grids: Conflicting visions, common perspective (Mihaela Albu - UPB)
3) Future Smart Grids: the DSO Perspective (Gitte Thybo – ENIIG)

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Presenting the USM / SMX

The USM/SMX was presented on 28th September 2017 at the Energy Day in Romania. Mihaela Albu (Professor at UPB) has been invited to a debate on regulatory and legal issues hindering a larger uptake of PV installations at household level. The meeting has been hosted by the non-governmental organization EFDEN, and was attended by TSO and DSO representatives, energy regulator, policy makers and individuals interested in PV and storage installations at household level.

Storage4Grid organised a special session named "Trends in Energy Storage for Future Grids" at the 23rd ICE/IEEE ITMC Conference (http://www.ice-conference.org/) at Madeira Island, Portugal

Mihai Sănduleac (UPB) and Riccardo Tomasi (ISMB) presenting Storage4Grid papers at ICE/IEEE ITMC 2017.

Promoting the USM / SMX solution

The USM/SMX was presented at the 8th edition of the "Smart metering 2017" International Symposium, where representatives from the major companies in the metering industry relevant for the energy networks operators, both from Romania and abroad reunites. Mihaela Albu (Professor at UPB) has been invited to speak about smart metering systems in the global context of the energy sector transformations. Her presentation (co-authored with Mihai Sanduleac, the Storage4Grid Technical Manager) has been devoted to the Universal Smart Meters' applications for energy communities with prosumers and examples from the Storage4Grid project use cases. Mihaela Albu has been also invited to the discussions organized as part of the round table: *New challenges for DSOs – The Digital Transformation*, where the Storage4Grid solutions enabled by smart metering have been promoted.

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