# STORY – Demonstrating the added value of storage in distribution systems

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**Kurzfassung:** The HORIZON 2020 project STORY aims at developing new ways to use storage and demonstrating these. It includes an analysis on the impact of large scale rollout of the demonstrated storage technologies. It develops business model archetypes and determines the required policy and regulatory framework to support them.

This paper gives an overview on the demonstration cases, which are the key activity of the project, on which further analysis builds. Furthermore it describes the role of ICT in integrating storage technologies into the grid. Finally it gives an outlook on the analysis of the impact of a large scale rollout of storage technologies in Europe.

**Keywords:** Energy storage, ICT, data management, HORIZON 2020 STORY

## 1 Introduction

Today, an increased share of highly variable renewables already challenges the European energy grid. In the future this situation will be intensified, as the EU has set a target of at least 27% for the share of renewable energy consumed in the EU in 2030. The European Commission's Energy Union strategy[1], published in February 2015, states the commitment of the European Union to become the word leader in renewable energy. To fulfil these aims and targets, storage technologies are outlined as a major requirement.

Therefore, energy storage is the focus of the HORIZON 2020 project STORY[2].

STORY aims at

- Developing new ways to use storage and demonstrating these on a number of sites;
- Analysing impact of large scale rollout of the demonstrated storage technologies;

[1] European Commission (2015) Energy Union Package Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank, COM(2015) 80 fin, Brussel, 25.2.2015, http://ec.europa.eu/priorities/energy-union/docs/energyunion_en.pdf, accessed 26.11.201

[2] http://horizon2020-story.eu/

- Developing various business model archetypes and determining the required policy and regulatory framework supporting them;
- Communicating the findings to a wider public through systematic strategies for impact creation.

These topics are addressed by the STORY project team consisting of 18 European institutions from 8 countries, which started their work in May 2015 and will work together until 2020.

First, this paper presents the demonstration cases, which are the key activity of the project, on which further analysis builds. Second, it describes the role of ICT in integrating storage technologies into the grid. Third, it gives an outlook on the analysis of the impact of a large scale rollout of storage technologies in Europe.

## 2 Demonstration cases[3]

STORY presents six different demonstration cases, each with different local/small-scale storage concepts and technologies, covering industrial and residential environments. Table 1 gives an overview of the investigated demonstration cases.

Table 1: Overview of the investigated demonstration cases

| | | **Case 1** | **Case 2** | **Case 3** | **Case 4** | **Case 5** | **Case 6** |
|---|---|---|---|---|---|---|---|
| | | Residential building scale | Residential neigh-bourhood scale | Storage in a factory | Storage in residential district | Large scale storage unit | Roll out of private multi-energy grid |
| Type of storage | thermal storage | ✓ | ✓ | | | ✓ | ✓ |
| | battery | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | CAES | | | | ✓ | | |
| Connected to the power grid | | ✓ | ✓ | | ✓ | ✓ | |
| Energy technology | CHP | | | | | ✓ | ✓ |
| | vacuum solar collectors | ✓ | ✓ | | | | |
| | heat pump | ✓ | ✓ | | | | |
| | PV | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | wind power plant | | | | ✓ | | |
| | tidal energy plant | | | | ✓ | | |
| | biogas plant | | | | ✓ | | |
| | fuel cell | ✓ | ✓ | | | | |
| User sector | | residential | residential | industrial | residential | residential & industrial | industrial |
| Location | | Belgium | Belgium | Spain | Northern Ireland (UK) | Germany & Slovenia | Belgium |

[3] Demonstration leaders: Case 1&2: TH!NK E (www.think-e.be); Case 3: Exkal; Case 4: B9 Energy Storage (www.b9energy.co.uk) Case 5: Enersys (www.enersys.com) and Elektro Gorenjska (www.elektro-gorenjska.si); Case 6: Beneens en Zonen (www.beneens.be).

# 3 ICT as a supporting service[4]

The focus of ICT as a supporting service for the management of STORY systems in smart multi-energy grid is to facilitate communication, integrate control algorithms, increase interoperability and provide measurement services. One major challenge is that STORY energy requests and sensed measured data is reliably transferred both internally within the demo site and externally outside of the company's network. This reliable transfer includes, besides availability and robustness, also additional security and privacy issues that arise when data is transferred outside the company's network. To cover these issues, a novel gateway will be developed, capable to perform some local optimisation regarding local needs and also to enable the distribution system operators to access and perform grid support actions under secure conditions.

## 3.1 Smart Grid communication and information technologies

Extensive analysis of smart grid standards has been done in the past by numerous projects. Projects that contributed noteworthy effort in this regard were the STARGRID[5] and FINSENY[6] projects, supported by the 7th framework programme of the European Commission. Based on this, a look at the most applicable communication standards and technologies for the STORY project demonstrations is performed and determined how to replicate the data communication in STORY demonstrations.

In the smart grid environment, communication and information technologies continue to evolve. This process can possibly be disruptive. Other domains have already undergone such transition into smart system and lessons learned should be considered appropriately. A look at the ICT domain shows that de facto standards often outperform formal standards (e.g. REST will outperform, concerning development effort and time, so-called formally standardised alternatives e.g. SOAP, RPC and CORBA). Critical user mass within the software/system developers communities is decisive, not the number of large companies and organisation expressing / enforcing a (formal) standard.

In STORY, existing and forthcoming equipment will be integrated into smart storage-centric installations. In other words, the project employs (but does not develop) this equipment. Therefore, it needs to cope with the existing and forthcoming smart grid reality while preparing for upcoming solutions – which are being developed elsewhere.

The following communication technologies and standards are of interest for STORY and contribute to the selection of the gateway:

Firstly, there exists a range of communication technologies distinguished by the manner in which data is transmitted. Therefore, beginning from dedicated communication wiring (e.g. Ethernet or serial communication links), powerline communication or wireless communication

[4] Savolainen, Kyntäjä, Vallant, Marksteiner, Aertgeerts, HaleWeyck, Valckenaers (2016), Structured Overview of Communication Standards for Smart Grids, STORY Deliverable 4.1

[5] http://stargrid.eu

[6] http://www.fi-ppp-finseny.eu

will be used. The choice of communication mechanisms toward the devices, sensors and actuators will be constrained by the (energy) application and much less by ICT concerns.

Secondly, there are a significant number of legacy technologies within the smart grid, both at industrial sites (often using SCADA systems and PLCs) and home automation (also using simple PLCs but increasingly mainstream computers, often ARM-based favouring EU technology).

Thirdly, the Internet of things and smart grid research and development has proposed and produced technologies that cope with hyperconnectivity (IPv6) and are state-of-the-art software (REST).

Fourthly, there are internet technologies that are relevant regarding to a sustainable replicability of STORY developments. RESTful HTTP has become a de facto standard used in many applications. WS* alternatives[7] cannot compete, especially in resource constrained environments.

Finally, the standardization efforts aim at modelling from an energy/electrical/semantic perspective versus other standardization bodies which are active in adding application-aware semantic elements to their repertoire.

## 3.2 Gateway requirements

Besides some general cross section characteristics (availability, redundancy, scalability and price), the STORY communication gateway requirements are aligned to four layers (Table 2).

Table 2: Layers of the STORY communication gateway requirements

| STORY Layer | |
|---|---|
| Application layer | closest to the end user applications, heavily depends on the algorithm modelled by the demo sites (processing unit, operating system, programming language/libraries) |
| Security Layer | responsible for STORY energy requests and sensed measured data to be reliably transferred both internally within the demo site and externally via network outside the territory of the company's network |
| Data exchange layer | ensures that all the information transferred by the data transport protocols are conveyed between the systems parts, no data losses nor errors during data transformations occur and finally that all data packets are routed to the correct receiving entities of the system |
| Communication layer | handles the different types of communication networks for STORY four types of generalised communication networks are compared (Cellular networks, Low Power Wide Area, HAN, Ethernet) |

[7] http://www.w3.org

## 3.3 Security requirements

One major challenge for the management of STORY systems is that STORY energy requests and sensed measured data is reliably transferred both internally within the demo site and externally via network outside the territory of the company's network. This reliable transfer includes besides availability and robustness also additional security and privacy issues that arise when data is transferred outside the company's network.

### 3.3.1 Security Requirements for STORY

Authentication and access control is one of the most crucial elements to secure the STORY infrastructure. Therefore, depending on the size of the storage production capacity and their integration into the grid, two categories are introduced:

- For demo sites with a storage capacity which are mainly for their own consumption identity based, individual user login/ password or eID are proposed.
- Demo sites, which are mainly under control by a DSO a more sophisticated authentication process including a combination of a certificate and role based authentication and access control process is planned. This two-way authentication needs more administrative interaction, but at the area of DSO such an expertise to manage is assumed. Therefore, the maintenance of certificates is pre-existing.

The roles defined in the authentication (and authorization) may also be used for alerting; the system MUST be capable to report certain safety and security relevant events to distinctive people or groups thereof. Reporting methods may include email and SMS. Furthermore the system may contain a security dashboard, displaying recent events on the management interface. We also propose four levels of alert classes to categorize these events and assign it to roles or groups to be alerted.

The access control also includes measurements to prevent unauthorized access. To achieve this, the device MUST be hardened (all unneeded services must be deactivated; a customized, reduced kernel is also recommended to provide a smaller target to adversaries). Also a host-based firewall and strict patch management MUST be in place.

Also, communication channels have to be secured. Due the limited resources normally available at embedded systems, a hybrid cryptosystem approach is used which combines the security benefit of a public-key cryptosystem with the efficiency of a symmetric-key cryptosystem. During the communication establishment, the asymmetric key is used to exchange the symmetric key, which used afterwards for an efficient data throughput. Such a hybrid approach is part of various cipher suites and should be enabled.

In order to provide authentication and encryption, Transport Layer Security (TLS) MUST be used to provide communication security while traversing over foreign networks. For this implementation, TLS is chosen as requirement over alternatives (e.g. IPsec) for the following reasons[8]:

- TLS is easier to integrate between different vendors

[8] Alshamsi, A., & Takamichi S. (2005). A Technical Comparison of IPSec and SSL. In Proceedings of the 19th International Conference on Advanced Information Networking and Applications. AINA, 2005.

- TLS needs less overhead
- TLS allows quicker handshakes
- TLS is easier to configure

In constrained environments such as STORY demo sites which mainly use their own consumption Datagram Transport Layer Security (DTLS) might be used as a lightweight alternative.

In the same manner as in communications, data stored locally on the device has to be secured from unauthorized access. Apart from system access controls, this data has to be encrypted and integrity checked by the same algorithmic methods as communication lines. This is distinctively a requirement for security relevant data (explicitly logs that contain security events), which MUST be encrypted and integrity checked. Additionally, for privacy reasons, some sort of anonymization method has to be implemented, if personal data is to be processed. As it is a sensitive part, special focus on the key management is needed. A key derivation function that is deemed state of the art by current research MUST be used. A smart card-based key derivation function is recommended. To protect systems (i.e. ICS) in contact with the gateway, some sort of filtering (ICS intrusion protection or anomaly detection system) is also recommended.

### 3.3.2 Privacy Recommendations for STORY

Privacy aspects in STORY are not limited to confidentiality and access control. The sensors in use will generate a large amount of data and partly highly sensitive personal data about activities within the demonstration site. At residential building demonstrations the connection to smart household appliances or smart home functionality has to be considered, because such a connection has a huge impact on the privacy of a person. Such an amount of personal data can deliver a lot of information about the person's behaviour, location and actions, as well as health and finance status. In the area of industrial demo sites, the interconnection to other deployed systems may have serious impact regarding accessibility of confidential internal information (data protection) and processes. Therefore, measurements have to be undertaken to protect this information from unauthorized access.

- All personally identifiable and sensible data must be encrypted using state of the art encryption standards
- Establish state of the art access control mechanism to all data
- Specify which personally identifiable and sensitive data types and attributes are collected and used and for what purposes
- If sensitive data is transferred outside the premises, only part of the data which is reasonably useful for the functionality have to be transferred
- If data is transferred outside the premise, personalized data has to be pseudonymized
- If data is transferred outside the operations, personalized data has to be anonymized
- During the transfer, all data has to be encrypted by using current generally accepted state of the art security standards
- In general, data must only be stored within storage devices located inside the EU

- Collected data is not shared with third party organisations
- Specify how long data will be stored
- Provide information about policies, terms and conditions to the user
- Provide information and control how the user can decline and personalized data is being removed.

# 4 Outlook: Large-scale impact assessment

The results from the six demonstrations feed into a large-scale impact assessment with the central question being: "What if a large amount of storage is integrated in the distribution grid?" The assessment considers challenges to the grid infrastructure, the impact on the integration of local decentralized and large scale centralized renewable energy sources. It includes economic, social and environmental impacts as well as the identification of business model archetypes and business preconditions.

## Project contact

To follow STORY and get the latest project news visit http://horizon2020-story.eu/. You will also find information on other HORIZON LCE6-10 projects.

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